MOBILITY-SUPPORTING REHABILITATION CLINICS

Investigating Barriers and Facilitators to Stroke Inpatients’ Independent Mobility
This project is a result of the PhD thesis completed in February 2020 and published in April 2020 at the Technische Universität Dresden (Germany). All data was collected and analysed by the author. The proposed new design model for rehabilitation clinics was fully developed by the author.

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THE BURDEN OF STROKE

Stroke is the second most common cause of death in Germany and globally and one of the most frequent causes of disability in adults.\(^1\) Up to 40% of survivors will have long-term impairments in daily activities, such as motor impairments, cognitive and speech impairments, memory and concentration problems, which affect their everyday life and the experience of the environment around them.\(^2\) Stroke also causes a greater range of disabilities than any other condition.\(^3\)

Stroke is the most common condition that is treated in neurological rehabilitation clinics in Germany. The numbers of people affected by stroke are expected to steadily increase in the following decades, resulting from improved stroke care, population growth, generally longer lifespan, and increase of main stroke risk factors.\(^4\) There are also indications that the COVID-19 virus is likely to be another risk factor for stroke.\(^5\)\(^6\)

Compared to the stroke care in the UK and Scandinavian countries where the rehabilitative phase takes place in stroke units, German stroke units still mainly focus on the diagnostic and medical treatment in the unstable acute phase, with rehabilitation taking place in a hospital or inpatient rehabilitation clinic.\(^7\) Patients live in rehabilitation clinics as inpatients for several weeks to several months and the clinic becomes the patient’s temporary home and the environment in which they need to relearn the lost functions and prepare for going back to their normal lives.\(^8\)

Since patients experience various post-stroke impairments and attend several therapies per day, their mobility limitations, exhaustion from exercise and general fatigue are likely to be the reasons for the patients’ low activity levels.\(^9\)\(^10\) At the same time, the built environment of rehabilitation facilities is another likely contributor to patients’ inactivity, since these environments can hinder patients’ activity by creating barriers,\(^11\) promote loneliness and inactivity by not offering suitable and motivating common spaces,\(^12\) and lack opportunities for activities and additional exercise.\(^13\)
RESEARCH PROBLEM

Until today, rehabilitation clinics as environments remain largely unexplored and very little is known about the role and significance of their built environment in the recovery of stroke patients. They are important environments to investigate since they are not only functional spaces for the rehabilitation practice to take place but also spaces where patients’ daily life occurs during their rehabilitation process. For them, the rehabilitation phase sets the basis for their future recovery and coping with the impacts of stroke. Even though the patients’ wish to be more proactive is evident from studies on their experiences in rehabilitation, the current built environment of rehabilitation clinics continues to promote long periods of patients’ inactivity and not providing the opportunity for patients to carry out their proactive role. The disabling and limiting environment potentially plays an important role in the low levels of activity during the rehabilitation period. Nevertheless, there is a great lack of knowledge about the spatial properties that hinder or support the activity and mobility of stroke patients in rehabilitation clinics.

RESEARCH STEPS

1. LITERATURE REVIEW
   Scoping literature review was conducted to identify the existing knowledge about the formulated research problem.

2. VISITS TO CLINICS
   7 clinics were visited in the form of a guided tour followed by an interview with the head physician in each clinic.

3. DATA COLLECTION
   Data was collected in 7 rehabilitation clinics using 3 research methods.

4. DATA ANALYSIS
   Collected data was analysed both qualitatively and quantitatively.

5. RESULTS
   The quantitative and qualitative results obtained in the previous step were interpreted and discussed.

6. NEW DESIGN MODEL
   Based on the obtained results, the new design model for rehabilitation clinics was developed in the form of a catalogue.

7. REFLECTION
   The new design model for rehabilitation clinics was discussed and reflected on with the four consulted physicians.
EXISTING KNOWLEDGE

A scoping review of the existing studies investigating the relationship between the rehabilitation environments and stroke survivors was conducted two times (once at the beginning of the study and once the data was collected), to evaluate their results and research quality and to identify significant research gaps. The inclusion criteria were: (1) empirical studies (quantitative, qualitative or mixed-method) written in English and published in peer-reviewed journals, (2) study participants were recovering from a stroke, (3) the relationship between stroke patients and the healthcare environment design was investigated, (4) the studied relationship was related to patients’ recovery process, activities and behaviours or physical and psychological well-being.

Only 18 out of a substantially high number of identified articles (e.g. 6094 articles only on the Web of Science) satisfied the inclusion criteria and were included in the literature review. Although there was a vast number of search results in each of the databases for the defined search terms, the great majority were strictly medical studies or studies related to the use of different machines and devices for exercise and mobility.

There was a clear lack of empirical studies discussing the space and the influence of architectural design in the context of stroke rehabilitation. All the studies were evaluated according to the Levels of Evidence for Healthcare Design developed by Stichler (2010).

There were seven main findings in the identified research studies:

1: Patients are inactive;  
2: Physical environment is hindering;  
3: Better accessibility increases activity levels;  
4: Room environment does not affect psychological well-being in bed-ridden patients;  
5: Built environment promotes loneliness;  
6: View to the outside provides positive distraction;  
7: Spatial needs are changing during recovery.

The results of the review show that the built environment of stroke care facilities is often incompatible with the patients’ vulnerable health condition and with the stroke care guidelines for promoting activity and avoiding bed rest. The evidence-based design knowledge on what hinders and what supports the activity and mobility of stroke patients is, therefore, still greatly lacking and it is needed to design buildings that are contributing to the rehabilitation process.
VISITING THE CLINICS

After the evaluation of the existing research studies and after establishing the research gaps, **preliminary fieldwork** was conducted in the form of visits to various rehabilitation clinics and informal interviews with the medical staff (chief physicians, therapists, nurses and an architect of one of the visited clinics).

These visits were crucial for observing and assessing how patients were accommodated in rehabilitation clinics, how the clinics were spatially organised and what kind of spatial features could potentially play a role in patients’ mobility and recovery.

After the preliminary field visits, it was clear that the visited clinics faced the same issue: patients were often passive, spending most of their time isolated in their rooms and without any planned activities between and after therapy times. During the visits, it was also noticed that the built environment was often not supportive of patients’ independent mobility. This was especially reflected in the use of transfer service to bring patients using a wheelchair from their rooms to therapies because of the long and complicated paths to therapy.

Thus, the preliminary fieldwork was **critical for identifying mobility as an aspect that is not well-supported in the built environment** and for defining the main research question that guided this research study.
RESEARCH OBJECTIVE

Regaining mobility and independence are regarded as the main goals of rehabilitation by both patients and medical professionals and they are also crucial for maintaining a sense of control. Patient mobility was taken as the central activity examined in the study for its importance in the recovery process. The main research question guiding this study was:

“How does the built environment of rehabilitation clinics hinder or support the independent mobility of stroke patients?”

This study aims at contributing to the identified research gap and at informing all professionals involved in the process of planning rehabilitation clinics about the spatial experiences of stroke patients in rehabilitation and the potential ways that their mobility and activity could be supported in the built environment.

THEORETICAL FRAMEWORK

The research study investigates the concept of barriers that imply non-participation and exclusion, as well as the concept of accessibility that enables participation. The input from the social disability model is used to shift the focus from a body with impairments as a reason for challenges in the built environment to the disabling practices in the built environment itself. The ideas of the affordance theory are utilised to look at mobility as a phenomenon crucial for stroke patients and to analyse the architectural features that offer positive (enabling) and negative (hindering) affordances to mobility within rehabilitation clinics. Using the social disability model and the affordance theory as a basis for formulating the research questions, this research study evaluates the fit between the users (stroke patients) and the built environment (rehabilitation clinics).
METHODS

One researcher (trained architect) lived with patients in seven different rehabilitation clinics for 14 weeks (2 weeks per clinic), spending one whole ordinary day with each participating patient (n = 70) and systematically documenting how they interacted with space, how much distance they covered in the clinics, the locations they visited for scheduled and free-time activities, the barriers they encountered and locations of those barriers, as well as their opinions and personal experiences. Every patient was shadowed for 12 consecutive hours (from 07:00 h to 19:00 h). Total observation time in all clinics was 840 hours. The data was collected in paper form with the use of clinics’ floor plans and time log sheets.

Out of the 70 observed patients, 60 were able to complete the questionnaire. The patient questionnaire addressed the perspective of the participant on the role of the clinics’ physical environment in the patients’ independent mobility. It was focused on the personal daily experience of the rehabilitation participants in seven rehabilitation clinics and divided into three sections: spatial preferences, wayfinding and architecture of the clinic. The questionnaires were in German language and they consisted of open-ended and multiple-choice questions.

The staff questionnaire examined the expert perspective of the medical staff in the participating clinics. This questionnaire focused on the significance of independent mobility for patients and the barriers that patients encounter in the built environment of rehabilitation clinics. Staff members treat and observe a large number of patients and have the experience of the most common mobility issues that patients encounter every day. For this reason, the staff questionnaires added the third important perspective to the research methods chosen for the study.
The use of a particular mobility aid changed the way patients interacted with space, the dimensions that they needed for being mobile and the mobility barriers they encountered. Since the patients’ rehabilitation phase (according to the German neurological rehabilitation system) and the Barthel Index did not explain the way patients used and interacted with space, the mobility aid that the patient used/did not use was taken as the mobility criterion in this study.

The mobility levels were determined to be:

- **Level 1**: wheelchair user;
- **Level 2**: walker user;
- **Level 3**: independently walking.

These three mobility levels were taken as the main characteristic of the participating patients. They were used to analyse the types of barriers and facilitators to mobility that patients encountered, as well as to determine the differences in their spatial experiences.

### Participants

The participants were stroke patients living as inpatients in rehabilitation clinics and able to perform activities outside their patients' room independently (Table 1). Each patient that participated in the research study gave their consent (written or verbal). The participants were able to drop out of the study at any time.

#### Table 1: Participants’ characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Participants (n=70)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age ≥ 65</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>32 (45.7%)</td>
</tr>
<tr>
<td>Male</td>
<td>38 (54.3%)</td>
</tr>
<tr>
<td>Mobility level</td>
<td></td>
</tr>
<tr>
<td>Wheelchair</td>
<td>16 (22.9%)</td>
</tr>
<tr>
<td>Walker</td>
<td>23 (32.8%)</td>
</tr>
<tr>
<td>Independently walking</td>
<td>31 (44.3%)</td>
</tr>
<tr>
<td>Barthel Index (BI) for mobility</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>11 (15.7%)</td>
</tr>
<tr>
<td>10</td>
<td>16 (22.9%)</td>
</tr>
<tr>
<td>15</td>
<td>43 (61.4%)</td>
</tr>
<tr>
<td>Length of stay (days)</td>
<td>Median: 19.5</td>
</tr>
<tr>
<td></td>
<td>Range: 3 - 139</td>
</tr>
<tr>
<td>Number of therapies per day</td>
<td>Median: 4.36</td>
</tr>
<tr>
<td></td>
<td>Range: 3 - 7</td>
</tr>
</tbody>
</table>

To reduce the selection bias, the participants were selected by the medical staff, considering their health status, psychological state, and the inclusion and exclusion criteria. Ten patients were selected per clinic. This number of participants was determined as a suitable number for reaching data saturation after the pilot study. The study included 70 patients that: suffered a stroke, were over 60 years old on the day of the observation, were able to move independently in the clinic (with or without the use of a wheelchair, walker or other equipment) and gave their consent for the study. The exclusion criteria were: dementia, severe communication and cognitive impairments, severe multi-morbidity (somatic, psychiatric or psycho/geriatric), significant mobility impairment before stroke; and/or orthopaedic, neurological or other condition of consequence for the study.
RESEARCH SETTINGS

Each clinic is presented with size characteristics, a typical floor plan and an exterior photograph.

**BDH Klinik Elzach**
- Beds: 225
- Floors: 4
- Surface: 17505.2 m²

**Schwarzwaldklinik Neurologie**
- Beds: 188
- Floors: 6
- Surface: 13056.4 m²

**BDH-Klinik Hessisch Oldendorf**
- Beds: 240
- Floors: 4
- Surface: 19702.7 m²

**Aatalklinik Bad Wünnnenberg**
- Beds: 210
- Floors: 4
- Surface: 18024.7 m²

**VAMED Klinik Hagen-Ambrock**
- Beds: 250
- Floors: 7
- Surface: 22730.8 m²

**Gesundheitszentrum Glantal**
- Beds: 207
- Floors: 4
- Surface: 15292.7 m²

**Fachklinikum Brandis**
- Beds: 218
- Floors: 7
- Surface: 20694.3 m²
RESEARCH PROCEDURE

The potential study participants were approached during their free time, usually in their rooms, by the researcher and a member of the staff well-known to them. The research study was briefly explained and they were asked if they were interested in participating. If answered affirmative, the large-print information sheet and consent form were left with the patient and the observation day was scheduled. Each participant was shadowed during one working day, from 07:00h to 19:00h (total of 840 hours) by a single researcher.

To reduce the selection bias, the participants were selected by the medical staff, considering their health status, psychological state, and the inclusion and exclusion criteria. Ten patients were selected per clinic. This number of participants was determined as a suitable number for reaching data saturation after the pilot study. The study included 70 patients that: suffered a stroke, were over 60 years old on the day of the observation, were able to move independently in the clinic (with or without the use of a wheelchair, walker or other equipment) and gave their consent for the study. The exclusion criteria were: dementia, severe communication and cognitive impairments, severe multi-morbidity (somatic, psychiatric or psycho/geriatric), significant mobility impairment before stroke; and/or orthopaedic, neurological or other condition of consequence for the study. To limit the Hawthorne effect, the patients were only told that their usual daily paths in the clinics were observed, without giving any specific information about the study aims.

ETHICAL CONSIDERATIONS

The complete research study titled “Mobility of stroke patients in neurological rehabilitation clinics“ was approved by the Ethical Committee at the Technische Universität Dresden (no. EK 452102016) and confirmed by the Ethical Committee at the Universität Witten/Herdecke specifically for the study in VAMED Klinik Hagen-Ambrock. Each patient that participated in the research study gave their consent (written or verbal). The participants were able to drop out of the study at any time. All collected data were anonymised.

DATA ANALYSIS

Collected data were analyzed to test the previously formulated hypotheses. They targeted two main topics in the research question: barriers hindering mobility and facilitators supporting mobility. Both quantitative and qualitative analysis (questionnaire coding, floor plan analysis, etc.) were employed to analyse the data. The thematic analysis with NVivo Pro 11 was used to analyse the open-ended questionnaire responses of patients and staff members. Shadowing data were analysed both qualitatively and with the use of four different statistical tests, depending on the analyzed relationships: Fisher’s exact test, Mann-Whitney U test, Kruskal-Wallis test and General Linear Model (GLM).
The results of all three research methods consistently show that the built environment of rehabilitation clinics hinders patients’ mobility in five main aspects: wayfinding, long distances, insufficient width of corridors, flooring and physical obstacles.

Wheelchair users are a group that encounters the highest number and the largest variety of barriers in the built environment of rehabilitation clinics. Even in the category of patients that could walk independently, 38.7% of the patients encountered barriers in the built environment, mainly in the form of challenging wayfinding.

<table>
<thead>
<tr>
<th>Mobility level (l)</th>
<th>Number of patients (n)</th>
<th>Barriers in the built environment (no. of patients)</th>
<th>Prevalence of barriers (no. of observed events)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>l = 1</td>
<td>n = 16</td>
<td>12.5%</td>
<td>87.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>n = 2</td>
<td>n = 14</td>
</tr>
<tr>
<td>l = 2</td>
<td>n = 23</td>
<td>43.5%</td>
<td>56.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>n = 10</td>
<td>n = 13</td>
</tr>
<tr>
<td>l = 3</td>
<td>n = 31</td>
<td>61.3%</td>
<td>38.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>n = 19</td>
<td>n = 12</td>
</tr>
</tbody>
</table>

Each of the identified barriers was further analysed for their architectural properties.
MAIN RESULTS: MOBILITY BARRIERS

Patients using a wheelchair were found most vulnerable to insufficient dimensions of corridors, long distances and unsuitable floor surfaces. Since these patients have a low mobility level and are using the mobility aid, it is more challenging for them to avoid barriers and cover large distances. They also need more clear space in the corridors to manoeuvre their wheelchair. Hence, the patient group with mobility level 1 is the most vulnerable to the barriers in the built environment. A more accessible and supportive environment could potentially enable them to be more active and more independent during their rehabilitation, without the concern for their safety. The results show that differences in the experience of the built environment among the three mobility levels are highly significant.

Comparison of numbers of encountered barriers for each mobility level

<table>
<thead>
<tr>
<th>Barrier category</th>
<th>Mobility levela</th>
<th>Significanceb</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>l = 1 vs. l = 2</td>
<td>l = 2 vs. l = 3</td>
</tr>
<tr>
<td>Wayfinding</td>
<td>p = 0,918</td>
<td>p = 0,926</td>
</tr>
<tr>
<td>Dimensions</td>
<td>p = 0,046*</td>
<td>p = 0,184</td>
</tr>
<tr>
<td>Distance</td>
<td>p = 0,039*</td>
<td>p = 0,097</td>
</tr>
<tr>
<td>Flooring</td>
<td>p = 0,001**</td>
<td>p = 1,000</td>
</tr>
<tr>
<td>Physical obstacles</td>
<td>p = 0,948</td>
<td>p = 0,101</td>
</tr>
</tbody>
</table>

* statistically significant difference  
** statistically highly significant difference  

a Mann-Whitney U Test, comparison between two mobility level groups at a time  
b Kruskal-Wallis Test, comparison between all three mobility level groups
Wayfinding is a significant issue in rehabilitation clinics. According to the patients’ questionnaires, long distances, unclarity of the spatial configuration, similarity of corridors and lack of appropriate signage all contribute to wayfinding issues in the participating rehabilitation clinics. Based on the observed cases of wayfinding issues and the patients’ comments, common wayfinding barriers in the participating rehabilitation clinics were identified:

- Corridor symmetry;
- Similarity of floors;
- Layout complexity;
- Paths leading to therapy.

On an average path where stroke patients encountered wayfinding issues in this data set, there were 4 decision nodes where they had to choose between multiple directions.

The average possible number of choices in the particular decision node where the wayfinding issue occurred was two, meaning that the patient had to choose between going left or right in most cases.
MAIN RESULTS: MOBILITY BARRIERS - Wayfinding

Half of the participating patients reported getting lost in their clinics at least once, which is a substantially high number considering that people are often reluctant to admit having wayfinding issues and getting lost.

Have you ever gotten lost in this clinic?

- yes, more than once
- yes, once
- no

In 20 out of 35 cases of wayfinding issues, the observed patient covered a longer distance than necessary because of backtracking or walking around to find the right way. The average added length due to wayfinding issues was 43,78 m, ranging from 0,5 m to 172,04 m. Compared to the usual length of the path without wayfinding issues, the average added length that the patients covered because of wayfinding issues accounted for around 26% of the additional distance.

Additional distance patients had to cover due to wayfinding issues

<table>
<thead>
<tr>
<th>Measured dimension</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>total path length (m)</td>
<td>139,95</td>
<td>64,97</td>
<td>134,46</td>
</tr>
<tr>
<td>added length (m)</td>
<td>43,78</td>
<td>46,02</td>
<td>25,63</td>
</tr>
<tr>
<td>added length (%)</td>
<td>26,72</td>
<td>21,87</td>
<td>21,08</td>
</tr>
</tbody>
</table>

This result indicates that it was difficult for patients to find the right way immediately and they had to cover a considerably long additional distance after encountering a wayfinding problem in the building.
MAIN RESULTS: MOBILITY BARRIERS - Distance

Long distances between key spaces within rehabilitation clinics negatively affect patients’ independent mobility by increasing the number of encountered mobility barriers and patients’ dependence on staff. There was a significant effect of distance on the number of all types of previously defined mobility barriers that patients encountered in the built environment (Wilks’ Lambda = 0.379, F(2, 15) = 12.271, p = 0.01). When all categories of mobility barriers were observed in this sample, the longer distance was related to more barriers encountered and more help needed. The analysis of shadowing data had shown that patients encountered mobility barriers and needed help more often on distances that were around 110 m on average. Distances that were on average around 60 m in length were less challenging for patients to cover independently.

To understand the spatial needs of patients in terms of distance, it was necessary to look at their real-life spatial experiences, the ways they used space and where and how they encountered mobility issues. For this reason, certain patient paths were further examined to illustrate the way patients use space. One of these paths is presented below.
The dimension problems were observed to occur in places where there was heavy patient traffic in the corridors and where the widths of corridors were insufficient. This happened in clinics where there was **drastic zonal segregation** between functions, and a large number of patients were going to the same place at the same time (e.g. main dining room or the main therapy area). Although the originally planned corridor width was sufficient for two wheelchair patients to pass, the addition of different **permanent or temporary objects reduced their width**. This resulted in a significant barrier to patients’ mobility within the clinics.

Based on the observed cases of dimension issues and the patients’ comments, four major problematic areas stand out in terms of insufficient corridor widths:
- Therapy area corridors;
- Corridors leading to therapy and dining areas;
- Space in front of major elevators;
- Ward corridors at mealtimes.
Patients were generally very inactive and spent around 50% of the observation time in their rooms. The frequency of non-scheduled (voluntary) activity was low in all participating clinics (Mdn =21.2%, IQR 6.5%–21%) compared to the scheduled activity. Corridors and seating areas in the corridors were the most frequent destinations of patients’ non-scheduled paths. The clinic with the most frequent non-scheduled activity (67% scheduled, 33% non-scheduled) had a distinctive spatial distribution of dining and common spaces.

The notable difference in the architectural layout that makes the Gesundheitszentrum Glantal an outlier compared to other participating clinics was the absence of the large common dining room for all patients. Instead, there were small dining/living rooms located in different areas on the ward, close to patient rooms. This difference in spatial organisation, together with the strategy of assigning a specific dining room to each patient on the ward for meals are likely to have positively contributed to the patients’ activity levels. It was observed that small patient communities were created in this way and it became easier to socialize with other patients who were already familiar from the meal times.

The majority of participating patients (72%) reported that they did not like to spend their free time in their rooms, even though 58 out of 70 participating patients were accommodated in single rooms.

Do you like to spend most of the time during the day in your room?

No 72%
MAIN RESULTS: MOBILITY FACILITATORS

gave examples of common room types they wanted to have in the clinics. The two most common answers were the cafeteria and the common living room. Even though each of the participating clinics had a common living room for patients and a cafeteria for patients’ meals, they did not fully meet the spatial needs of patients, which was evident from their open-ended questionnaire responses. Patients listed many other potential spaces in rehabilitation clinics that they would gladly visit in their free time, such as a music room, board games room, relax room, etc. These results highlight the importance of the built environment in patients’ free-time activities and the discrepancy between patients’ wishes and the types of common spaces that exist in rehabilitation clinics.

Therefore, it was found that removing barriers was not enough to support and motivate patients’ activity, it was also necessary to create attractive spaces close to their rooms - various corridor areas and common rooms. Upon leaving their room, patients would see and hear what is happening and may feel inclined to go there to participate.
**STAFF QUOTES**

**WAYFINDING**

“Patients often have difficulties to find their way around the winding clinic and find all the rooms in the back corners.”

“The house is large, there are many long hallways and levels. Also, several wards that look similar.”

**FLOOR**

“There are slopes on the wards.”

**DISTANCES**

“The problem is also long ways. The clinic is very labyrinthine.”

“Yes, they have difficulties. That is why we have the patient transport in the building, which transports the patients to the therapies, exercises.”

**DIMENSIONS**

“The corridors and too narrow and patients with the wheelchair are left unattended.”

“It is always tight on the therapy corridor (many people/chairs).”

**PHYSICAL OBSTACLES**

“Rooms are too tight, there is risk of falling because of obstacles.”

**OTHER**

“Elevator takes a long time.”

“Electric doors often malfunctioning.”

“Lack of handrails.”

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**PATIENT QUOTES**

**WAYFINDING**

“It is difficult to orientate, I always need to look left and right.”

“Wayfinding is difficult. Everything seems chaotic to me.”

“Everything looks alike.”

**FLOOR**

“There is a connecting corridor that is a slope. This can’t be handled alone using a wheelchair.”

**DISTANCES**

“You have to plan enough time to reach the therapies.”

“Distances too large with a walker, not enough seating opportunities to take a break.”

“Therapies need to be more centralized.”

**DIMENSIONS**

“It is a bit too tight to pass with walkers or wheelchairs.”

“There is no enough parking space for a wheelchair.”

**PHYSICAL OBSTACLES**

“Exit to the garden (door) not suitable for a disabled person.”

“Equipment that is left in the hallway!”

**COMMON SPACES**

“A comfortable sitting room, homely furnished, not in the hospital-style, but as a café.”

“A room where you can sit with several people to read, talk, play. Close to my room on the same floor.”

*Photos were taken by the author.*
THE NEW DESIGN MODEL - PRINCIPLES

The results of this study demonstrate that patients with different mobility abilities and in different rehabilitation phases have very different spatial needs. Patients at the beginning of rehabilitation need supportive design elements and patients who are preparing to go home need an additional challenge to exercise their mobility. The results also show that removing barriers is not enough, it is also necessary to provide spaces that would motivate patients to go out of their rooms more often. Thus, there cannot be a “one design fits all” solution for the design of rehabilitation clinics.

These study results were translated into a new design concept: The Transitional Model for Stroke Rehabilitation Clinics, presented in the form of a 40-page catalogue of recommendations that address the ward and therapy area design in terms of patient mobility. It is intended as a guideline on how to design rehabilitation clinics that support and promote patients’ mobility and their changing spatial needs during the transition towards recovery. Goal-setting for patients was taken as the main criteria for the division in levels in the proposed transitional model. These levels were created based on the main ideas of the phase rehabilitation model in Germany.

In each of the levels, the built environment is specifically designed for the needs of the patient group that would be accommodated within that level.

The design recommendations given for each ward type are not intended to limit the creativity in architectural design, but to give recommendations on how to design specific ward elements in a way that supports patients’ mobility. Therefore, the recommendations are not offered in the form of a perfect ward model that would fit all clinics, but rather as a set of “patterns” focusing on particular elements in the stroke wards and therapy areas that should be incorporated to enable and support patients’ independent mobility.
THE NEW DESIGN MODEL - STRUCTURE

The developed catalogue of design recommendations is divided into two parts, each addressing a different functional unit: patient wards and therapy areas. The ward design recommendations are divided into three parts according to the levels of the transitional model. The recommendations for each ward type, as well as for the therapy areas are divided into 6 categories corresponding to the main results of this study: wayfinding, dimensions, distance, floor, physical barriers and common rooms.

**1 PATIENT WARDS**

**LEVEL 1**
* mobilisation and activation
No. of beds: 10 - 16
Patient type: 

**LEVEL 2**
* regaining independence
No. of beds: 14 - 18
Patient type: 

**LEVEL 3**
* preparation for going home
No. of beds: 16 - 22
Patient type: 

**2 THERAPY AREAS**

wayfinding
dimensions
distance
floor
physical obstacles
common rooms

The developed catalogue of design recommendations is divided into two parts, each addressing a different functional unit: patient wards and therapy areas. The ward design recommendations are divided into three parts according to the levels of the transitional model. The recommendations for each ward type, as well as for the therapy areas are divided into 6 categories corresponding to the main results of this study: wayfinding, dimensions, distance, floor, physical barriers and common rooms.

**LEVEL 1**
* mobilisation and activation
No. of beds: 10 - 16
Patient type:

The primary goal of the built environment in the Level 1 wards should be to provide a barrier-free space that is easy to navigate, with short distances between rooms. By removing the barriers and physical obstacles, as well as reducing distances between spaces, the patients are given the opportunity to exercise their independent mobility within the range of their abilities. This ward type would enable patients to gain mobility independence by exercising the independent use of a wheelchair on short distances, which would greatly help them in their recovery process.

**LEVEL 2**
* regaining independence
No. of beds: 14 - 18
Patient type:

The primary goal of the built environment in the Level 2 wards should be to provide an environment that is easy to navigate, offers a variety of common areas for socialising and provides an opportunity for mobility exercise. Patients accommodated in this ward type should be encouraged to have meals in the main restaurant in the clinic. For this reason, the main dining/living room on the ward would not be used as the main dining room during meal times, but as a space for socialisation and a self-serving cafe.

**LEVEL 3**
* preparation for going home
No. of beds: 16 - 22
Patient type:

The primary goal of the built environment in the Level 3 wards should be to provide a community-like environment, with the goal of preparing patients for going back to their normal lives. This ward type is organised as a large apartment without the nurses’ station and with single bedrooms for each patient and a large central common area. This area also contains the communal kitchen where patients can practice some of the activities of daily living with the therapists or their families in a less clinical atmosphere.
THE NEW DESIGN MODEL - CONNECTIONS

Recommended connections between the main functional units in a rehabilitation clinic.
Presented are the design “patterns” recommended for the Level 1 wards.

Patients that are intended to be accommodated in the Level 1 wards are at the beginning of the rehabilitation process and have severe functional impairments. The Level 1 ward would, therefore, be most suitable for patients belonging to the rehabilitation Phase B with a lower Barthel index. Those patients are usually bed-confined or using a wheelchair, very dependent on the staff, and not able to cover long distances. Patients belonging to rehabilitation phase C with severe cognitive impairments could also benefit from being placed into the Level 1 wards.

The main recovery goal of this ward is mobilisation and activation of patients. This more specifically means enabling patients to start using a wheelchair and to move around in the controlled environment of their wards, under the supervision of the medical staff. Patients that are already able to cover short distances in a wheelchair could also visit the therapists on their own, provided that the therapy area is in the recommended distance radius from the ward.

The primary goal of the built environment in the Level 1 wards should be to provide a barrier-free space that is easy to navigate, with short distance between rooms. Stroke patients that are at the beginning of their rehabilitation usually suffer from complex impairments that limit their mobility ability and therefore increase the difficulty of independent movement in the built environment. By removing the barriers and physical obstacles, as well as reducing distances between spaces, the patients are given the opportunity to exercise their independent mobility within the range of their abilities. This ward type would enable patients to gain mobility independence by exercising the independent use of a wheelchair on short distances, which would greatly help them in their recovery process.

Central functional units in a Level 1 ward are the nurses’ station with the nurses’ common room and the dining/living room for patients (Figure 7). These spaces need to be closely connected so that nursing staff can easily monitor patients in the dining/living room and help them during meal times. Since the patients in this ward are bed-confined or learning how to use a wheelchair, they will have their meals served in their rooms or the dining/living room on the ward and will not use the main clinic’ restaurant on a daily base.

Figure 7: Scheme of recommended connections between the functional units in a Level 1 ward

The small and easily accessible therapy room is needed on the ward for patients that are not able to go to the main therapy areas of the clinic. The bathing room is also needed for assessing and training the activities of daily living and for bathing the immobile patients in a safe environment. Since the majority of patients are using a wheelchair and often need to be transferred from their beds to a wheelchair, storage space on the ward is needed for transferring lito and other necessary equipment. The storage space should be closely connected to the therapy room, for storing the additional therapy equipment.

Some patients on this ward are bed-confined patients that often need mechanical ventilation. The rooms of these patients should be closely connected to the nurses’ station, for easy monitoring and quick access. A physician’s office should also be planned on the ward, closely connected with the nurses’ station.

Level 1 wards should be placed near the main therapy area, to avoid the unnecessary use of the transfer service and to enable the patients in a wheelchair to, when possible, reach the therapies independently. These wards should also be near the exit to the outdoor area of the clinic. Since most patients are limited in their mobility, close and easy access to the outdoors would allow them to spend more time outdoors, which would be beneficial for their well-being. These general characteristics of the Level 1 ward are followed by a catalogue of architectural guidelines. The specific architectural design guidelines are divided into six categories, based on the main results of this research study. The catalogue categories are: wayfinding, distance, dimensions, floor, physical obstacles and common rooms. Design recommendations for each category are given in the form of a visual and textual explanation. The goal of these guidelines is not to offer a fixed solution for the design of the whole ward, but to emphasize the spatial elements that need to be taken into account when designing this type of ward.

1.1 Straight corridor

It is common for stroke patients that would potentially be accommodated in Level 1 wards to suffer not only from physical impairments limiting their mobility but also from severe cognitive impairments. For this reason, the corridors of these wards should be designed as simple and clear as possible. This more specifically means that the shape of the corridor should be completely straight, without any angled or curved walls and segments. Introducing the angle or curve into the corridor layout would create an environment where the whole corridor cannot be seen from all of its parts. This kind of design is likely to generate significant wayfinding challenges for the patients in Level 1 wards.

1.1.2 Asymmetrical layout

Stroke patients were found to often encounter issues with finding their way in the clinic when the corridors were symmetrical in the decision nodes. Therefore, slightly asymmetrical layouts should be avoided, especially in the areas with Level 1 patients. This kind of layout results in corridors being similar in the decision nodes, which makes them less challenging for wayfinding of patients recovering from a stroke.

1.1.3 Symmetrical corridors

Corridor similarity and symmetry was found to be a repeating pattern in places where patients encountered wayfinding issues. Another common pattern was that patients usually had problems to find the right way when they had to choose between two directions, usually turning left or right. This could likely occur due to the corridors being similar. As a result, the patient could not decide which way was the right way to go. Therefore, the similarity of corridors in the decision nodes should be completely avoided.

1.1.4 Corridor asymmetry

Corridors should have clearly different endings, marked with a spatial element, such as a widening at the end with a large window and a seating area (illustration on the left), or with a contrasting colour, different materialisation, etc. A straight wall could be used for leading the way and making the orientation center (illustration on the left). The recessed areas in the sidewalks can also be used to create different characteristics of the two corridor sides: corridor ending illustration on the left and corridor beginning illustration on the right. Another strategy could be using different wall materials/colours for the two endings of the corridor so that a patient can clearly see where to go when they look out of their rooms.

1.1.5 Nurses’ station and dining room as the ward’s centre

The central area of the ward, where the patients’ dining common room and the nurses’ station is placed, needs to be clearly marked. This central area should be clearly visible from all parts of the corridor for patients’ easier spatial orientation. The area should be marked by ceiling or wall accents or different materialisation. Since these two spaces are the most important in the daily functioning of a ward, they should be easy to find for all patients accommodated in any part of the ward.

1.1.6 Clear door signs

Numbers on patient rooms should be designed to be clear and easily recognisable. Large simple numbers in colours that have good contrast to the door surface should be used and these symbols should be placed at the eye level of a wheelchair user.
Presented are the design “patterns” recommended for the Level 1 wards.

1.2.1 Minimum corridor width
Since some patients in Level 1 wards will be bed-confined, the recommended minimum usable width for these ward corridors is 2.25 m. This recommended width satisfies the fire safety regulations for corridors where patients would be transported horizontally. The corridors need to stay free of all objects to satisfy the usable width of 2.25 m.

1.2.2 Recessed areas
The width of corridors in clinics is often reduced by adding different permanent or temporary objects. To keep this recommended corridor width completely clear and usable, the corridors could be walled in certain parts. This could be done by recessing the walls and creating small areas that could be used for different purposes.

1.3.1 Distances between spaces
Since patients in Level 1 wards who are using a wheelchair are not able to independently cover long distances (see 4.1.1.1), the total length of the corridor should not exceed 40 m. The distance from both ends of the corridor to the central ward area needs to be equal.

1.3.2 Visual connections
Patients in this ward are in a vulnerable health state and at the risk of falls and other accidents. For this reason, the nurses’ station needs to have a direct visual connection to the main dining/living room for easy and quick access and monitoring of patients’ behaviour.

1.3.3 Mechanically ventilated patients
Some patients in the Level 1 ward will be mechanically ventilated and completely dependent on frequent nursing care. These most vulnerable patients need to be accommodated in the rooms directly next to the nurses’ station and have quick access for intensive care on a daily basis and in case of complications.

1.3.4 Handrails
Many patients in Level 1 wards are wheelchair users that can cover certain shorter distances independently. A wall handrail with a height of 90 cm is recommended for the patients’ mobility. The handrail needs to be in a contrasting colour to the wall to be visible for patients with vision impairments.

1.4.1 Avoiding reflective flooring
Highly reflective flooring can create an illusion of water or other obstacle on the floor in contact with the sunlight. Flooring in ward corridors should not be highly polished. The material used for flooring should also be durable to wheelchair use and slip-resistant.

1.4.2 Avoiding carpet flooring
Carpet flooring creates friction between wheelchair wheels and the floor surface, which makes it challenging for patients to manoeuvre. The flooring needs to be smooth and level, flush with the floorings used inside patient rooms and low maintenance.

1.5.1 Automatic doors
One of the main identified physical obstacles was found to be heavy non-automatic doors. For this reason, the automatic doors should be used between the ward corridor and the unsecured areas of the clinic, to ease the transition for patients using a wheelchair.

1.5.2 Storage areas in the corridor
Although there is usually a storage room on the ward, the equipment such as additional wheelchairs and transfer lifts are often left in the corridor since they are used on a daily basis. To keep the corridors free of obstacles, the recessed areas in the corridors can be used for storing the necessary equipment.

1.6.1 Three types of common areas on the ward
Patients in a Level 1 ward are not able to cover long distances to use the main common areas of the clinic. For this reason, they need a variety of different common areas on the ward for socialisation and spending time outside of their rooms. A large closed dining/living room is necessary since most patients would have their meals here or in their rooms. Other common areas could offer different views, art or plants, but they should also be visible and easily accessible for the nursing staff in case of emergencies and falls. For the reason, the common areas, except for the dining room, should be open towards the corridor.

1.6.2 Access to the outdoors
In case that the Level 1 ward is not on the ground floor and does not have easy access to the outdoors, the main living room should have an accessible large enough balcony for bed-confined patients to be able to enjoy the fresh air under the supervision of the nurses.

1.6.3 Accessible balcony
If the balcony is designed on the ward, the railing should be transparent and below the eye level of wheelchair patients for a better view of the surroundings. The balcony is also necessary to be planned. The balcony's threshold needs to be flush for accessibility of patients in wheelchairs and beds.
THE NEW DESIGN MODEL - CATALOGUE

Presented is an example of the design “patterns” recommended for therapy areas.

4.1.1 Avoiding multiple decision nodes
Patients should not be given too many choices in navigation on the way to therapy. The common number of decision nodes was found to be 4 on the paths where observed patients encountered wayfinding issues. The number of decision nodes on the paths to therapy from especially Level 1 and Level 2 wards should be reduced to three or less.

4.1.2 Clear paths
The patients were found to encounter the most wayfinding issues on the way to therapy. These paths should be designed as clearly as possible. This most specifically means avoiding angled and curved corridors, as well as a large number of decision points.

4.1.3 Orientation cues
As already highlighted in the previous recommendations, the number of decision nodes on the paths to therapy area should be maximally reduced. Different identity and visual character should be created in different corridor parts at each decision node. Various levels of landmarks could be used to provide orientation cues and memorable locations. The landmarks could be provided by widening the corridor and creating a more open space, creating different environments with the use of plants, etc., adding specific, memorisation, colour, etc. Therefore, the paths need to be well planned and clearly structured.

4.1.4 Elevator exits
Patients were found to encounter wayfinding issues when the corridors directly at the elevator exits were designed in the same way on all floors.

4.1.5 Different environments at elevator exits
To minimize the wayfinding challenge when all the floors look completely the same at the elevator exits, the floors should be designed in different ways in this area. The use of different landmarks or the corridor configuration could be the ways to differentiate the floors at the elevator exits. For example, on one floor there could be a simple situation of left and right corridor (left illustration), on the other floor there could be a larger open space with more possible directions (right illustration).

4.1.6 Orientation cues at elevator exits
Corridors should be given different identities at the corridor exits and corridor symmetry should be avoided. These different identities should be created to help the patients remember where they need to turn, reducing the wayfinding challenges within the building. Different corridor configurations and dimensions, corridor widenings, and space openings, different colors, or various landmarks could be used to establish these different identities. These special spatial elements serving as orientation cues should be in patients’ sight lines when exiting the elevator, to show what’s ahead and to help spatial orientation.

4.2.1a Therapy corridor width
Therapy corridors often don’t have suitable dimensions for the number of patients that use them at the same time. It is often necessary to add waiting chairs in the therapy corridor, which reduces the clear width of the corridor. This addition of chairs has to be planned for in advance, by designing the corridor that is wide enough to allow for the unobstructed patient’s traffic. Therefore, the minimum recommended width for the therapy corridors is 2.80 m.

4.2.1b Therapy corridor width
Patient traffic or waiting are not the only activities occurring in therapy corridors. These corridors are also used for walking therapy of ambulant patients. The presented schematic section illustrates why the width of 2.80 cm is necessary to accommodate all patients’ activities in the corridor: walking, passing through and exercise.

4.2.2a Width of corridors leading to therapy
All the clinic’s corridors leading to the therapy area need to have a minimum clear width of 1.80 m. This is a necessary corridor width for two patients in wheelchairs to pass each other. To maintain this clear width, no chairs and other equipment should be added to these corridors. If chairs are planned in some areas of the corridor, the total width should be expanded to a minimum of 2.30 m, to keep a wide enough clear area for the unobstructed patients’ traffic.

4.2.2b Width of corridors
The minimum width of 2.30 m is necessary for corridors where the chairs are added since the addition of chairs to a narrower corridor would create mobility issues for patients. Since patients going to therapies have different mobility levels and use various mobility aids, they need enough clear space to pass other patients on the way.

4.2.3 Spaces for wheelchair
Wheelchair users in therapy corridors were found to encounter issues with parking their wheelchairs during waiting time. Thus, the whole length of the corridor should be occupied by waiting chairs. Since patients using a wheelchair are not able to use chairs, enough space needs to be planned for them in the therapy area corridors.

4.2.4 Folding chairs and armrests
When possible, folding chairs should be utilized in the corridors to reduce the occupied corridor surface during times when they are not being used. Any type of waiting chair used in the clinic’s corridors must have solid armrests of at least 5 cm width, to assist elder and less mobile patients with sitting down and standing up from a chair.

4.2.5 Minimum free surface area in front of the elevators
Corridor areas in front of the elevators need to accommodate a large number of patients during the peak therapy and meal hours. These spaces can often obstruct patients’ visual traffic through the corridors since many patients waiting for the elevators and going out of the elevators would block their path. Firstly, a single elevator area that serves all the patients in the clinic should be strictly avoided. Secondly, a suitable surface area should be planned in front of the elevators for enable patients that use mobility aids to have enough space to wait without fully blocking the path of the patients passing through the corridors. Minimum clear surface of 10 m² should be planned in front of elevators when the corridor is adjacent to the waiting area. If the corridor is passing through the waiting area, the minimum surface of the area should be 16 m².
REFLECTION

Since the proposed new design model is based on the research results and differs significantly from the current practice of designing rehabilitation clinics, it is not clear if it would bring improvements that are significant enough to be implemented into future designs. In the opinion of the consulted physicians in the final e-mail interviews, the adaptation of wards (stations) to address specific patient needs would be very beneficial in the design of rehabilitation clinics. They highlighted the changing needs of patients in different rehabilitation phases, which should be considered when designing the patient wards. Therefore, the specifically designed wards are considered as a favourable solution for patients, and for addressing their spatial needs by supporting them on the way to recovery.

Another mentioned argument for the specifically designed environments is that patients should be given an opportunity to exercise their abilities in the built environment. Patients at the beginning of rehabilitation could significantly benefit from a ward designed to support their early mobilisation and activation since this is likely to improve and advance their rehabilitation process and reduce possible complications. The environment that is challenging for patients with severe mobility limitations might not be motivating and supportive enough for completely mobile patients. Therefore, the patients do no benefit from the design that is the same for all.

Creating the wards are not designed only according to the needs of patients in different rehabilitation phases, but also according to their functional deficits should be considered according to the consulted physicians. In this way, the architectural design and the increased focused therapy might accelerate the patients’ recovery of impaired functions. The respondents of the e-mail questionnaires agree that this type of design would benefit the patients and is likely to enhance and possibly speed up their recovery process.

At the same time, there are certain challenges to the implementation of the proposed new model for rehabilitation clinics, as discussed with the four consulted medical professionals. Rehabilitation in German neurological clinics has a strictly defined system of sorting patients into rehabilitation phases that does not completely correspond to the levels of the Transitional Model.
RESEARCH IMPACT

Implementation of the proposed new design concept could benefit all involved in the process, from stakeholders whose revenue could be enhanced to patients whose well-being and recovery process could be improved. The workload on the staff, as well as the employee turnover, could be reduced in a rehabilitation clinic where wards with highly dependent patients would have significantly less patient beds, where patients would require less constant care and where they would be more independent due to the mobility-supporting environment.

Patients are the group that would benefit the most from the mobility-supporting environments, not only from the physical recovery perspective but also from the perspective of psychological health. The specifically designed environments could potentially improve their feelings of loss of control and increase their independence and motivation for rehabilitation. Patients’ improved mobility and independence could also reduce the burden on stroke survivors’ caregivers after their return home.

Therefore, the implementation of the proposed design concept is likely to benefit not only patients but also all involved persons in the rehabilitation of stroke patients. The main (planned) impact of this study is to demonstrate the influence of the built environment on patients’ mobility and activity, and the significance of incorporating EBD research into the design process of healthcare facilities.

LIMITATIONS

The first limitation of this research study was the process of accessing the clinics to conduct the field study. Out of around 60 neurological rehabilitation clinics in Germany, seven clinics accepted to participate in this study. Since the clinics could not be chosen by the researcher, the participating clinics might not have included all the clinic typologies and therefore the results might have resulted in a biased sample. Although the participating clinics have around 200 patients each, only 10 patients from each clinic participated in the research study. This limitation of the sample size was generated by selecting shadowing as the main research method and by the research study design. It was determined in the pilot study that the sample size of 10 patients was enough to reach data saturation, after which point the information was repeating itself. Further research that would study the topic in a more specified and quantitative way would benefit from a larger representative sample of stroke patients, but a much larger sample was not possible in this study due to the time-consuming nature of the shadowing method that caused the researcher to spend three and a half months living in rehabilitation clinics and collecting the observational data. Since shadowing, the main research method in this study is an observational method, the behaviour of the participants in the study might have been impacted by the Hawthorne Effect. To mitigate the complete change of behaviour from the participants’ side, the patients were not told that barriers and facilitators in the built environment were observed, but only their usual daily paths in the clinics.
The main innovative way of data collection was that the researcher lived in rehabilitation clinics for (non-consecutive) 14 weeks while collecting the data, spending one whole day with each participating patient (from 07:00h to 19:00h). This was exceptionally useful for understanding the daily life and experiences of patients in rehabilitation.

This is also the first study where patients were the main subject of shadowing on such a large scale (70 patients, 840 hours of observations). Shadowing was usually a method more commonly used to observe the nursing staff. The innovative systematic use of the shadowing method that was adapted to the architectural context demonstrated the potential of this method for investigating the needs and behaviours of different kinds of users.

The main outcome of this study is the first-ever catalogue of architectural design recommendations focusing directly on rehabilitation clinics and patients' mobility. The findings of this research study and the resulting catalogue of design recommendations are intended to facilitate the dialogue between the actors involved in the process of planning rehabilitation clinics, and especially the two main professions involved in this planning process: the architects and the medical professionals.
CONCLUSION AND FUTURE RESEARCH DIRECTIONS

The results confirm the findings of previous research studies and further demonstrate that the current way clinics are designed in terms of common spaces does not satisfy patients’ needs and does not contribute to their recovery. If rehabilitation clinics are considered to be patients’ temporary homes during recovery, they need to accommodate not only the care processes taking place but also patients’ everyday activities. Therefore, the design of these facilities should provide an environment that enriches the daily life of patients and offers them opportunities for solitude and withdrawal, as well as for socialising and performing various activities, without hindering their mobility. It is crucial to create an environment where patients can be independent and autonomous as much as possible. The results of this study highlight the importance of the built environment in patients’ lives during inpatient rehabilitation stay.

With the results that emerged from shadowing and questionnaires and the development of the catalogue of architectural design recommendations for neurological rehabilitation clinics, this study contributes to the evidence-based design knowledge and architectural practice. Although this research study was conducted on a limited sample and it faces the issue of the potentially limited generalisability, it provides essential information on the spatial needs of stroke survivors in rehabilitation clinics and it opens up many new directions for future research, such as further examination of patients’ non-scheduled mobility and the spaces that would activate them to leave their rooms, the wayfinding needs of stroke patients, spatial requirements of therapy rooms within the clinics, etc.

The presented results could be taken as a basis for further investigation of the topics regarding the role of the built environment in hindering and facilitating the independent mobility of stroke patients. This study, therefore, provides a foundation for further research on the mobility of stroke patients and their needs in the rehabilitation built environments.
The complete PhD thesis titled
Mobility-Supporting Rehabilitation Clinics - Architectural design criteria for promoting stroke patients' independent mobility and accommodating their changing spatial needs during the transition towards recovery

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