

## Article

# GREEN: Cool & Care—Research and Development of Greening Measures in Nursing Homes in Austria. Technical and Social Interconnections

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**Abstract:** According to demographic data, the percentage of elderly people within the population is growing, representing a vulnerable group to the effects of increasing heat, but little attention has been paid to developed adaptation measures. In addition, many older people leave their familiar homes and live in nursing homes. The person-centred care pursues creating spaces of high living quality for these people in nursing homes, to which plants and greenery can contribute. Greening is also considered an effective climate change adaptation measure. To create healthy conditions for this vulnerable group of elderly, both technical and social factors must be considered, and accordingly, a successful solution can only be achieved in an interdisciplinary way. The research and development of the project “Green: Cool & Care” dealt with this outset from a building physics, social, and nursing science perspective, and concepts to integrate greening measures in nursing homes were developed jointly by researchers, planners, staff, volunteers, and residents. For this purpose, measurement campaigns of air quality parameters, individual interviews and focus groups, as well as co-creative workshops were conducted aiming to include the objective building conditions as well as the subjective needs in developing and, in a further step, implementing greening measures.

**Keywords:** indoor environment quality; elderly care; nursing home; healthy cities; urban green infrastructure; plant-based solutions; interactions between urban green and human wellbeing; interdisciplinary approach; co-creation; climate change adaptation; hygrothermal comfort; vulnerable population groups

## 1. Introduction

Climate change, causing, inter alia, longer lasting heat waves during summer months, can negatively impact living quality, overall human wellbeing, and even lead to physical health consequences, especially for vulnerable groups, such as the elderly, sick, and disabled people.

According to demographic data, the percentage of older people within the population is increasing. Currently, 24.4% of the Austrian population is more than 60 years old (2017), and according to the prognosis, it is about to reach up to 35% by 2080. With an ageing population across Austria and Europe, the importance of care provision for older people is widely recognised. Care and nursing homes are growing in importance and are challenged by an increasingly dependent clientele [1,2].

In this context, it should be mentioned that gender plays an important role in nursing homes [3]. From the perspective of the proportion of those involved, the nursing home is a woman's world. In Austria, almost 70,000 people live in a nursing home, 72% of whom are women [4], as are 84% of care and nursing services staff [5]. The Austrian situation regarding gender relations is typical for Europe [6].

People in developed countries spend most of their time indoors [7]. Inadequate indoor environment quality can negatively influence the quality of human life as well as affect their health status. Studies regarding indoor environmental conditions are strongly related to health, wellbeing, and overall performance [7].

Thermal comfort is an important factor affecting indoor environmental quality. Humidity, air temperature, air movement, and the temperature of room surfaces, such as ceiling, floor, walls, etc., as well as clothing are among the essential factors influencing thermal comfort [1]. According to ASHRAE Standard 55–92 [2], thermal comfort is defined as the condition of mind that expresses satisfaction with the thermal environment.

From a building physics point of view, there are two commonly used approaches in the current thermal comfort research. The first can be defined as rational, while the second one is characterised as the adaptive approach. Individuals feel the indoor climate differently and can adapt differently over a period of time to various thermal stimuli (adaptation) or thermal environmental conditions (acclimatisation). Therefore, there cannot be one indoor climate that is considered optimal by every individual. The classic work of Fanger [8] related thermal sensation to the existence of heat balance by observing a large number of people in a laboratory experiment [3]. He established a lab-based PMV–PPD method. The PMV (predicted mean vote), based on this theory and deriving from climatic chamber studies, is the most widely used thermal comfort index. The PMV index divides the human perception of the indoor thermal climate into a 7-point scale, which ranges from “too warm” (+3) to “cold” (−3). The PMV index has captured the climate in space by a group of people, but the observation of an individual differs from the mean. For this reason, the PPD index, also known as the Predicted Percentage of Dissatisfied, indicates the percentage of people who are dissatisfied with the indoor climate [8].

In addition to the above-mentioned, several other factors can contribute to the wellbeing of the person in terms of the indoor climate. These are divided into physiological, intermediate, and physical influences, according to Frank [9].

There are several publications about the optimal temperature and the optimal humidity in houses and rooms [10–12]. Frank [9] evaluated that the temperature should not be below 17 °C and not above 25.5 °C. The comfort area of humidity depends on the temperature. It should never be below 18 % or above 87 % [9].

Often, the hygrothermal conditions in the interior do not meet these requirements and thus contribute to dissatisfaction and can even provoke and aggravate diseases [11–13]. Greening can contribute to a healthier indoor climate and is considered an effective measure for improving comfort conditions. In addition to effects that have already been proven in international studies, such as the improvement of room acoustics, greening has an effect on hygrothermal comfort. [14–16] Along with these measurable improvements, greening can contribute to an enhancement of the room and also to an improvement of wellbeing through aesthetic effects [17,18].

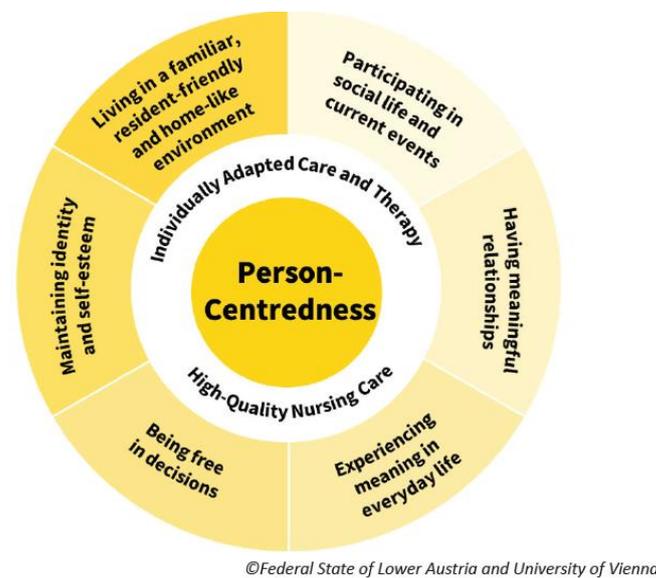
The impact of greening in nursing homes is a fairly new premise, and thus, its contribution to creating comfortable living conditions for the vulnerable group living there has not yet been studied. In order to create healthy conditions for this vulnerable group of elderly, both technical and social factors must be taken into account, and accordingly, a successful solution can only be achieved in an interdisciplinary way.

To include all aspects of comfort, it is therefore essential and necessary to focus on the so-called person-centred care accordingly. Person-centred care aims at meeting the needs and wishes of residents in nursing homes. It focuses on the emotional and social aspects of care, and the emphasis is on relationships. Individualised approaches support opportunities for social engagement and help people live their lives and experience

wellbeing. An understanding of the perspective of the person and respect and value for the individual as a full member of society guarantee appreciation and acceptance [19,20]. McCormack [21], as one of the leading researchers in this field, argued that four core “modes of being” are the heart of person-centredness: being in relation, being in a social world, being in place, and being with self.

Person-centredness thus means treating people as individuals, respecting their rights as persons, building mutual trust and understanding, and developing a therapeutic relationship [22] to provide appropriate care and enable individualised treatment decisions [23]. Person-centredness is further understood as a normative value system to which individual professionals and teams of all disciplines in health care or entire organisations commit themselves and further includes relatives, associates, and professionals, as they play a central role in the care and recovery process [24]. Person-centredness can thus provide a comprehensive framework model for all health care settings.

In Lower Austria, the theoretical framework PeoPLe (Person-Centred Practice in Long-term Care) [25] offers a model of individual and high-quality care that underlies the organisational culture of the nursing homes, which is based on the person-centred approach according to McCormack [25]. Figure 1 visualises all six principles of this approach.



**Figure 1.** Fundamental principles of person-centred care [25]. Reprinted with permission from Federal State of Lower Austria, 2015.

Some studies demonstrate the positive effects of gardening and green surroundings for older people [26–28], especially for the nursing home setting [29–31] and day-care centres [32,33]. These studies focus on outdoor and therapeutic interventions and less on how gardening activities are integrated into everyday life. Indoor plants and the influence of temperature and humidity on quality of life and wellbeing is not the subject of these social science studies.

Currently, there is a broad knowledge base on the impact of the physical environment on care, support, and recovery. In reality, however, healthcare facilities are often designed with a focus on clinical efficiency rather than person-centredness. Therefore, individualised consideration must be given in each healthcare facility to how existing environments can be improved in the context of a person-centred approach to facilitate effective person-centred practice [22].

Basically, it is necessary to consider the “(health)-enhancing characteristics” of buildings; the equipment and furnishings of the spaces (architectural design concepts) that are intended to support, empower, or activate the residents individually; and the characteristics of the environment in which care and support take place. It is also important to focus on

the aspect of emotional connection with places: places have deep meanings, are associated with memories, and connect the individuals both metaphorically and physically to their history [22].

A healthy, aesthetic, yet functional environment is important to residents, relatives, staff, and also visitors. The physical environment is a direct determinant of wellbeing [22]. Such a condition can only be achieved in an interdisciplinary way, taking into account all expertise.

There have been notable developments in designing healthcare facility environments that are aesthetically pleasing, ensure a relaxed atmosphere, and promote healing, security, social activities, belonging, and sensory stimulation. These include strategic placement of, for example, greenings (flowerbeds, plants, herbs, trees, fruits) and artworks (paintings, sculptures, installations) for sensory and emotional stimulation and the use of light, sounds, and smells to promote relaxation [34].

Whether the intent is therapeutic or social, aesthetics is important, and greenings and art play a significant role in creating aesthetically pleasing spaces. The aesthetic qualities of the environment are related to the sense of self, the sense of being, and the sense of being connected to the world and thus are important components of a person-centred practice [22].

Especially in this context, the literature emphasises the importance of green environments for health care institutions as well as the importance and potential of including all six fundamental principles of care within the PeoPLe concept. The fulfilment of the needs in terms of the fundamental principles of care can mainly influence and increase the quality of life of the clients in the health care institutions.

In order to meet all the requirements as well as the needs of all, the method of participation is prevalent. Any form of participation process enables people to become the architects of their own surroundings. All forms of participation build upon sharing information, assessing needs, identifying possibilities, looking jointly at possible future steps or implementations, building a consensus between different parties, and creating and implementing a plan [35]. Co-creation is, on the one hand, a way of producing knowledge among participants, and on the other hand, it creates inclusion, seeking to combine different views of diverse people. It is essential to acknowledge the heterogeneity of participants and take all views seriously. As there is a gap between knowing and doing, both aspects are essential and have therefore been included in the participatory process to ensure the final impact and tailor-made solutions. Co-creation is a multifaceted process with a solid relation to knowledge: knowledge production, knowledge transfer, and knowledge use have to be considered and applied in the overall process [36]. Action research pursues action and research at the same time. It is an iterative process that is, in most forms, also participatory. Participants are partners and experts in their surroundings within the research process. It is often used for organisation questions, leading to case studies to understand particular organisations to improve a particular situation. It is a method that helps to ensure acceptance and acquiring of changes among participants [37].

In order to counteract the urban heat due to climate change and creating healthy cities in the long run, especially in the case of nursing homes occupied by elderly people, a new approach and innovative solutions are needed. This is why the research and development (R&D) project “GREEN: Cool & Care” addresses innovative greening solutions focusing on older people in need of care living in nursing homes in Lower Austria. Four nursing homes in Lower Austria served as examples for finding innovative solutions for living walls and green open spaces explored and developed in co-creative settings and adapted to the requirements and wishes of the targeted groups, such as residents of nursing homes, nurses, and other staff members (e.g., occupational therapists, physiotherapists) as well as volunteers.

The technical innovations developed within this project will be put through profound monitoring, including hygrothermal comfort, which will be discussed briefly in this article, as well as social parameters and criteria. Special attention lies in the interdisciplinary coop-

eration between civil engineers, landscape planners and designers, landscape gardeners, social scientists, professionals regarding caregiving, and delegates of the nursing homes.

With the concept of person-centred care, the interest lies in the meaning plants have in the lives of nursing home residents, what experiences they bring with them, and how this personal relationship to plants can be implemented well in everyday life in the nursing home organisation. Although all six principles can be important within the context of the R&D project “GREEN: Cool & Care”, most notably, principles like “living in a familiar, resident-friendly, and home-like environment”, “participating in social and current events”, and “experiences meaning in everyday life” were explored within the qualitative part of the research project, including thermal comfort, as it affects a person’s wellbeing in general and health benefits specifically, as mentioned previously.

## 2. Materials and Methods

People tend to feel more comfortable within a specific temperature and humidity range, depending not exclusively on the measured physical parameters but equally on a person’s own specific state. In addition, several other factors can contribute to the wellbeing of a person, such as physiological, intermediate, and physical influences, as explained in Section 1. This can include a green environment as well. Therefore, an interdisciplinary approach is crucial.

In the context of the investigations presented in this article, methods from the fields of building physics, social science, and applied science were therefore used and combined. The individual procedures are presented in the following chapters.

Four nursing homes in Lower Austria, in which investigations were carried out, and finally, green infrastructure was implemented with the aim of improving health conditions, served as the subject of the research. In this article, two of the four nursing homes and the activities and investigations carried out there are presented in the form of case studies. The initial building situation at these two facilities is briefly described in the following.

The Nursing Home St. Pölten has been in operation in its current building near the riverbank since the year 2000 and has space for 121 people in need of care. The whole site is approximately 11,800 m<sup>2</sup>, and more than half of it is the garden. In the house, special emphasis was placed on cosiness and a view of nature. Residents can look out into the open air through the floor-to-ceiling windows onto the winter garden even in the cold season. In the warmer season, barrier-free paths invite visitation of the garden with its art and therapy garden.

The Nursing Home Wolkersdorf is situated in the western part of the city, surrounded by residential flats and a school. It has the smallest area out of the researched homes and has a garden in the back of the building. The site is approximately 8000 m<sup>2</sup>, of which one-third is a barrier-free garden.

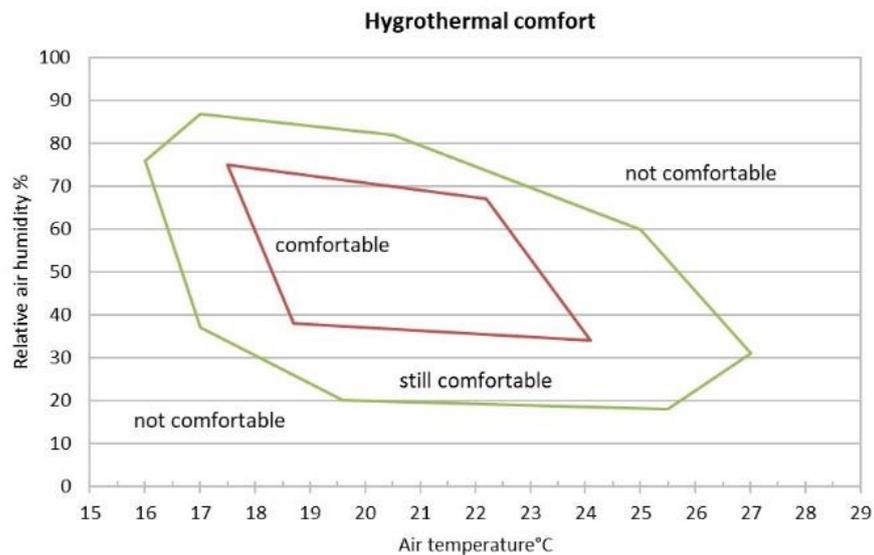
All four nursing homes are situated in the residential areas of Lower Austria cities. Although all the nursing homes have rather extensive gardens around the building, due to the limited mobility of the inhabitants, the interior plays a significant role, even if the outside environment of the facility is already green. Specific greening measures are therefore also developed for these facilities, because the view of the surrounding gardens is not given from every position of the interior of the house.

In a first step regarding thermal comfort for “non-standardised” but elderly people, temperature and humidity were measured during several interviews with residents. No further parameters were considered, as this was to get a preliminary understanding of the very personal perception of thermal comfort. In order to obtain a better understanding, further investigation will be carried out within the framework of the project. A brief outline of the data will be shown.

Based on the conducted interviews and focus groups, which will be introduced briefly in the following sections, aiming at discovering the needs and desires of the inhabitants of the nursing homes concerning innovative greening solutions, co-creative workshops were conducted and will be continued throughout the project.

### 2.1. Building Physics Methods

The hygrothermal indoor climate is, in essence, described by the parameters of air temperature and humidity. These two parameters were therefore measured and evaluated in a further step. The analysis of hygrothermal comfort was performed using the Frank comfort diagram. The “comfortable”, “still comfortable”, and “not comfortable” ranges of the temperature and the humidity are shown in Figure 2.



**Figure 2.** Range of “comfortable”, “still comfortable”, and “not comfortable” temperature and humidity in a room, after Frank [9].

Two long-term measurement campaigns, carried out in rooms before and after installation of the greening measures, were considered in order to highlight the effects of indoor greening on the parameters of air temperature and relative humidity, which can be measured in terms of building physics. Furthermore, measurements of these two parameters were taken during the interviews of several residents of the four nursing homes as a qualitative approach to explore the residents’ experiences, attitudes, and needs regarding plants, whose methodology is explained in Section 2.2. This combined approach allows a demonstration of the individual response to measured physical parameters.

During the entire interview period (on average 45 min; between 30 to 60 min), the air temperature and the relative humidity were measured continuously. The interviews took place in the rooms of the interviewee or the common areas of the centres. Two RTR 53 data loggers were used. After the interview, the data were evaluated and compared with the participants’ answers to get a better understanding of the subjective perception of the residence perception of thermal comfort, which could then be evaluated with the measured physical parameter of temperature and humidity. No further parameters were considered, as this first approach was to get a preliminary understanding of the very personal perception of thermal comfort. In order to obtain a better understanding of the perception of thermal comfort for “non-standardised” people, namely mostly elderly people, further investigation will be carried out within the framework of the project.

The wireless recorder RTR-53 used has a recording range for temperature from 0 °C to 55 °C and humidity from 10 to 95%. The measurement accuracy is  $\pm 0.3$  °C for temperature and  $\pm 5\%$  for humidity. In this research, the recording interval setting was 60 seconds. Through the RTR 57U unit, the RTR-53 can be connected with a computer, and data can be transferred into the software developed by the company T&D. There, data can be seen as a graphic for each temperature and humidity or as a list with the corresponding data for the measurements. Additionally, the data can be exported into a text file that can be imported into an Excel file for further analysis.

## 2.2. Social Science Methods

A qualitative approach to explore the residents' experiences, attitudes, and needs regarding plants from the perspective of those affected was selected. Methodologically, qualitative research is about understanding the meaning of those involved. The procedure is theory-generating, which means that by means of inductive logic, conclusions are drawn from the particular to the general [38].

Qualitative interviews were conducted with the residents [39]. On the one hand, the interviews aimed to address certain aspects relevant to the project and get the residents' perspectives on the topics of interest. On the other hand, it was also about stimulating stories, especially when it came to the biographical meaning of plants. The interviewer directed the interview. The questions were designed to be open so that the person questioned could speak freely and introduce new aspects relevant to the researcher. Additionally, pictures of the greening solutions were shown to find out about the reactions on these planned changes. The interviews lasted between 30 and 60 min and took place in the respective nursing homes, in residents' rooms or common areas.

In each of the four elderly nursing homes participating in the project, people were selected for an interview in coordination with management and employees. For the selection of residents, criteria were defined in advance in the sense of selective sampling [40]. The sampling aimed to attract a heterogeneous group of participants to capture the relevant phenomena in the field under investigation as broadly as possible. The criteria were gender (according to the gender ratio in the nursing homes), mobility (bedridden, using wheelchairs or walking aids, mobile without aids), age, the individual's affinity for plants, and health. A total of 29 residents between the ages of 62 and 97 years were interviewed, including 24 women and five men.

The interviews were recorded on tape and then transcribed verbatim. The qualitative data from the interviews were evaluated using qualitative content analysis [41] with MAXQDA, a software specially developed for qualitative content analysis. The data relevant for the evaluation were filtered in the form of text passages from the transcripts and clustered according to specific research topics and focal points.

## 2.3. Co-Design Methods

Based on the conducted interviews and focus groups aiming at discovering the needs and desires of the residents of the elderly homes concerning innovative greening solutions, co-creative workshops were conducted. These co-creative workshops were designed in an interactive and participative manner, focussing on the interface of human beings and greenery. Innovative greening solutions were prepared and demonstrated vividly to show the workshop participants what different greening solutions could look like. The greening solutions were planned together with the workshop participants in the different elderly homes. Even the choice and arrangement of different plants and soils was demonstrated vividly and discussed in detail with the participants. The planning of the greening solutions was performed together with residents and employees of the nursing homes, following their visions, ideas, and needs. Therefore, it was a very comprehensive co-creative and participatory process. Methods of co-creation, participatory planning, and action research were combined to lead to tailor-made solutions. The basis for applying these methods and their matching to the project goals was the concept introduced through PeoPLe, which also focuses on the fact that supporting and encouraging self-responsibility and self-reliance for the elderly is beneficial for their overall health and wellbeing. Overall, the concept for the co-creation workshops was threefold: (1) Knowledge transfer about different greening solutions and plants to lay the foundation for the co-creation process, (2) co-creational decision process for the type of greening solution and the favoured plants, and (3) detailed co-creational, hands-on planning process. This means the entire process chain was and is being guided and supported.

The combination of aspects of these methods created a process that ensured knowledge transfer, assessing needs and experiences, building a consensus among participants who

acted as experts within their surroundings, and creating a plan for their greenery with hands-on material.

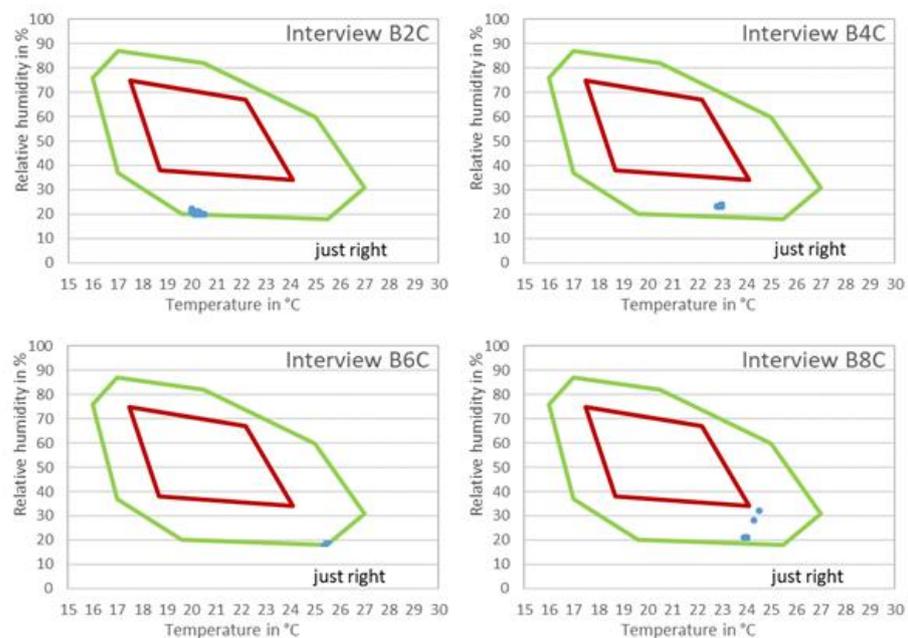
### 3. Results

In this section, the results are presented from the perspective of the individual disciplines, and the first crossovers between the disciplines that were carried out are reported. The more in-depth interdisciplinary evaluation and consideration of their added value then follow in Section 4.

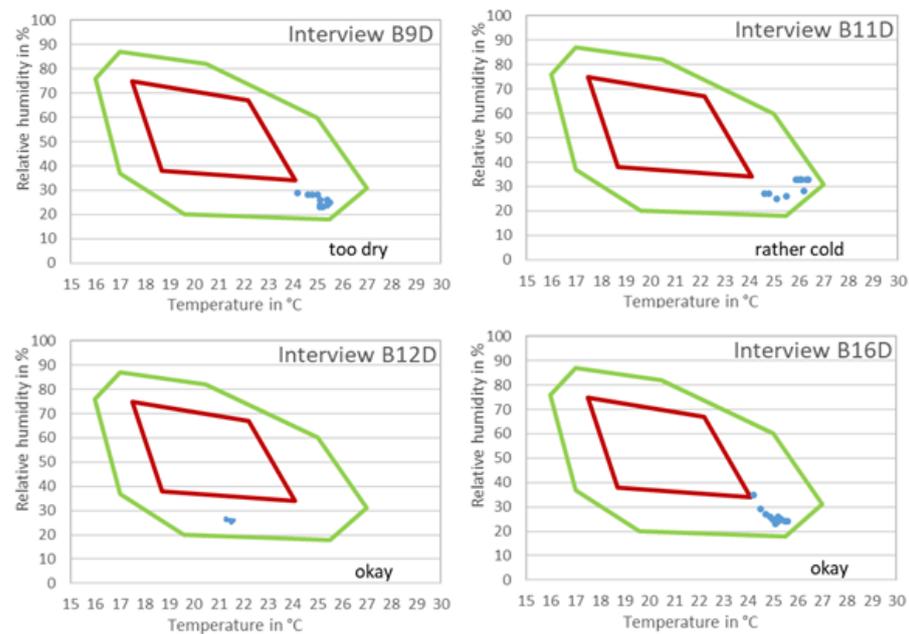
#### 3.1. Results from a Building Physics Point of View

The collected measurement data of air temperature and relative humidity were evaluated as described in Section 2.1 using Frank's comfort diagram for the period of each interview conducted.

The subjective perception of a person's thermal comfort is illustrated in the following examples in the combination of the measurement data and the statement made by the interview during the respective time (Figures 3 and 4). The last letter of the interview code, C or D, stands for two different elderly nursing homes, with C as code for nursing home Wolkersdorf and D for nursing home St. Pölten. The measured conditions, indicated by the blue dots representing the collected data during the interview, are very similar and lie within the "still comfortable" area during all conducted interviews. Still, the person's reception and corresponding statements vary, indicating the subjective perception of comfort or discomfort at almost similar thermal conditions. In a further step, additional information could be integrated into the evaluation to link the subjective perception of quite similar thermal conditions, such as the person's health condition, clothing, or general thermal response.



**Figure 3.** Diagrams of hygrothermal comfort, after Frank [9], for four exemplary interviews conducted in the care centre Wolkersdorf (C), with measurement data during the interviews and statements of the interviewees.



**Figure 4.** Diagrams of hygrothermal comfort, after Frank [9], for four exemplary interviews conducted in the care centre St. Pölten (D), with measurement data during the interviews and statements of the interviewees.

For the nursing home in St. Pölten, the measured temperature varies between 20 and 25.6 °C, and the humidity varies between 18 and 32%, representing conditions within the “still comfortable” area at all times. As shown in Figure 4, all interviewees in St. Pölten stated that the temperature was “just right”, “not too cold”, and “not too hot”. The same was true when asked about humidity; all interviewees reported that the condition was “just right”. Through these statements, one can see the subjective perspective of those who were interviewed. According to ASHRAE [42], relative humidity should be in a range between 45 and 55 % to manage health effects and illness. Even though the humidity was below these values, the interviewees reported being “okay” with the condition.

One cause of this could be that the interviews took place in winter, when the humidity should be lower to avoid condensation on windows caused by the temperature difference between the indoor and outdoor environment. Overall, the elderly living in this care centre were satisfied with the indoor climate.

Compared to the nursing home in Wolkersdorf, where all interviewees answered that they were satisfied with the climate, the interviewees from the nursing home in St. Pölten had different opinions from each other. Even though it can be seen in Figure 4 that all the blue dots are in the “still comfortable” range, the temperature here was between 21.3 and 25.5 °C, and the relative humidity was between 23% and 35%. In addition, in this case, the humidity was below the 45% recommended by ASHRAE [42], but only one interview participant, (B9D), said the air was “too dry”. One can very well see the subjectivity of each person in the case of interview B11D, who stated that the temperature was “rather cold” even though, compared with the temperature measured in the other interviews, during which the interviewees had answered that the temperature was satisfying, it was higher.

### 3.2. Insights from a Social Science Point of View

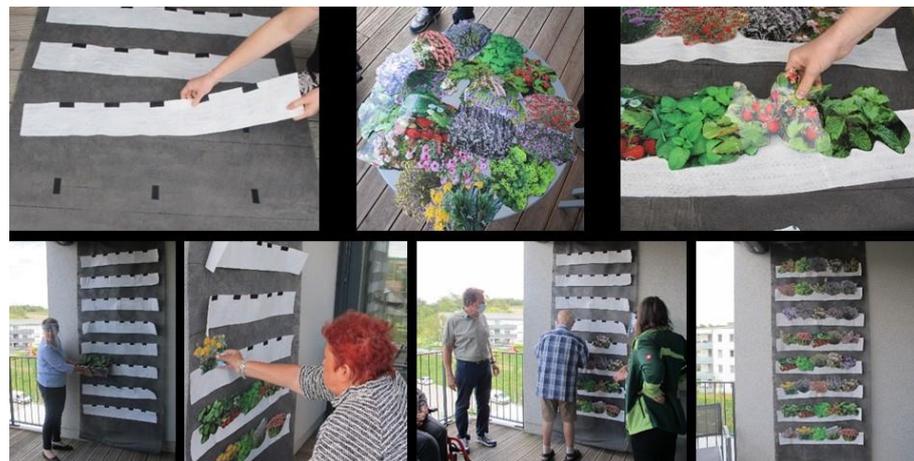
For the majority, mainly women, it turns out that plants play a significant role in their lives. They bring much experience and favour a more intensive greening of the nursing homes. Concerning the desire to participate in gardening activities, there are different approaches. For example, some would welcome the joint planting and care of raised beds as an activity in the nursing home. At the same time, another part believes that too many participants cause confusion and advocate clear responsibilities for individuals. It is seen as

problematic who takes over the plant care in view of the perceived shortage of staff. As the reactions in the interviews on the new greening solutions show, residents greatly welcome, in general, more plants and flowers into their closer surroundings. Spring flowers are emotionally very positively connoted, and herbs are very popular. The meaning of plants for the residents can also be understood in the context of nursing homes as the last place of living: “I had a garden at home, I had everything grown (...), everything was once”, as one resident put it. Therefore, some of the residents have rich knowledge about plants. In this way, the use of the garden or terrace is very important for most residents. Plants indoors and outdoors are closely observed and bring joy: “I am happy about every flower that is freshly blooming”.

### 3.3. Results from a Co-Creation Workshop Point of View

#### 3.3.1. Case Study Wolkersdorf with Regards to the Concept of Co-Creation

The co-creative workshops in the nursing home of Wolkersdorf were conducted with the residents of the elderly centre, which means that residents were significantly involved in the planning process and could introduce their ideas, wishes, and needs, which were then taken up by the designing and implementing/construction team. Impressions of these workshops can be seen in Figure 5.



**Figure 5.** Impressions of the co-creation process at a nursing home, case study “Wolkersdorf” ©B-NK GmbH.

Two consecutive co-creative workshops were planned and conducted. At first, the team presented a broad input and information about greening solutions (indoors and outdoors) and different plants to lay the foundation for the co-creation process. After jointly deciding on implementing vertical green walls outdoors on the balconies of the nursing home, different plants were introduced, pictures shown, and visual descriptions and actual plant samples used to stimulate all the senses in terms of aesthetics, scents, and textures of the plants. This step was combined with discussing and taking up biographies of the elderly and their experiences and feelings towards plants. It was then established which plants were most favoured by the residents, and specific plants for the green wall were chosen. This led to a follow-up workshop inspired by the method of action research (Figure 5). A model of the vertical green wall was provided, and workshop participants were invited to paste pictures of the chosen plants hands-on in their preferred arrangement and order, considering colours, necessities, scents, aesthetics, etc. According to the residents’ choice and arrangement of the plants, the vertical green wall was then built. Resident-adapted vertical green walls on balconies of the elderly centre in Wolkersdorf were developed. The green walls have easily manageable water connections. Materials, dimensions, and planting plans were co-created together with the residents as future users, with the project team’s expertise ensuring a functioning green wall.

### 3.3.2. Case Study St. Pölten with Regards to the Concept of Co-Creation

In this nursing home, the management declared their wish to include all employees and professional groups of the elderly home in the co-creation process. This means nursing staff, occupational therapists, physical therapists, everyday accompanists, voluntary workers, and coordinators were included in the co-creation process. Two consecutive co-creative workshops were planned and provided. The co-creative process started the same as the previous one, with presenting input and knowledge about greening solutions and different plants. In this case, the focus was put on plant profiles printed in A3 format and described in detail, especially in terms of plant care, culture, history, how different plants can be used, their benefits, etc. Knowledge about different plants was provided and conveyed in a clear and vivid manner. After it was jointly decided that as outdoor solutions, plant boxes on the balconies would be implemented, the co-creation process was further dedicated to precisely detecting what kind of boxes and plants the workshop participants wished for, asking how the boxes were pictured by the participants. Sketches were made by the design team based on the participants' ideas, and the first selection of plants was made based on plant samples; most notably, plants that address haptic senses were discussed in more detail. In the next step, the design and dimension of the plant boxes were discussed on-site on the balconies, with the help of measuring and visual aids/illustrative materials. A further workshop will decide if the plant boxes on each balcony should be arranged individually or the same way.

Figure 6 shows impressions of the co-creation workshop at the nursing home from the case study St. Pölten. L-shaped troughs with a climbing frame and standardised plants were planned on balconies from three different floors. Materials, dimensions, sizes, and plants were co-creatively decided together with the staff of the nursing home.



**Figure 6.** Impressions of the co-creation process at a nursing home, case study St. Pölten ©B-NK GmbH.

### 3.4. Results of the Interdisciplinary Process

Figures 7 and 8 are examples of greening measures that are already installed. These implementations incorporate the results of the co-creative workshops as well as the results of building physics and social science research presented in the previous sections. Further investigation will be carried out within the framework of the project in order to determine how the interdisciplinary process carried out before the installation of greening measures in

nursing homes can influence the wellbeing and satisfaction of the residents by the installed greening measures.



Figure 7. Greening solutions at the nursing home Wolkersdorf ©GREEN: Cool & Care.



Figure 8. Greening solutions at the nursing home St. Pölten ©GREEN: Cool & Care.

#### 4. Discussion

Interdisciplinary research and development regarding the quality of living and indoor environment in a nursing home for the elderly were conducted at an example of four nursing homes in Lower Austria, of which two exemplary case studies have been presented in this article.

Investigations were carried out and combined from the perspectives of building physics, social sciences, and applied science. The measurements of building physics parameters could be evaluated in combination with the interviews and focus groups conducted in the context of the social science research and thus provide added value to the subjective perception of hygrothermal comfort for elderly persons in nursing homes. The subjective perception of thermal comfort of a person has already been demonstrated for the cases of the conducted interviews. However, creating a healthy and home-like environment for people in elderly nursing homes has to be an integrated effort, as the first results have shown. Feeling comfortable in changing climate conditions where summers are getting increasingly hotter and indoor conditions are dry during winter not only relies on the measured temperature and humidity but also includes the overall perception of “feeling at home and comfortable”, obviously including the proven and well-known positive effect of greening in terms of measurable physical parameters.

The evaluation of measurement data and interview results already provided a good understanding of the subjective perceptions of the elderly, which will now be taken into account in further evaluations and the implementation of the greening measures. Besides air temperature and relative humidity, no further building physics parameters were considered, as this first approach is to get a preliminary understanding of the very personal perception of thermal comfort. In order to obtain a better understanding of the perception of thermal comfort for “non-standardised” people, namely mostly elderly people, further investigation, such as gender-related impacts or those of individual health conditions, both physical and mental, need to be carried out within the framework of the project.

The project itself, the co-creation and participatory process in relation to the outside and inside greening of nursing homes, is a good practice example for putting humans and their needs at the centre of the project’s attention.

Since no conventional measures were aimed at influencing the indoor air environment, the quality of living is to be researched and improved holistically through greening measures, and thus, the needs of the residents and all other persons involved are to be addressed.; these aspects were also researched through the workshops. The implemented greening measures, some of which have already been installed, as well as those still in the planning stage take these interdisciplinary surveys into account.

Regarding social aspects, the following statements can be applied: subjective perception and meaning of “green”, plants, and flowers differ between residents, but an overall positive effect on the wellbeing can be observed. Therefore, a contribution to the person-centred care principle of “living in a familiar, resident-friendly, and home-like environment” can be stated. Engagement with the care of plants and flowers can enhance participation in everyday activities, but constraints of capabilities and motivation have to be respected carefully. Gender aspects have to be considered as a relevant factor of influence and need further investigation.

#### 5. Conclusions

Subjective perception of thermal comfort as well as the meaning of “green”, plants, and flowers differ between residents and persons involved in nursing homes. Nevertheless, an overall positive effect on wellbeing can be observed. In addition, the well-known benefits of greenery to address hygrothermal comfort have been confirmed for the setting of elderly nursing homes. Therefore, a contribution to the person-centred care principle of “living in a familiar, resident-friendly, and home-like environment” can be stated. Engagement with the care of plants and flowers can enhance these aims.

These insights support clearly that greening up nursing homes has to be set on the political agenda. From a short-term perspective, this includes sharing of knowledge and experiences as well as organising processes supporting greening up. The directors of the facilities are already involved in the project, along with the Austrian Climate and Energy Fund, the Department of Hospitals and Care Centres of the Lower Austrian Federal Government, and the Health Agency of Lower Austria. For the year 2022, an event is planned aiming to bring together stakeholders and directors of nursing homes interested in greening their care facility. Furthermore, at the end of this research project, a guide about green innovations in care facilities for elderly people will be published, and it will be available for all interested in greening a nursing home.

Taking the critical staff situation, which is becoming worse throughout the COVID-19 pandemic, in nursing homes into account, greening measures and the changes that come with them need resources on different levels. At the same time, and in the long run, collaborative activities growing in the context of “caring communities” should also be promoted within the context of gardening, context of interior design, health, and wellbeing.

However, further investigation and differentiations addressing the subjectivity of thermal comfort perception and long-term investigations on the actual effectiveness of the greening measures realised in the course of the studies need to be done.

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