A Study of Architectural Barriers and the Potential Role of Assistive Technologies in Long-term Healthcare Centres for People with Alzheimer's

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Abstract. Alzheimer's disease (AD) changes a person's relationship with space. While research exists on how an interactive therapeutic environment can enhance the quality of life for people with Alzheimer's disease (PWAD), PWADs as end-users are not sufficiently studied. This paper examines (1) the daily activities that PWADs need to perform to understand potential architectural barriers and (2) assistive technology (AT) used in PWAD rooms at long-term healthcare centers. A questionnaire (n = 25) and interviews (n = 5) with five professional experts in daily contact with PWADs were conducted for this study, together with an observation of one resident in his room at a selected healthcare center in Vienna, Austria. Four interrelated aspects emerged from the analysis: (1) orientation of PWADs in space, (2) occupational therapy, (3) assistive technology, and (4) potential architectural barriers. PWADs generally prefer therapeutic environments that let them control their lives. Occupational therapy enhances the ability of PWADs to remember how to perform daily activities. AT can serve as a tool in interactive indoor therapeutic environments and occupational therapy. The results of this study show that healthcare designers should consider PWADs as end-users when designing interactive therapeutic environments, especially by employing user experience design concepts.

Keywords: Assistive technology, orientation, Alzheimer's disease, therapeutic environments, interviews, occupational therapy, UX design concept.

1 Introduction

AD is a progressive disease that affects people's life, especially concerning the performance of daily activities, including self-care, for instance. AD accounts for 60-80% of dementia cases [2]. A more precise definition of AD is the problem of "how-to" [3]. Spatial disorientation, a decline in orienting ability, a lack of motivation to begin activities (including self-care), capacity to persist with activities, and withdrawal from social activities are among the earliest symptoms of AD that emerge at some time in

PWAD's disease [4–7]

Although there is no cure of AD yet, it is useful to develop supporting solutions that can help reduce AD's progress through "Occupational Therapy" (OT). Occupations are part of life, defining people's identity and bringing meaning to life [8]. OT aims to enable PWAD to participate in everyday life activities by engaging in the activities they want to, need to, or are expected to do, for instance: personal hygiene, communicating, moving around, and eating. Furthermore, OT applies purposeful activity, therapeutic exercise, special equipment, skills training, and environmental modifications to support their occupational engagement to enhance PWAD's independence in daily activities [9].

Assistive technology (AT) has potential benefits for PWADs and is tailored to each individual's needs [10]. This includes solutions such as IPad, an interactive projector (using the kinetic system), or a digital calendar alarm day clock with a non-abbreviated day and month alarm clock, which helps reduce the disorientation in time for PWADs. Using AT as an assistive tool in OT improves PWAD's independence outcomes, while also reducing caregiver stress [11].

Most PWADs who live in long-term healthcare centers experience that this is not the environment in which they used to live [12, 13]. A feeling of comfort and security, according to Bollnow's concept, occurs in protective environments where one feels at home and able to self-orient [14].

Supporting PWAD's ability for self-orientation is essential for therapeutic environmental design [15, 16]. PWAD-friendly architectural concepts can support daily activities, independence, and quality of life. Designers can develop improved solutions by considering the fundamentals of PWAD's environments [17] , aiming to ease the process of self-orientation and performing daily activities. This is especially important in long-term healthcare centers, the environment where patients stay for a long time [13, 18–20].

According to recent studies [21, 22], PWADs may form a cognitive map after repeated movement in a specific environment which serves orientation and navigation. This article examines in greater depth PWADs' movement and daily activities in their rooms at a long-term healthcare center. The goal is threefold: (1) to elucidate the relationship between PWADs spaces and assistive technology as an assistive tool, (2) to uncover architectural barriers that present obstacles to PWAD's self-orientation and (3) to explore the role of AT in addressing these obstacles. This involves the following questions: (1) What are PWAD's daily activities in their rooms at the healthcare center? (2) What architectural barriers present obstacles to PWAD's self-orientation? (3) How can AT support PWAD's self-orientation in their room? The answers to these questions are expected to inform better designs of a friendly interactive therapeutic environment for PWADs.

2 Methods

2.1 Study Design

A mixed methods study with sequential design [23] was conducted to enable an in-depth understanding of the PWADs space, needs, and potential role of AT [24–26].

This involved quantitative data collection and analysis, followed by qualitative data collection and analysis. The principle for combining quantitative and qualitative data is that neither method is sufficient by itself to examine specifics of circumstances, such as a complex topic of how AD changes a person's interaction with space. The combination of quantitative and qualitative data provides a complete understanding of the research problem than either approach by itself [27]. Data was acquired through a quantitative questionnaire (in the German language) followed by qualitative face-to-face interviews (in the English language) with caregivers and professional experts [28] at an Alzheimer's healthcare center in Vienna, Austria. The healthcare center was built in 2005. The structure of the building is divided into two main wings (Fig. 4), the east and the west wing. The building has four floors, each one containing 12 wards for people with different care needs, while the ground floor (Fig. 1) contains the treatment and therapy rooms on the west of the central entrance hall, and on the east is a restaurant, event rooms, the chapel, library, hairdresser and the administration area. In addition to the therapy area, there is an independent 2-group kindergarten with an outdoor area. Furthermore, a qualitative narrative study was conducted using shadowing observation for one of the center's residents in single-room occupancy. Among other qualitative methodologies, shadowing characterizes itself by (1) combining observation and interaction and (2) focusing on a single perspective within a larger social situation [29]. Due to COVID-19-related access limitations to the center, observing only one patient in the early stage of AD was possible.

This study design, consisted of three steps: (1) quantitative data is collected and analyzed first, (2) qualitative, text data is collected and analyzed second in the sequence, which helps elaborate on the quantitative results obtained in the first stage, (3) and a qualitative narrative study using shadowing observation for a resident in his room. In this study, the quantitative data elaborated a broad vision of PWADs' health status, needs, and daily activities, highlighting the case study facilities and professional experts' awareness of AT use and purposefully selecting the informants for the second stage. Then, a qualitative interview approach was used to identify the most common barriers fronted by PWADs in their daily life at the center and professional experts' knowledge about the AT, tested in the first stage. Furthermore, the shadowing observation [29] explored the architectural barriers PWADs face in their rooms while doing their daily activities. While the quantitative data and results comprehensively picture the study problem, the qualitative data and its analysis refined and explained the quantitative results by exploring the participants' views on persistence in more depth [29].

The study's priority [25, 27, 32]was given to the qualitative approach because it focused on in-depth explanations of the results obtained in the first quantitative stage and involved extensive data collection from multiple sources. The quantitative and qualitative methods were connected when selecting five participants for qualitative case studies and developing the interview protocol based on the results from first phase. The quantitative and qualitative methodologies' results were integrated [30, 31] during the discussion of the outcomes of the entire study.

Since the data and selected cases contain sensitive personal information, maintaining participant confidentiality and privacy is essential. Confidentiality was

addressed during the data collection, data cleaning, and dissemination of the research results. The participants' and organizations' names were replaced with pseudonyms.

2.2 Participants

A total of 30 professional experts (Table 1, 2) participated in the survey. Emails were sent to the responsible person at the long-term healthcare center with information about the study and the questionnaire form. The target participant in this study's quantitative questionnaire and the qualitative interview were active professional experts working in the Alzheimer's long-term healthcare center (the case study), and in daily contact with PWADs. The professional experts' statuses varied regarding position, years of experience, age, and gender. Criteria for selecting the participants in the first stage, the quantitative questionnaire, included: (1) active working in the long-term healthcare center (the case study); (2) a period of experience caring for PWADs; (3) in daily contact with PWADs; (4) completed professional training related to healthcare; (5) speaks the German language. A total of 25 professional experts participated in the survey (Table 1).

Table 1: Questionnaire Respondents.

		Number of Respondents (n = 25, %)	
Position	Psychologist	5	**20%**
	Nurse	10	**40%**
	Sociologist	4	**16%**
	Nursing Assistant	5	**20%**
	Occupational Therapist	1	**4%**
Years of experience	0-5	8	**32%**
	6-10	6	**24%**
	>10	11	**44%**
Age-Range	20-30	10	**40%**
	30-40	6	**24%**
	40-50	4	**16%**
	50-60	4	**16%**
	>60	1	**4%**
Gender	Male	14	**56%**
	Female	11	**44%**

Criteria for selecting the participants in the second stage, qualitative interview, included: (1) active working in the long-term healthcare center (the case study); (2) at least 8 years of experience caring for PWADs; (3) in daily contact with PWADs; (4) completed professional training related to the healthcare; (5) speaking the English language. Five individuals were interviewed (Table 2). The variation between the two languages is due to not all professional experts working in long-term healthcare center speaking English. However, the shadowing observation participant criteria included:

(1) PWAD is in the early stage of AD, (2) single room occupancy, (3) living in a long-term healthcare center for at least two years, and (4) having no disabilities (for instance, blindness). Due to COVID-19 restrictions, only one PWAD was shadowed. This male patient was 78 years old, in the early stage of AD, and stayed in a single room. He was shadowed during three time periods on different weekdays from 09:30 am to 12:30 am, from 1:30 pm to 4:15 pm, and from 5:30 pm to 8:00 pm.

Table 2. Interviews Participants

Interviews				
Participant	**Age-Range**	**Years of experience**	**Gender**	**Position**
Interviewee 1	50-60	35	Female	Nurse
Interviewee 2	40-50	16	Male	Nurse
Interviewee 3	30-40	18	Female	Psychologist
Interviewee 4	30-40	8	Female	Psychologist
Interviewee 5	40-50	17	Male	Sociologist

2.3 Data collection

Quantitative and qualitative were used based on a topic list [32]. The themes of the topic lists were derived from a scoping review [1], resulting in four topics lists divided into a structured and semi-structured section with a focus on:

(1) The PWADs health status and daily needs.
(2) What assistive technology is currently in use in PWADs rooms, and which purpose do they serve?
(3) Draw out general opinions and experiences of how to motivate the PWADs to do a specific activity.
(4) Draw out the architectural barriers PWADs face in their rooms while doing their daily activities.

Interviews were directed, though not determined, by a prepared interview guide based on an extensive literature study. The use of semi-structured interviews made it possible for participants to influence the focus of the interview and for the researcher to adjust the interview course to each participant's situation. Interviews were verbatim transcribed [25, 31].

Quantitative data collection. The first step entailed sending the questionnaire to the professional experts to explore the experience of PWADs through experts' opinions. The participants, who matched the criteria, filled out a hard copy survey. The questionnaire in total contained 118 questions (Qs), and was divided into two parts:

(1) PWADs health status and their daily needs [33], information about the use of the assistive technology (AT), and facility information, for instance, the equipment in each room for single and double room occupation.

(2) Participants' information (profession, age, years of experience, etc.), their opinions about the use of assistive technology, and the barriers which patients face in their daily tasks in their room.

The participants answered all questions related to (1) facility information in total (n= 91Qs) as follows; building areas contained (n= 15Qs); building entrance equipment contained (n= 10Qs); social areas equipment; living room and dining room contained (n= 19Qs); training and therapy room equipment contained (n= 13Qs), PWADs' single occupancy room equipment contained (n= 17Qs) and PWADs' double occupancy room equipment contained (n= 17Qs), (2) PWADs health status and their daily needs and actives contained (n= 9Qs), (3) the barriers that PWADs face in their daily tasks in their room contained (n= 3Qs), and (4) the participants' information contained (n= 8Qs). Furthermore, AT had in total of (n= 11Qs) divided into two parts as follows; firstly, the existing AT in the facility (Q1- Q6), all participants answered the first part; secondly, participants' opinions and knowledge of AT (Q7- Q11), only (n= 8P) answered the second part of AT.

Qualitative data collection. The interview structure was based on the quantitative results from the first stage of the study. From this step, new questions emerged. These included, for instance, inquiry into the professional experts' knowledge about assistive technology. The next step comprised of interviews with the professional experts who matched the participants' criteria (Table 2). During each interview, notes were made in the margin. These notes contained verbatim extracts from the transcript. The face-to-face interviews were semi-structured questions that employed a blend of closed- and open-ended questions, often accompanied by follow-up why or how questions. Questions aimed to explore the role of five factors ("therapeutic environment," "assistive technology," "PWADs' self-disorientation," "PWADs' daily routine in their room, and "coping and support"). The interviews took place at the healthcare center. Each interview was followed by taking pictures (by the author) to illustrate what the interviewed person talked about.

Finally, the shadowing observation [34] is a qualitative narrative study to explore in-depth PWADs' self-disorientation in their room and if the room layout/ equipment considers as an architectural barrier. In the case study, the focus points for observation included the following:

(1) Was the PWAD aware of his surroundings?
(2) What were the PWADs daily activities in his room?
(3) What were the PWADs daily needs in his room?

(4) What was the PWADs room's equipment?
(5) What architectural barriers does the PWAD face when moving in the room or using assistive technology?
(6) What type of assistive technology did the PWAD use?

The participant with the first AD stage was shadowed for three hours during each observation. The objective of the author was to observe and record manually on an observation sheet with the room plan using different colors and symbols and taking notes in a table (Fig. 2), and not to participate in the activities actively. The natural (no-interference) approach had been chosen to observe the natural way PWADs' self-orientation was performed in his room. Combining observation and debriefing helps to grasp the participant's perspective and gives a "voice" to PWADs concerns and experiences. The author drew the room's plan with the actual dimensions and the existing equipment (Fig. 2). The researcher paid close attention to nonverbal reactions, for instance, PWAD's body language taking notes with them. He was shadowed during three time periods on different weekdays from 09:30 am to 12:30 am, from 1:30 pm to 4:15 pm, and from 5:30 pm to 8:00 pm.

2.4 Data Analysis

NVivo [35] was used for data analysis for the questionnaire forms and the interviews. The transcript reading, note-making, and listed topics were used as codes in NVivo. These codes were either exact words or sentences from the transcripts. The criteria used to identify the codes are as follows: (1) familiarization to create preliminary codes relating to how a person–space–assistive technology relationship challenges PWADs in performing their daily activities were identified, (2) constructing initial thematic codes; consisted of five main categories, with several sub-themes for each; assistive technology, architectural aspects, values or beliefs, objects, and places, (3) indexing and sorting process was to find out "what parts of the data are about the same thing and belong together," after indexing, data were sorted so that material with similar content could be viewed as a whole; (4) reviewing data extracts aimed to review the indexed data to determine other potential ways of organizing the data to create more coherent sets; and (5) data summary and display reduced the material to a more manageable level. The codes served to gain an improved understanding of PWAD's experiences through professional experts' knowledge and the potential role of integrating interactive architecture into an indoor therapeutic environment for PWAD at healthcare centers. The codes were not used to structure this article. Instead, the subheadings in this article reflect the topics that emerged from the questionnaire and interview responses, focusing on how a person–space–assistive technology relationship challenges PWADs in performing their daily activities.

2.5 Ethics

Approval for this study was obtained from the center by signing an informed consent form that explained the study's aims and what participation would entail [30]. Participants approved the use of obtained data. All participants were informed about the study and their rights in written form, and all gave written consent to participate.

All data was handled confidentially, and the results were presented in a non-identifiable way at a group level in the present study. In presenting the findings using specific quotations, it was explicitly considered if this could lead to the identification of a participant via deductive disclosure. For this reason, additional details in the direct quotations were removed. Only the researcher can trace the quotations included in this article based on the participant code.

3 Results

The overall result from the text was the participants' experiences in how AD changes one's relationship with the surrounding environment and the possible alternative solutions to enhancing PWADs' quality of life. Understand how a person–space–assistive technology relationship challenges PWADs in performing their daily activities (Table 3). The focus was on knowing PWADs' daily needs, activities, and challenges they face, the other supportive solution to enhancing their quality of life from the professional experts' perspective, the assistive technology, and the potential architectural barriers.

Table 3: The coloration between the three research methods

Theme/ Subtheme		**Questionnaire from (n= 25)**	**Interview (n= 5)**	**Shadowing Observation (n=1)**	**Convergence**
1. PWADs (Person)	**Health status**	- Having difficulty performing tasks - Losing or misplacing objects	- Need help performing an activity - Forgetting objects, places	- Aware of his surroundings - Knows the colors - Knows what he wants - Do not know where to go to do a specific activity.	Typical symptoms of AD early stage, each symptom may differ with each resident.
	Fundamental daily needs	- Self-hygiene, dressing, eating, and sleeping	- Self-hygiene, dressing, and sleeping - Eating sometimes in the residents' rooms or dining room, depending on the PWADs' status.	- Self-hygiene, dressing, and sleeping in his room. - Eating in the dining room with other residents.	- Three fundamental activities for all PWAD - Interviews and Shadowing were more precise for the activity timing and place.
	Daily activities	- Diversity in participants' answers; reading, watching TV, etc.	- Diversity in participants' answers, depending on the PWADs' identity and hobbies.	- Watching TV. In his room after breakfast. - Imitating he was fishing, as it was his hobby while watching TV.	- Depending on PWADs' identity and hobbies - Interviews and Shadowing were more

				- Sitting in the garden evening. - Sometimes sitting in the living room afternoon.	precise for the activity timing and place.
	Daily challenges	- Disorientation - Forgetting how to do the activities - Anxiety	- Disorientation in Place, cannot find their rooms - Disorientation in Time. - Loss of Motivation, sometimes, not with all residents	- Self-disorientation in his room - Lack of displayed information, for instance on the doors - Prefer to be guided than to choose between options (he waited the nurse to guide him to the bathroom)	Disorientation in place - Self-disorientation in PWADs' room - Prefer to be guided
2. Facility information (Place)	**The Healthcare center in general**	- Identifying of the existing spaces, each room area and equipment	- PWADs in the early stage of AD are allowed to use the stairs alone - PWAD are not allowed to use the elevator alone - The building had four floors, each had a different level of Alzheimer's/ dementia - Two gardens exist, one at the building entrance, and the other on the rooftop - All the rooms had a glass facade - All the social activity on the ground floor, e.g., hairdresser, OT room, Restaurant, etc. (Fig. 1) - Each floor had a small living room for residents and a nursing station		- All the PWADs' activities exist on the ground floor - There are daily three main routes in the PWAD's room

	PWADS' rooms	- Single room occupancy: Rooms' area and equipment - Double room occupancy: rooms' area and equipment	- Taking photos of each room (the single and double occupancy) - Explanting the PWADs' daily movement	- Three main routes started at 9.00 am; 1. From the bed to the bathroom; 2. From the bathroom to the wardrobe; 3. From the wardrobe to the room's door - The same three routes reversed at 8.00 pm	
3. Assistive technology	**Usage Purpose**	- PWADs' safety - Rehabilitation	- Monitoring PWAD in their rooms - PWADs' safety - Sensor bar on the PWADs' bed (Fig. 2) - Sensor carpet under the bed at nighttime - The nurse call button in each room (Fig. 3) - Paro-Robot stimulates communication and has a calming effect on PWAD	- Sensor bar on the resident bed (Safety and monitoring at night time) - The nurse call button the resident did not use when he was confused about the doors	- AT used for PWADs' safety and monitoring at nighttime - Using, e.g., IPad for rehabilitation under caregiver supervision - PWAD forgot to use the nurse call button when needed help - PWAD interacts significantly with IPad and Paro-Robot more than the nurse call button
	Implemented place	- Special room - PWADs' rooms	- OT rooms - PWADs' rooms	-PWADs' rooms	
	Participants' opinion and knowledge	- Only eight participants answered this part - Lack of knowledge about the AT - It is a helpful tool for PWADs' safety - Useful for rehabilitation	- Lack of knowledge about what already exists in the market - Companies offer only the expensive one - Covering the lack of nursing, especially at the night time - PWAD interacting with it perfectly, e.g., Paro - There is a plan to implement more AT in the next five years		**Only the questionnaire and the interview** **-** Lack of knowledge concerning AT devices and systems - Need to implement AT because of lack of nursing

4. Coping and support	- OT - Daily routine - Social activities in the group	- OT in a particular room - Motivating the residents - Adding signs/ symbols on the residents' rooms door - Using some types of AT, like IPad, Paro, etc - Daily routine	- OT two times per week - Physiotherapy in his room - Adding figures related to his hobby on the room wall	- OT is essential for PWAD - Motivating is needed sometimes - Daily routine improve PWADs' performance
5. Architectural barriers		- All the rooms' doors have the same color, confusing the residents. - Lack of privacy in double rooms occupancy - Artificial lighting is not sufficient, annoying the residents	For Single Occupancy room: - The doors face each other, confusing the resident with which one to use. - The doors have the same color without any clarification signs or symbols. - The resident cannot see his room at once because of the hidden corner	**Only the interview and shadowing** - Rooms doors have the same color - Hidden corner in the PWADs' rooms - Doors are facing each other in the PWADs' room - Lack of displayed information for each door

The following four themes identified in the structural analysis and followed by a summarized description of each theme are (1) PWADs' orientation in space because all participants mentioned disorientation in place as the main observed barrier for PWAD; (2) occupational therapy because it is an effective therapy for PWAD and the physical environment, influences OT activities; (3) assistive technology and its potential role, and (4) architectural barriers in the PWADs rooms.

3.1 PWADs' orientation in space

The expert participants were asked to identify the most common barriers encountered by PWADs in their daily life at the center. All participants mentioned disorientation as the main observed barrier for patients and discussed it from different perspectives. According to one of the experts, all PWADs have problems with orientation: "there is no difference in disorientation problem when they are in the early or intermediate stage of Alzheimer's disease" *(P5)*. Half of the experts said orientation in space is a challenge in general*:* "losing their way back to their rooms" *(P4)*, while others pointed towards orientation in time, losing the sense of day and night time, or self-orientation to do a specific activity.

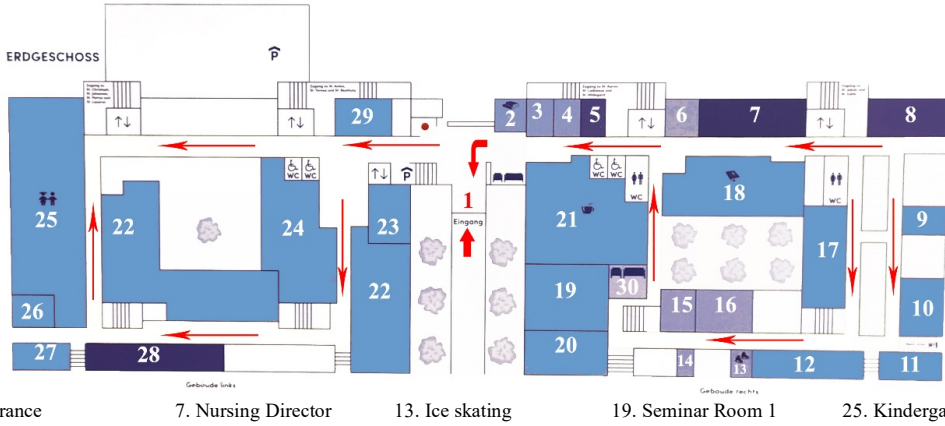
"(PWADs) are suffering from self-disorientation to do a specific activity, especially in their room. This might differ depending on the patients' case; some know what they

want, but forget where to do it, while others head to the place and forget what they have to do" *(P2)*. According to one interviewee, there are two different types of self-disorientation: PWAD needs information on how to do a specific activity and where to go to do a specific activity. This information is required in PWAD's rooms because caregivers are not always there. If PWADs can access this information, they can act independently, which may increase their self-esteem and quality of life.

Different answers were given by the expert participants regarding how they solved disorientation problems. Solutions differ "depending on the patient's case" *(P1)*. Some residents find a solution for finding their way back to their room by hanging a unique sign or element or "putting their photo on the front door, to find their room easily" *(P1)*. In this way, PWADs were able to overcome some disorientation problems in locating their room. On the other hand, according to the interviewees, there was no clear solution for solving the disorientation problems inside PWAD's rooms. PWADs are frequently unable to orientate in their rooms and therefore often cannot act independently.

3.2 Occupational Therapy

"Occupational therapy" (OT) was mentioned in several professional participants' answers when asking what alternative supportive methods are used in the healthcare center to enhance PWADs' daily activities. It was a question of: "stimulate activities," work on memory." Some of the participants had more precise objectives directly aimed at achieving an essential activity, such as "take PWADs for a wash" *(P1, 4)* or "making a family photo album." *(P5)*. Overall, the professional participants mentioned that OT had several aspects; one is related to "everyday life activities" *(P2, 3, 4)*, and other activities are "individualized" *(P5, 1,3)* depending on the PWAD health status. Some participants expressed their disappointment; although the OT is an effective method to enhance PWADs' quality of life, it is not done daily and only in a "specific room" *(P 2, 3)* (Fig.1), not in the PWADs' rooms. They added; because of several reasons, for instance, "lack of occupational therapist" or "unsupportive environment" *(P 4,5)* like the PWADs' room.



1. Entrance
2. Library
3. Hairdresser
4. Residents' service point
5. Administration office
6. Conference Room
7. Nursing Director
8. Institute Director
9. Management Director
10. Quality Management
11. Communication
12. Technical Director
13. Ice skating
14. Consultation Room
15. Conference Room 1
16. Conference Room 2
17. ICT Service
18. Church
19. Seminar Room 1
20. Seminar Room 2
21. Restaurant
22. OT room
23. X-Ray
24. Medical Control Room
25. Kindergarten
26. Cardinal Schönborn room
27. Ignatius Nascher room
28. Medical Director
29. Technical Room
30. Paris Salon

Fig. 1: Floor plan of the Alzheimer's center (ground floor), illustrates the OT rooms' layout

3.3 Assistive technology

AT as an assistive tool for PWAD can serve different purposes such as, for instance, safety, monitoring, rehabilitation, socializing, etc. According to the experts' answers, AT is mainly used in two ways: firstly, for residents' safety in their rooms, and secondly, for occupational therapy.

"Due to nursing shortage" *(P1)* the caregivers use AT to monitor the residents' movement in their rooms during their sleeping time. If the residents get out of their bed, "a sensor bar (Fig. 2a) or sensor-carpet" *(P1, P4)* are used to detect the PWADs movement" *(P5)*.

Furthermore, when the residents need assistance from a caregiver, they use the nurse call button (Fig. 2b). However, there is a problem concerning the nurse call button, as the residents "forget to press the button" *(P4)* most of the time.

Caregivers also use AT in some activities in occupational therapy (OT). Assistive technology includes, for instance, using an IPad and an interactive projector to improve cognitive, mobility, and communication skills. Brain-boosting games and apps have been shown to improve multi-tasking ability, memory, and focus, gradually integrating into daily activity. Another kind of AT used in OT is the "Paro-robot" *(P5, P2)* which helps PWADs become more engaged and relaxed. PWADs have improvements in positive emotions and behaviors when interacting with Paro-robot.

From the participants' experience, there exists a lack of awareness about available and suitable types of AT. Furthermore, they pointed towards technical problems regarding specific types of AT, for instance, that sensors "do not work" *(P3)* due to "daylight reflection, or furniture that was accidentally moved in front of it" *(P1,P5)*.

(a) (b)

Fig. 2: (a) the sensor-bar to detect the residents' movement if they get out of the bed; (b) The nurse call button

3.4 Architectural barriers

This section outlines the results of the questionnaire, the interview, and PWAD observation to identify architectural barriers that might prevent the implementation of an interactive friendly therapeutic environment in PWAD's room.

Room layout and equipment. The studied long-term healthcare center offers single

occupancy rooms (one resident per room) and double occupancy rooms (two residents per room). The surface area of the single occupancy room is approx. 28m^2 while the double occupancy room is approx. 39m^2, including the bathroom (Fig. 3). The expert participants stated that living in a single or double room "depends on the residents' desire and needs." *(P3,P5)*. Each room has seven main elements: (1) door, (2) bed, (3) wardrobe, (4) bathroom, (5) dining table, (6) TV table, and (7) balcony with large windows (Fig. 4).

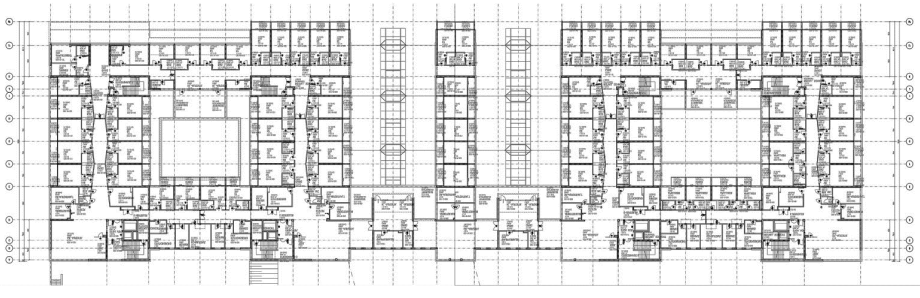


Fig. 3: Floor plan of the Alzheimer's center (1st floor)

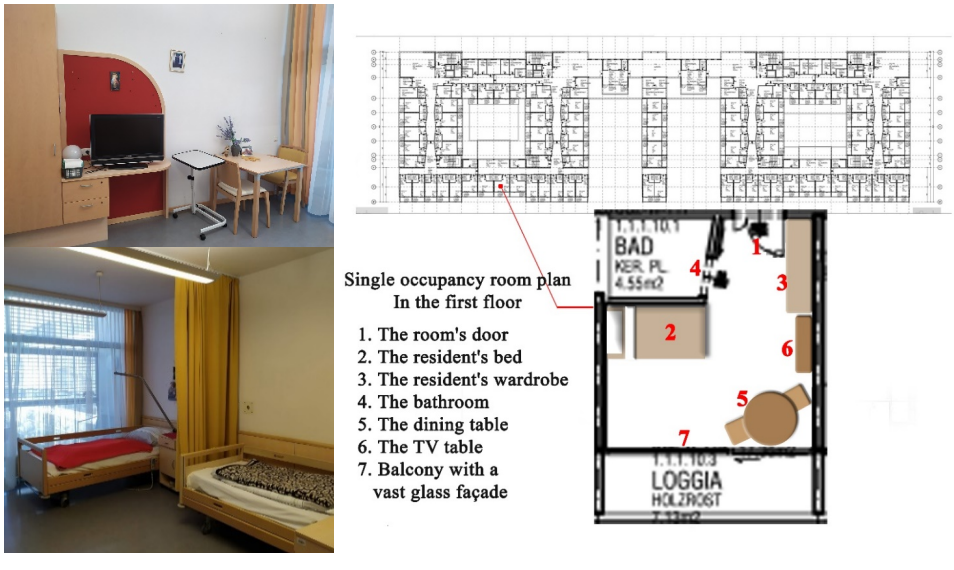


Fig 4: Floor plan and images of a typical resident's room in the Alzheimer's center

Each resident has seven main paths related to the seven main room elements. Four of them are related to daily activities, such as: (1) getting out of the bed (element no. 2), (2) toileting (element no. 4), (3) dressing (element no. 3), and (4) eating (element no. 5). Expert participants clarified that eating in the resident's room "is not a routine" *(P1,P3)*. As a result, the PWADs main daily activities in their rooms are getting out of bed, self-care, and dressing.

The residents need to be oriented inside their room in relation to "three paths" *(P3)*: (1) from the bed to the bathroom, (2) from the bathroom to the wardrobe, and (3) from the wardrobe to the room's door. This sequence establishes the "daily routine" *(P2,P4)* for all residents. While this sequence might sound simple to an average person, it is a complicated sequence for PWADs. Based on the questionnaire responses and the interviews, there exists no displayed information that would help clarify these three paths to PWADs. Furthermore, the observation of a PWAD in his room pointed to additional architectural barriers. During the observation time, the resident was sitting in his wheelchair, watching TV while imitating fishing, which was his favorite hobby. When finishing the imagined fishing activity, the resident moved in his wheelchair, heading directly to somewhere inside his room. Then he stopped in confusion, facing three doors in front of him: (1) the room door, (2) the bathroom door, and (3) the wardrobe door (Fig. 5, Fig. 6). When the nurse entered the room, he expressed the wish to wash his hands after fishing. The nurse then guided the resident to the bathroom, where he washed his hands without the nurse's help. The resident knew what he wanted but did not know how to get to the bathroom. In this case, the location of the doors in the room acted as an architectural barrier. All three doors are located in one corner of the room and face each other without any displayed information, thereby leading to the resident's confusion.

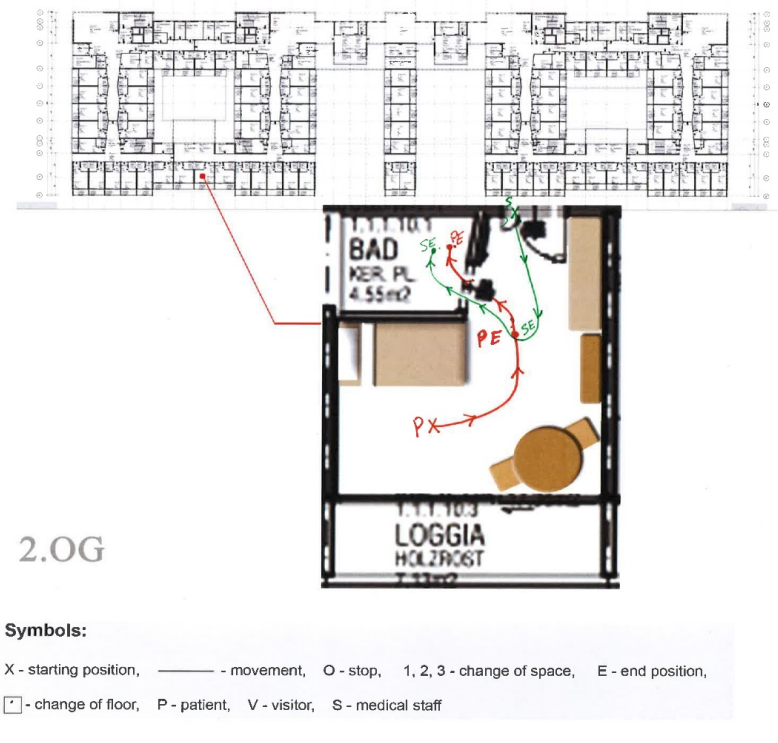


Fig. 5: The point where the observed resident became disoriented in his room shown on the room's floor plan

Fig. 6: The three doors that made the resident disoriented in the corner of his room: 1. The room's door, 2. The bathroom door, 3. The wardrobe door

Therefore, self-orientation seems to be an essential aspect of a person's well-being or ill-being. In the context of care for PWADs,' it was valuable to investigate the PWADs' daily needs, activities, and movement in their room. Consequently, the new research questions emerge: How can the therapeutic environment afford the feeling of coming or being home, supporting PWADs' self-orientation in their room using AT? Considering the PWADs as end users of the therapeutic environment raises several sub-questions: which essential activities in PWADs' room need self-orientation supported by AT? Which design concepts are suitable for designing a friendly therapeutic environment with a positive outcome? How would an OT be beneficial in the healthcare-building industry? How could the AT help to improve the shadowing-observation method in case of epidemics?

4 Discussion

From the professional experts' answers and the observation, it is clear that PWADs are missing information that can help them achieve basic activities independently in their rooms and often also motivation to perform the activity [6, 37]. One of the biggest challenges PWADs face was disorientation, which was addressed by medical staff in both the questionnaire forms and the interviews. The disorientation problem for PWADs is divided into two categories:

(1) Disorientation in the building in general;
(2) Disorientation in the residents' rooms;

Caregivers addressed the first problem by adding different items and signs on the PWADs room doors to make it easier for them to find their rooms. In contrast, there

were no clear solutions for disorientation inside PWADS rooms, whether single or double occupation. It is evident from the first problem solution that the caregivers considered the residents as end-user. Because every PWAD has a different interaction with the surrounding environment, the caregivers usually find out what suits each of them and apply related solutions to the residents' room door. Moreover, the professional experts addressed the importance of the OT to maximize PWADs' independence with a specific activity [38]. OT might assist PWAD in relearning the activity in a new way or adapting to the environment. Furthermore, OTs are trained to consider how the physical environment influences PWADs' activities. According to the Occupational Therapy Practice Framework (OTPF) [39] the physical environment can support or present barriers to engaging in meaningful activities. OTPF states that OT practitioners acknowledge that for PWAD to achieve full inclusion, they must engage comfortably with their environment [40]. OT uses way-finding programs to overcome PWADs' disorientation [41]. However, Making rooms easy to navigate is an essential therapeutic environmental modification that supports OT [42]. Observation shows that the current layouts of PWADs rooms are not easy to navigate. In the observation described in this article, the PWAD got lost in his room when he faced three doors, all located in one corner in front of him without any displayed information regarding where these doors lead to. In architectural terms, this means rooms without a well-considered spatial arrangement that can be perceived at a glance are not beneficial. Spaces that turn a corner or are otherwise hard to visualize are unsettling and may cause anxiety [5, 15, 17, 43].

Moreover, these studies [5, 15, 17, 43] have identified the optimal layout plan that significantly supports the spatial orientation for PWADs as follows: (1) PWADs should have visual access to all the spatial that are related to them, and they should be able to oversee their entire immediate living environment; (2) PWAD should be guided and directed rather than required to choose from several options to self-orientation, and (3) Improve architectural legibility; by considering the fundamentals of PWAD's environments, aiming to ease the process of self-orientation and performing daily activities. By comparing the OT rooms' layout (Fig. 1) and the PWADs' rooms' layout (Fig.5), it is clear that those aspects had been applied and considered only for the OT rooms' layout.

Preliminary research suggested three main focal aspects for designing a user-friendly therapeutic environment [17]. These include: (1) considering PWADs as end-users, (2) considering what is fundamental about the environments one lives in, and (3) PWADs individual characteristics, i.e., knowing PWADs hobbies, background, habits, etc. [14, 44, 45]. Recent studies show the importance of a friendly therapeutic environment and the positive outcome on the PWADs when designers consider them end-users [12, 16].

Depending on the previous aspects; User Experience Design Concepts (UX) are suitable for designing a friendly therapeutic environment with a positive outcome. UX focuses on understanding users' needs, abilities, limits, and what they value [46]. UX enhances the quality of the user's interaction with spatial characteristics because the design depends on seven main factors: (1) useful, (2) usable, (3) desirable, (4) findable, (5) accessible, (6) credible, and (7) valuable. By applying these primary factors, spatial characteristics can be converted into a sense of space to provide orientation and help PWADs feel safe and comfortable.

How to adopt the UX design concept in PWADs' room (in the existing building) to support their self-orientation/ to create a supportive environment for OT activities in the PWADs' room? AT can provide a connection between the PWADs' OT and their surrounding environment to create an interactive therapeutic environment that supports PWADs' self-orientation (Fig. 7) [47]. AT is any device or system that enables PWADs to accomplish tasks they would otherwise be unable to perform or improves the ease and safety with which the task can be performed [2]. AT includes a wide variety of devices that, according to their purpose, can be divided into three main groups: (1) supportive technology for helping PWAD to complete tasks, (2) responsive technology for managing risk and raising the alarm, and (3) preventative technology for preventing harm and raising the alarm. Several studies examined the effectiveness of applying the three groups of AT in PWADs therapeutic environments [48–51].

Fig. 7: Illustrate the relation between the Occupational therapy, Assistive Technology and the Interactive Architecture

The three AT groups can be applied in the PWADs' rooms to partially solve the residents' disorientation problem. This can be done as follows: (1) supportive AT can display information, showing the route, for instance, to the toilet, wardrobe, or the bed, (2) responsive AT can raise alarm, and (3) preventative AT can be of use when the resident does not follow the displayed information. In the current case study, these three groups could be applied to reveal the hidden corner in the PWADs' room as follows:

(1) The resident will get out of bed in the morning, the sensor will detect his movement and start displaying information guiding the resident to the bathroom's door, for instance, using interactive projection (PWAD wearing a sensory bracelet, projector, radar, and computer in the nursing station).

(2) When the resident reaches the bathroom door, he will face three doors in front of him/her; the following information will emphasize the bathroom door. The way of displaying the information might differ according to the PWAD's identity and his/her response to his/her surrounding, as some might interact with color or figures, symbols, etc.

(3) If the PWAD does not respond to the displayed information, the responsive and preventative AT will raise the alarm in the nursing station according to the sensors' signals.

This study revealed the following research gaps:

(1) a knowledge gap regarding the PWADs' needs in their residence rooms and the room layout and its equipment;

(2) a knowledge gap regarding supportive AT in the long-term healthcare center applied in a specific room, not in the residents' rooms, because of: (a) lack of awareness from the caregivers, (b) low budget, as most of the time the companies offer the expensive devices, (c) a need to study each resident individually, which is challenging due to the nursing shortage, and the ethical consideration;

(3) a knowledge gap regarding the categorization of AT according to (a) center budget, (b) how it could help in motivating the residents to do a specific activity in their rooms, and (c) what supportive AT helps the residents to enhance their independence in their rooms.

4.1 Study limitations

Due to COVID-19-related access limitations to the long-term healthcare center, it was possible to observe one patient staying in single-room occupancy. Further research could explore the daily activities and the resident self-orientation in the double room occupancy to define the architectural barriers. Conflicts in the self-care activities, privacy, and whether the room equipment creates a barrier to residents' movement should be explored further. Results are valid for long-term healthcare on an institutional basis. The study only focused on persons with Alzheimer's disease, not other types of dementia. Limited generalization of the result from interviews (as it is a qualitative method and there were only 5 participants).

5 Conclusions

This study examined the problems experienced by PWADs when performing their daily activities and navigating their rooms in long-term healthcare centers. Therapeutic environments have many prospects to improve PWAD's well-being that could be significantly improved by specific insights in architectural and other barriers resulting from the design of PWADs rooms, as well as advantages that can result from equipping the rooms with AT. OT is one of the supportive therapies that help PWAD engage in daily activities. Previous research showed that recollection effectively maintains and improves AD patients' cognitive functions because it helps clarify blurred memories [52, 53]. According to OTPF [39], the environment directly impacts PWAD's ability to do something. Therefore, this study recommends the following: (1) shadowing observation is essential to understand in-depth PWADs' needs and the architectural barriers they are facing in their rooms; (2) UX design concept is suitable for designing a friendly, supportive environment with a positive outcome for PWADs; (3) AT helping reveal the missing information for PWAD to enhance their self-orientation in their rooms, and (4) AT reshaping the therapeutic environment according to PWADs' needs and activity, (5) AT could help in creating a supportive environment for OT activities.

Further research should explore the daily activities and the residents' self-orientation in the double room occupancy to further define the architectural barriers, explore problems and conflicts experienced in self-care activities and privacy, and

analyze whether PWADs' movement and the room's equipment unintentionally create barriers. This will help build informed design strategies that can improve PWADs' lives by considering them as end-users. Based on the insights gained in the research described in this article, and since epidemics may continue to make such studies difficult by preventing the necessary continual and extensive observation, further studies should explore the AT's potential to collect data about PWADs' movements in their rooms at the long-term healthcare center.

Acknowledgment. The author would like to thank the professional experts in the long-term healthcare center who answered the questionnaire forms and participated in interviews for sharing their time, experience, and knowledge. Furthermore, the author thanks the person who gave an initial tour of the building and the observed resident of the long-term care center. The author thanks Dr. Maja Kevdzija for her editing and for giving ideas on the structure of the manuscript text/graphics.

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