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SPATIAL AND BEHAVIOURAL COGNITION OF WAYFINDING SYSTEM IN HOSPITAL BUILDINGS IN TERMS OF ONCOLOGY PATIENTS' COMFORT

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A b s t r a c t

This paper discusses the results of a study of the quality of space in hospital buildings in the context of solutions facilitating the orientation of patients in the space of the Outpatient Clinic, in the clinic building complex of the National Institute of Oncology in Gliwice (NIO). By combining qualitative research methods with a syntactic description of the space, the aim was to record the experiences of users and define objective design guidelines for the new visual identity system. Completed research walks testing selected patient routes in the clinic space made it possible to identify decision points as nodal spaces in the wayfinding system. On the other hand, the use of the Space Syntax method allowed the identification of key areas for signage visibility and orientation in space. The proposed method can be adapted for various types of public buildings, providing a flexible framework for pre-design research and analysis. Furthermore, the results show the potential of linking qualitative research methods with simulation-based user participation and digital tools for in-depth pre-design analyses.

K e y w o r d s: **Accessibility; Healing environment; Method of examining complex buildings; Qualitative research; Space Syntax; Wayfinding system.**

1. INTRODUCTION

The issue of wayfinding has been repeatedly studied in relation to hospital facilities due to the level of complexity of the functional and spatial structure of the facility and the need to optimise the treatment process for outpatients. Wayfinding system is considered both in terms of behavioural and physical factors and this perspective was adopted in many audit tools that are used by researchers and designers to define the main indicators that improve the quality of built environment [1]. To define the main factors influencing the wayfinding behaviours and signage system questionnaires combined with on-site examinations are used by researchers [5]. Using user testing approach outlining key stages such as planning, setup, commissioning and debriefing could be more effective method of evaluation wayfinding system in the hospitals [7]. To reach more accurate and efficient results, computer techniques are used i.e. Space Syntax method or other tools using simulations of users' behaviour. The research using the Space Syntax method in relation to wayfinding has been carried out since 90's. Already in 1990 Peponis, Zimring and Choi [8] demonstrated that studies of wayfinding and spatial learning can benefit from a more rigorous analytic description of building layout and exploration paths that exhibit their own pattern. In 1991, Neil studied the effect of floor plan complexity and several types of signage on wayfinding in a series of buildings on a university campus. Penn in 2003 reviewed the contribution made by syntax research to the understanding of environmental cognition.

It should be underlined that the concept of Space Syntax concentrates on defining the rules that determine how users move around and describing the configurations of space in terms of social and cultural attributes. However, from the point of view of a full analysis of building spaces, the behavioural patterns of users are important aspect in defining the wayfinding problems [6]. Typical Space Syntax analyses incompletely undertake the analysis of spatial features in terms of their accessibility, i.e. a range of behavioural factors that provide the user with knowledge of how to use the space [12]. The results of research work of Sadek and McCuskey Shepley shows that Space Syntax method used for healthcare facility design and research was extended in recent years to include correlated behavioural and perceptual features of the healthcare physical environment [12]. It was underlined that among the newly developed spatial methods the tool Place Syntax brings the Space Syntax description of the cognitive environment into a combined accessibility analysis model with the specified content and features. The relationship between wayfinding and spatial configuration was investigated in terms of parameters used by pedestrians to find their way in unfamiliar urban environment [13, 14, 14], in terms of wayfinding in complex multilevel buildings [16, 17]. To predict user routes and to investigate the relationships between the spatial configuration of the hospital areas and the wayfinding behaviour of patients the axial map and isovist analysis were used [18]. The results of the research obtained by combining qualitative methods with the Space Syntax method indicate effectiveness in obtaining more detailed data on modification of the functional layout and accessibility of the various zones of the hospital [20].

An extension of the research in the field is the use of data available in the form of a digital twin of a BIM-compliant building and statistical data on ongoing organisational processes (BIG DATA). Tools that introduce the ability to analyse the existing state using VR and AR, and simulations of user behavior with analysis allow optimisation of waiting time, movement and rational use of organisational resources. The goal is to assist users to move more easily through the spaces available to them, resulting in greater satisfaction. Simulations implemented with tools like AnyLogic allow research to be supplemented with analysis and simulations not available in the Space Syntax method. These are agent-based modeling, discrete event modeling and multimethod modeling and system dynamics modeling. They focus on mathematical simulations supported by ML, DL and AI machine learning. The crowd behaviours realised during the simulation allow remodelling the pathways in relation to processes and their impact on organisational efficiency. In particular, these tools also work well during the identification of information needed for wayfinding.

The issue of the efficiency of communication systems in healthcare facilities is closely linked to the efficiency of patient handling, especially in the case of extended outpatient or clinic areas. In many cases, the outpatient service area is widely dispersed in the hospital facility, which makes its logical organisation difficult and presents the patient with a challenging task in finding his or her way to the individual destination points. This undoubtedly has the effect of lowering the level of control and thus, according to Ulrich's environmental theory of supportive design (1991), this fact becomes a stress factor [21]. Taking the concept of implementing the principles of the therapeutic environment as paramount in hospital design, all possible measures should be taken to ensure that patients are as comfortable as possible in the treatment process. Our research adopts the definition of wayfinding as a system of spatial solutions to assist the patient in finding the destination point, targeting a sense of control and using visual, auditory, tactile and olfactory elements. In addition, the system aims to facilitate mental mapping by introducing elements that give individual spaces characteristics of place [1].

In the concept of universal design, the environmental conditions affect different individuals differently, while the methods using the syntactic models of the space generalise the integrated data about the behavioural patterns. These general environmental aspects of accessibility were studied by using the Space Syntax methodology in the urban scale [22]. This article presents a case study on wayfinding in the Outpatient Clinic of the National Cancer Institute of Gliwice. It is a facility made up of several buildings connected by connecting passages. The main part of the Outpatient Clinic is located on the first floor. The diagnosed problem relates to the confusion of patients and problems with getting to the doctor's offices and diagnostic points. The existing visual identification system lacks precise information, and the dispersed medical functions and the complex structure of the facility make wayfinding difficult. In addition, cancer patients are confronted with a number of dysfunctions that limit their efficiency, making the level of accessibility of the space an important factor in the efficiency of the system. The objective of the conducted research project was to determine the conditions to optimise the wayfinding system at the Institute, taking into account the functional and spatial characteristics of the facility. On the basis of the collected data, the main task was to define design guidelines to improve the visual identity system and the interior design in the node spaces. The research questions posed address the following issues:

- What are the essential observed relationships between the wayfinding system of the outpatient areas and the patients' behaviour?
- What are the opportunities and barriers in using the digital research methods in terms of determining the accessibility of the wayfinding system?

2. METHODOLOGY

In the presented research a triangulation approach was used and four different methods were used (Table 1). The criteria relating to user behaviour, behavioural limitations and the behavioural characteristics of the space were analysed with regard to spatial characteristics. On the other hand, to understand the intuitive behaviour of the users and to define possible modifications of the user paths, a syntactic analysis of space properties was performed for the current traffic system and for variant spatial changes. This approach has made it possible to comprehensively identify optimal strategies in terms of wayfinding system.

The spatial scope of the study included accessible outpatient areas on the first floor of the Institute (Fig. 3). In the period from December 2023 to March 2024, volunteers (n=22) were invited to find selected destination points (i.e., registration, surgeries of doctors). On the basis of guidelines obtained from medical staff, three target points relevant to outpatients were selected (Fig. 2):

- the Registration of mammography (path W1),
- the Magnetic Resonance MR1 (path W2),
- the Department of Nuclear Medicine (path W3).

A record of the observations was kept on a prepared form including the basis for the development of cognitive maps with a record of the most important phenomena and problems during each route. The volunteers were also asked to list their personal observations, which were grouped and formed the basis for adopting the main categories of phenomena and mapping user behaviour. On the facilities maps, the main observations made by every participant were noticed, and then a synthesis of all routes was developed on a summary plan for each of the three routes (Fig. 5–7). The result of this study was the determination of decision points where the need to choose a further direction of movement occurs, and the analysis of the space in terms of the course of the main patient routes.

On the basis of the defined phenomena, a tool was developed to study patients' behaviour, taking into account the following groups of issues: the way of moving around (independently or with the help of rehabilitation equipment), remembering characteristic

Table 1.
List of research methods used in the project

Research method	Main analyse criteria
Exploratory walks involving volunteers (n=22)	• direction and location signs: visibility of signs and their location, legibility of text; • occurrence of landmarks, • characteristics of landmarks: legibility and visibility of the existing visual identity system using volunteers' perception
Exploratory walks involving patients (n=8)	• characteristic features of the space (landmarks, interior colours, furnishings, graphic elements, views from the window, etc.). • legibility and visibility of the existing visual identity system using patient's perception
Mapping the behaviours	• identification of spatial features, user behaviour and phenomena and their location on object projections, definition of decision points
Space Syntax methodology	• checking the visual step depth (Visual step depth) for the selected starting point in the first floor and analysing building interiors as the visibility graph analysis (VGA)

elements to facilitate orientation, preferences in obtaining information about destination points and legibility and visibility of the existing visual identity system. This tool was used in in-depth interviews completed with patients (n=8). Research walks were conducted with selected patients who visited the Cancer Institute for the first time and were unfamiliar with the facility space. All of the qualitative method studies carried out formed the basis for determining conclusions in terms of the behavioural assessment of the Institute's space and comparison with the syntactic space analyses.

The objectives of using the Space Syntax analysis were to identify key spatial data in wayfinding and to assess what are the syntactic properties of the National Cancer Institute in Gliwice responsible for orientation of patients. Two spatial changes: the existing situation in Variant A and the circulation change in Variant B were analyzed in terms of the visual accessibility of the floor. The analyses were performed with the help of an open-source tool used by the Space Syntax community: depthmapX (previously known as Depthmap). The first part of the Space Syntax analysis that was applied to the selected case study is to check the Visual step depth for the selected starting point. The visual step depth shows the number of syntactic steps required to reach every other space in the graph, starting from the current – indicated location. The indicated current location has a step depth of 0. All locations directly visible from it have a step depth of 1. All locations directly visible from those at step depth 1 have a step depth of 2, and so on. The result is a cumulative isovist growing out of the initial location. The step depth tool, on the other hand, shows only the depth values for one, indicated location [23].

Another, and one of the main analyses of Space Syntax methodologies is the Visibility Graph Analysis (VGA). It was formulated by Turner et al. [24] as an extension of Benedikt's work on isovists and changes in visibility fields [25]. It is a way to quantify the configuration of a space as regular units, which can then be used to determine the relationship of that space to the behavior of the people who occupy it [26]. The VGA shows calculations of depth values for all locations in the graph and compares them with each other. The default attribute shown in depthmapX for VGA analysis is the number of connections for each location.

The use of the two described methods and related indicators in a hospital can be used to understand the user behaviour of finding the right access route to particular zones and offices. Such information can then be used to test multiple variants of changes to the designed solutions and compare results indicating the likelihood of choosing a particular access route.

For all syntactic analyses of the space described in this expertise, the following legend (Fig. 1) for the values of syntactic variables from minimum (the bluest) to maximum (the reddest) applies. Taking into account (in the analyzed visibility charts) the connectivity variable: the higher its value, the more red the result, and similarly the lower its value, the more blue the result. The ranges of the variables of the parameters studied are given in the visualization descriptions of each analysis.

The methodology is based mainly on topological features of space, firmly rejecting its metric nature. The research conducted in this field is concerned with the various relationships that occur between elements in space.

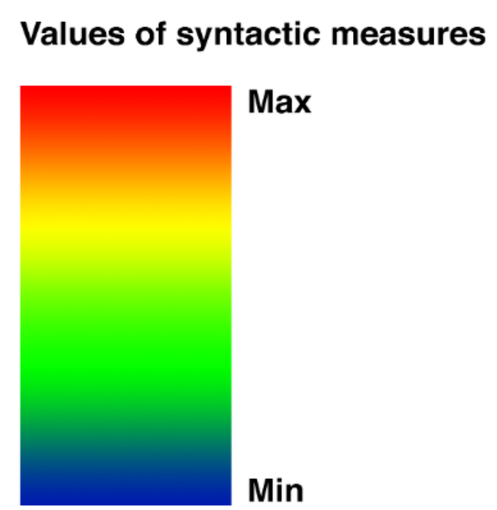

Figure 1.
Legend of the values of syntactic measures

The method also aims to answer one of the most important questions related to spatial planning: how space can be measured. The method proposes three main types of topological representation of a given place, each of which is attributed to a different activity of users in space: movement of users, interaction between users, and observation of the surroundings [27].

The 1st floor of the National Cancer Institute was studied as a key level in the diagnosis and treatment of outpatients. The following figure (Fig. 2) shows the floor zoning.

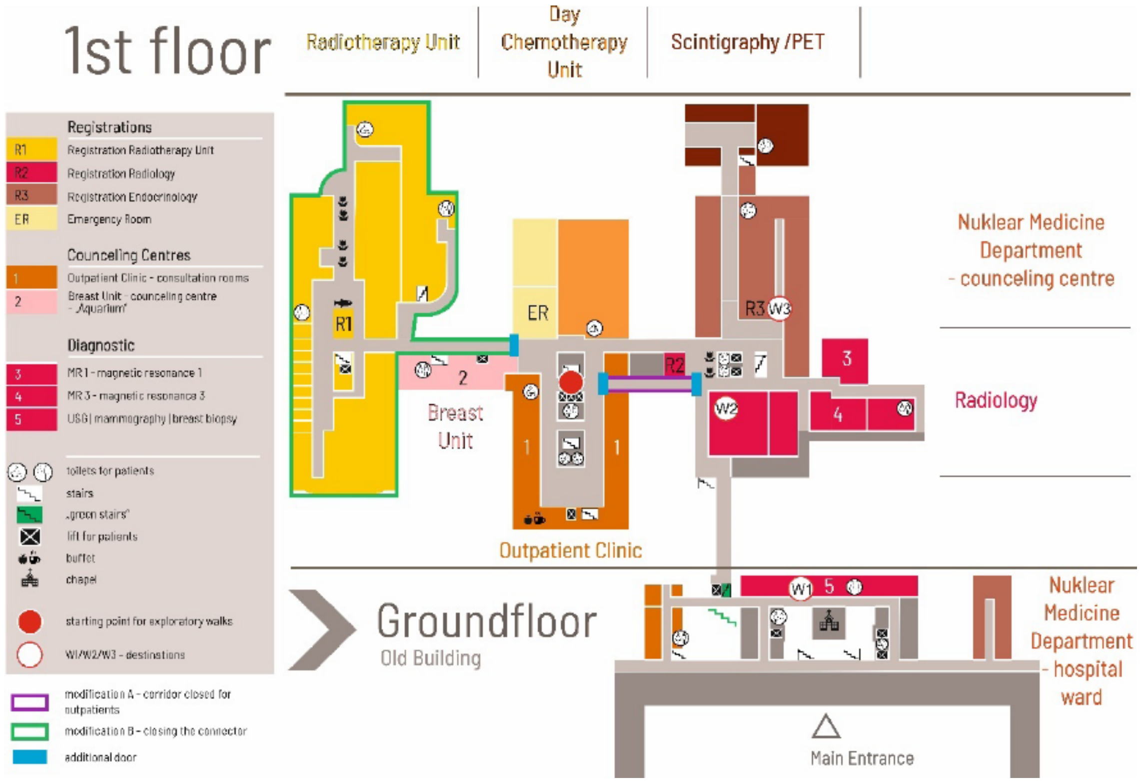

Figure 2.
First floor of the National Institute of Oncology in Gliwice; two variants of the changes made. Variant A and Variant B in Model 1

The main entrance to the floor was marked with a red dot. For visual step depth analyses, this point was used as the starting point. To organize the model, a conventional division of the first floor of the National Institute of Oncology in Gliwice into three main parts was made (Fig. 3):

- the first part (part I) includes the spaces and rooms of the Radiotherapy Unit,
- the second part (part II) includes the spaces and rooms of the Day Chemotherapy Department, associated with the general outpatient clinic,
- the third part (part III) includes: the spaces of the Scintigraphy (PET), Nuclear Medicine Department and Radiology associated with the building of the so-called Old Oncology, where some of the rooms of Radiology are located, associated with the Directorate of the Institute.

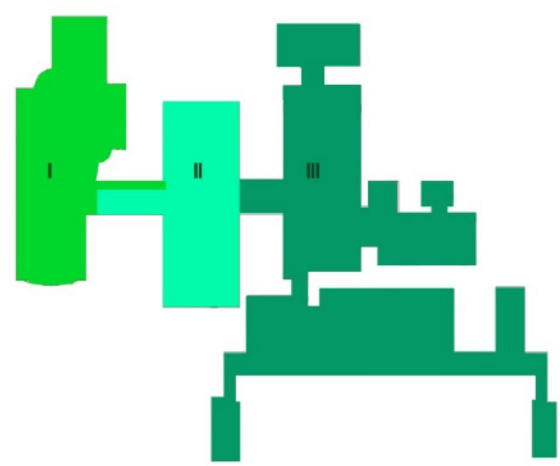

Figure 3.
Diagram of the conventional division of the first floor of the National Institute of Oncology in Gliwice

Description of Model 1 and Model 2

To perform Space Syntax analyses, it was necessary to prepare an appropriate convex space model. It was decided to prepare and analyse two basic models (Model 1 and Model 2), as well as two possible changes made during the variant stage of changes in the layout of the open spaces of the clinics based on Model 1 (Variant A and Variant B). The Model 1 (Fig. 4) shows the entire first floor of the National Cancer Institute divided into open spaces and public spaces for external users (who are not hospital employees) and closed rooms. It was prepared in order to select the spaces

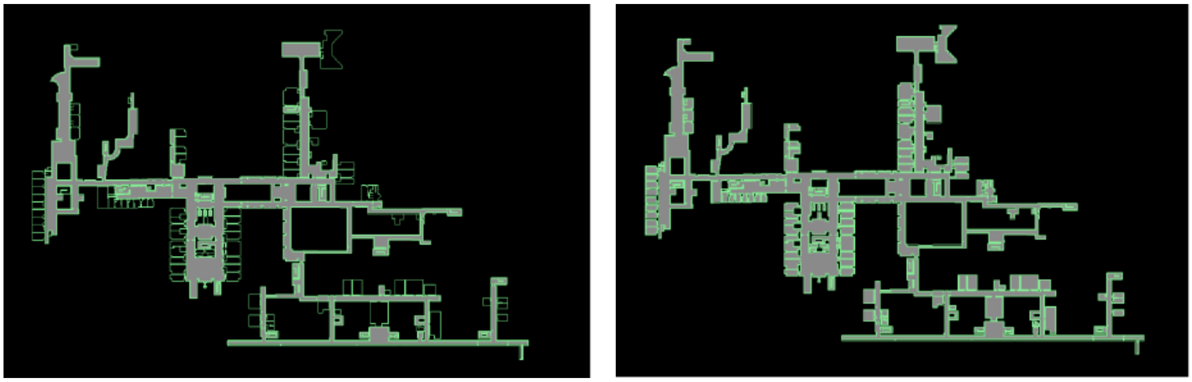

Figure 4.
Left: Model 1 – Branch divided into closed and open spaces (accessible to external users). Open spaces filled with paint. Right: Model 2 – All offices open and accessible to users

exhibiting the characteristics of the most and least accessible to outside users. The figure below shows the prepared Model 1 convex space of the floor.

Model 2 (Fig. 4) covers the entire first floor with all offices open to users. It was prepared to verify that the most accessible spaces are developed in a way that allows the most efficient use of them. The figure below shows the prepared Model 2 convex space of the department.

3. RESULTS

The following categories of results were obtained on the basis of the completed research process:

a. spatial features determining orientation in the building,
b. features of the existing visual identity system,
c. factors determining users' behaviour.

The complexity of the communication layout and the lack of clear functional zones is one of the most significant factors contributing to confusion in hospitals. The peculiarities of the Institute's buildings linked by connectors and the haphazard arrangement of functions make mental mapping and route memorisation difficult. The results of the walks with the volunteers indicate the location of sites lacking information and the absence of landmarks, which determined the decision points. However, a comprehensive analysis of the space, combining qualitative methods with simulation methods using digital tools, yielded a comprehensive analysis of the features that determine orientation in space.

3.1. Results of qualitative research

In the first stage, a diagnosis of the communication space was performed. As a result of this stage, decision points, characteristic elements of the space and flaws in the visual identification system were indicated (Fig. 5). The collected results were supported by observation of their own behaviour, grouped into separate categories and marked on behaviour maps (Figs. 6-7). This was the stage of recording the events and behaviours of volunteers as they travelled the selected routes. In particular, the results indicate that one of the main spatial issues causing orientation problems in the facility is the level of complexity of the functions, the ambiguity of the existing visual identification system and the different route options to the destination points.

The following behavioural maps are a sample record of events and observations that determine the efficiency of volunteers' movement in the Institute space. The locations of the density of markings for each category of events were interpreted as the locations of decision points that require design interventions. This mainly refers to places of traffic diversion, where visual identification was insufficient. In order to deepen the results the categories of incidents were assigned to particular methods (Table 2; Q – qualitative methods and S – syntactic methods).

In order to obtain a more detailed analysis of the phenomena, in-depth interviews were conducted with selected patients (n = 8), which helped to clarify the key categories of space description that determine patients' difficulties in wayfinding and orientation. The study identified preferred ways to get to the Institute, elements that help to navigate the facility, remembering distinctive elements to facilitate orientation, and preferences for obtaining information

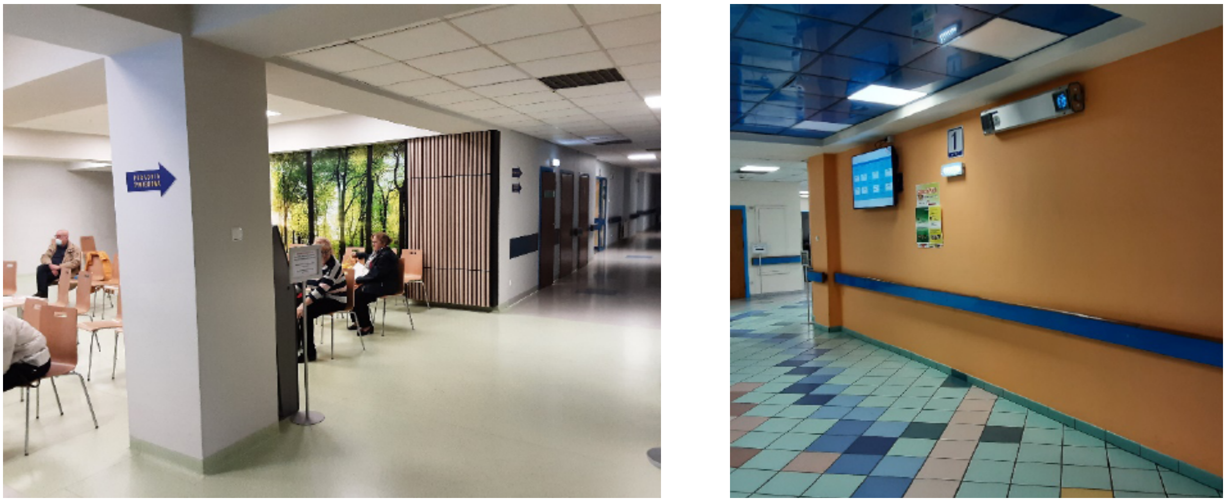

Figure 5.
The indicated decision points. Left: waiting room. Right: main hall by the patient lifts

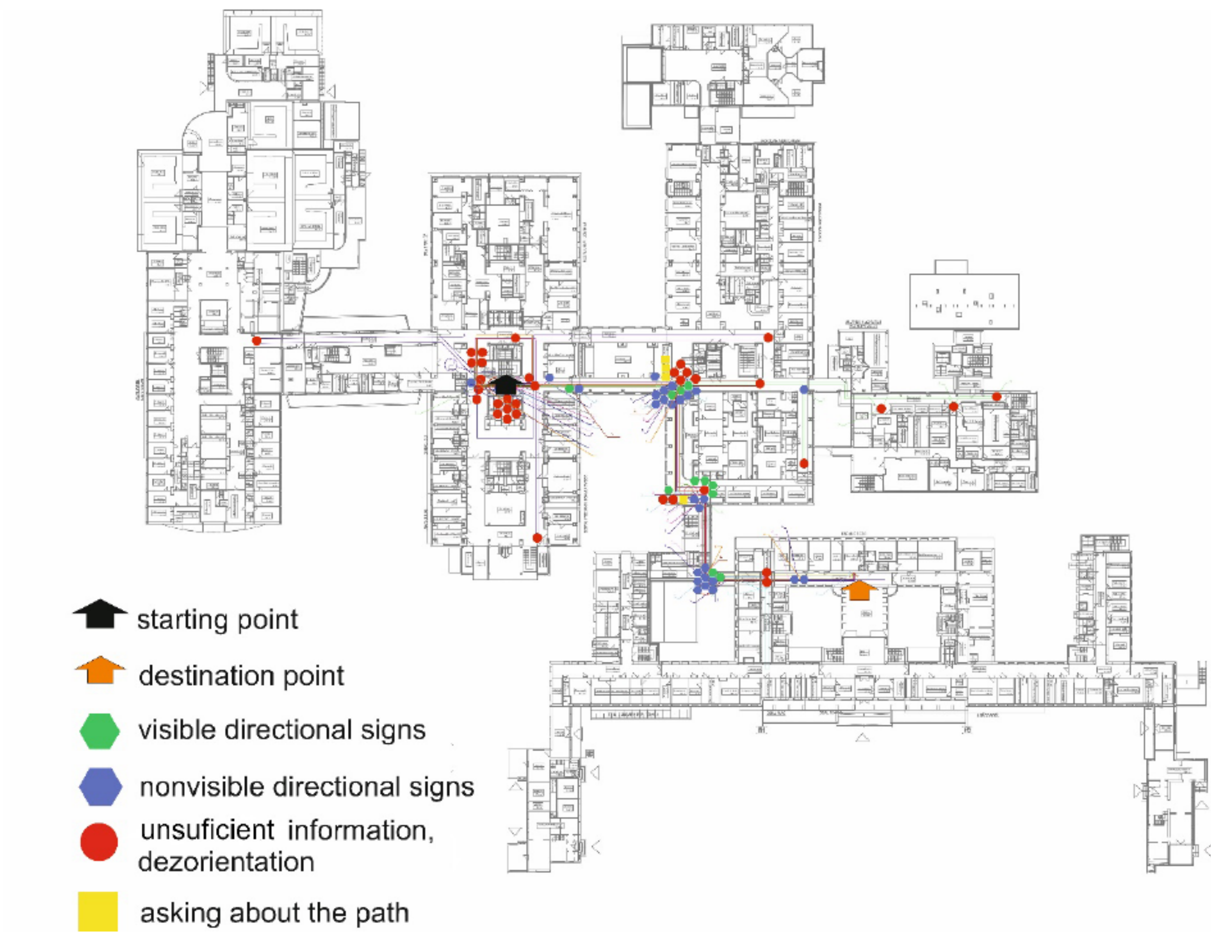

Figure 6.
Example results of users' behaviour mapping for the patient route to mammography registration (W1)

about destination points. On the other hand, the categories assigned to the simulation study were analysed using the Space Syntax method.

One of the main findings overlapping between the

Figure 7.
Results of users' behaviour mapping for the patient route to Nuclear Medicine Department (W3)

Table 2.
Main results of research walks

Criteria of analysis	Characteristics of the indicated features of the space	Proposed methods of further research
A. spatial features determining orientation in the building		
A1. Legibility of the communication layout	illegibility of the communication layout, numerous staircases that are not distinguished in the communication space	S
A2. Characteristic elements in the space (landmarks)	few landmarks to help remember routes,	Q
A3. Visual accessibility of the destination/decision point	insufficient differentiation of the target points in the communication space (no colour codes, no characteristic elements of the equipment)	S
A4. Zoning of the functional areas in the building, difference in areas and buildings at the site	No clear functional zones, no colour codes applied consistently, Excessive colour elements without a coherent system	Q/S
A5. Number of changes in direction along each route	multiple changes of direction	S
A6. Location of vertical communication	Failure to distinguish the location of staircases in the communication space	S
B. features of the existing visual identity system		
B1. Visibility of visual identification system	Location of signage in areas not visible from the initial decision point	Q/S
B2. Legibility of the signage system	Directional signage located under the ceiling is not always legible	Q
B3. Characteristic signs in the circular area	Individual landmarks, e.g., fishes, pots of greenery, murals with nature motives	Q
C. behavioural factors		
C1. Overloading of distractors and obscuring elements	Too much information posted, information posted is misleading (no update of information posted)	Q
C2. Cognitive bariers	Unintelligible names of medical functions	Q
Explanation: Q – qualitative research; S – simulation research		

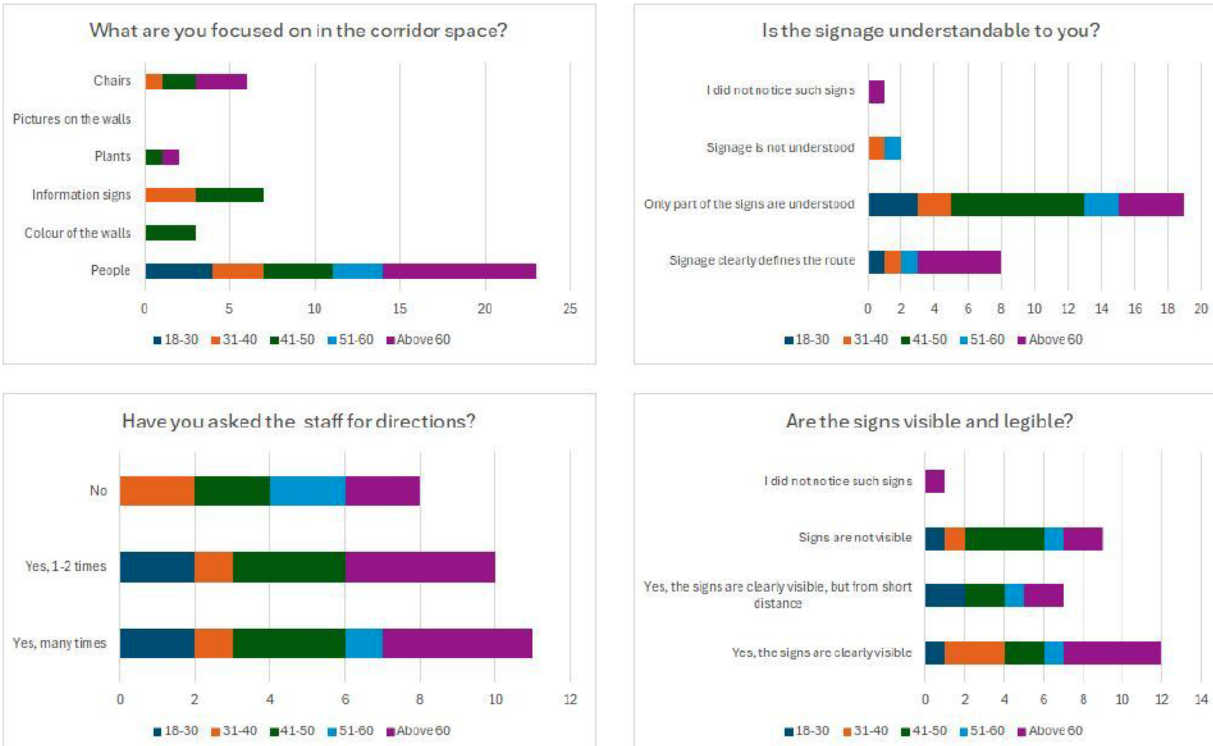

Figure 8.
Survey results regarding the criteria of analysis according to the age groups

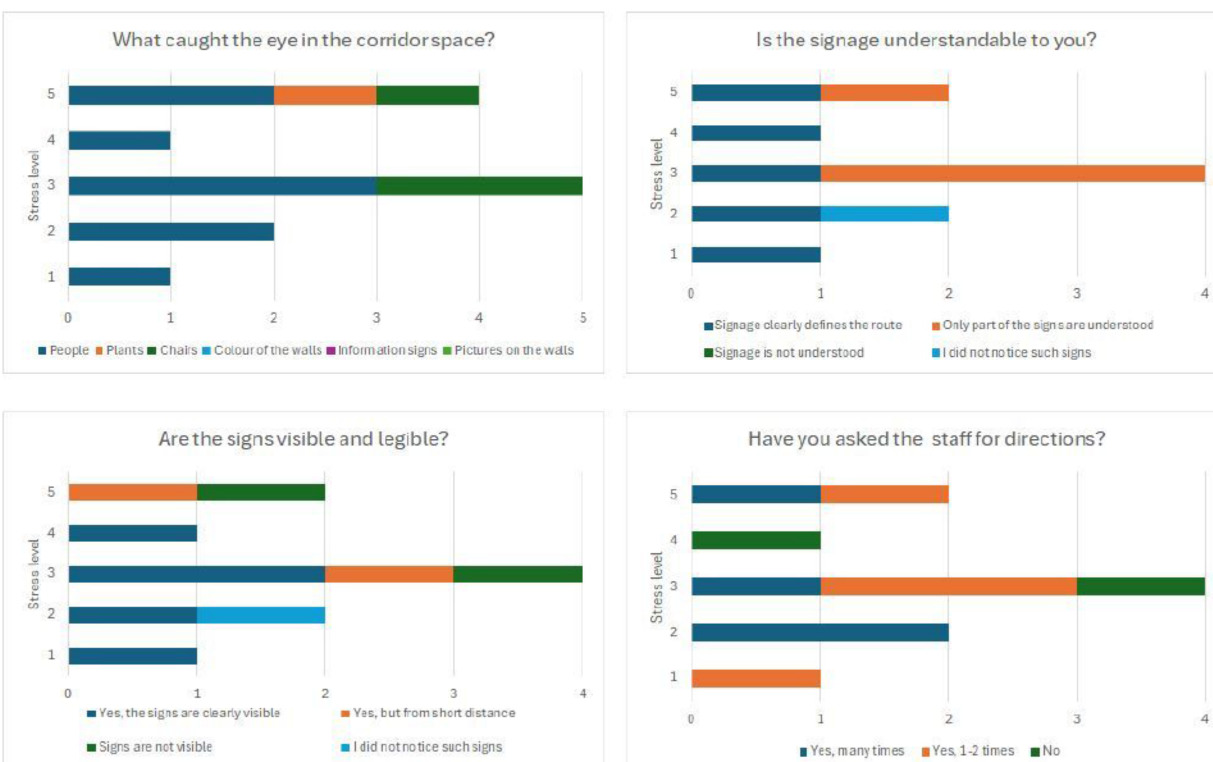

Figure 9.
The obtained data were analysed and grouped according to the specific of each factor (as it is presented in Table 3)

Table 3.
Wayfinding experiences indicated by patients and staff (in terms of criteria included in Table 2)

Criteria of analysis	Meaning of the indicated space features	Behavioural interpretation
A. spatial features determining orientation in the building		
A2. Characteristic elements in the space (landmarks)	Confusing movement to destination, asking people/staff for directions	Stress, sense of confusion,
A4. Zoning of the functional areas in the building, difference in areas and buildings at the site	Unconscious movement to destination, difficult finding the desired location,	The embarrassment of having to ask staff for directions
B. features of the existing visual identity system		
B1. Visibility of visual identification system	Location of signage in areas not visible from the initial decision point, difficult to find the right sign	Visual and cognitive barriers
B2. Legibility of the signage system	Directional signage located under the ceiling is not always legible, too little signage to see from a distance, and incomprehensible names of the locations	Visual barriers
B3. Characteristic signs in the circular area	Individual landmarks, e.g. fishes, pots of greenery, green steps	Difficulties in building the mental maps
C. behavioural factors		
C1. Overloading of distractors and obscuring elements	Older patients have indicated confusion with many information and inconsistent nomenclature	Confusion, stress
C2. Cognitive bariers	Unintelligible names of medical functions	Confusion

two methods is that patients focus most of their attention on other users of space in a hospital space lacking unambiguous information for orientation in space. This conclusion indicates that patients obtain information from staff or other patients. An assessment of the readability and comprehension of signage, was confirmed in in-depth interviews, according to the age groups and the declared level of stress (Fig. 8, 9).

The collected results indicate fundamental problems with existing visual identity system, mainly related to the age of the patients (34.5% of the respondents were 60 and over). Additionally, the declared level of stress can certainly affect the ability to interpret information from the environment, although this has not been studied in depth. The verification of the other criteria using the syntactic method complemented the diagnosis of existing problems in terms of spatial morphology.

3.2. Spatial analysis using the Space Syntax method

The results of the syntactic method research verify previous indications regarding spatial layout and its accessibility. For Model 1, the visual step depth from the indicated starting point was analyzed. In both cases (Model 1 and Model 2), depth values were calculated for all locations on the graph (VGA analysis) and compared with each other. The first part of the Space Syntax analysis is to check the visual step depth (Visual step depth) for the selected starting point. In the following analysis (Fig. 10), the starting point was established at the location of the main staircase and elevators in Part No. II (Fig. 3.). In the diagram below (Fig. 10), the red isovist 3600 (with a depth of 1) is the visibility field drawn on the surface bounded by obstacles, as seen from the starting point (whose syntactic depth=0). The orange isovist has a depth of visibility steps of 2, yellow 3, green 4, blue 5, dark blue 6. The analysis shows that the part of the space where the administration is located is farthest from the starting point.

The following VGA analyses for both models (Fig. 10 and Fig. 11) show in red the best-accessible places and in blue the most isolated from others throughout the model.

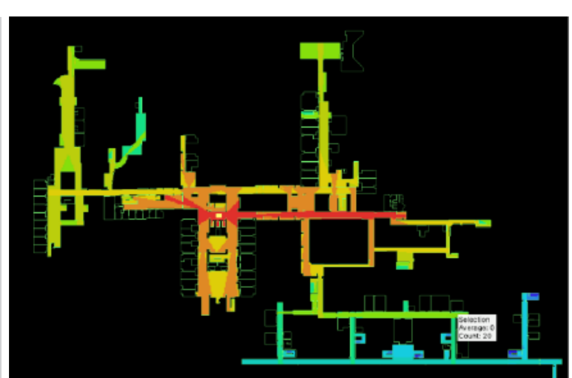

Figure 10.
Visual step depth for the starting point

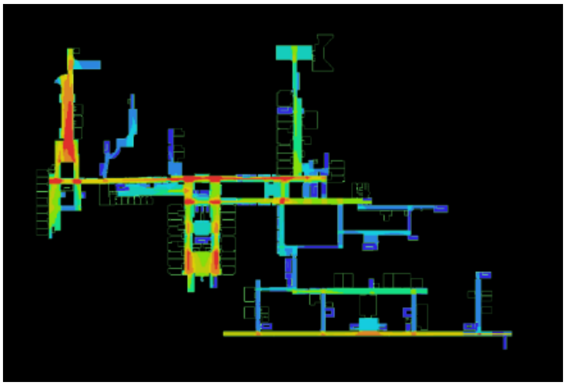

Figure 11.
VGA analysis of model 1 connectivity parameter (min. 15 – max. 2163)

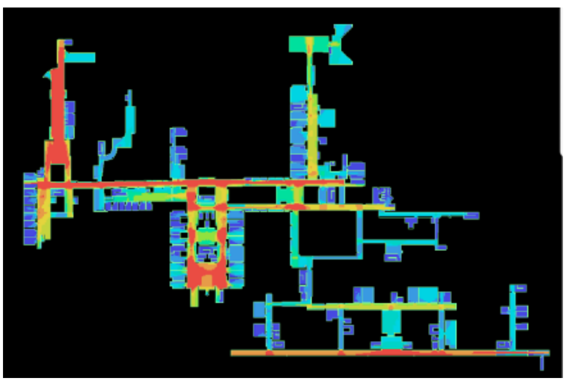

Figure 12.
VGA analysis of model 2. Connectivity parameter (min. 6 – max. 2208)

The result of the VGA analysis of Model 1 (Fig. 11) shows how accessible each individual model space is in relation to the entire model. It can be clearly observed that the longest corridor connecting Part I, Part II and Part III (See Fig. 4) is the most accessible to users due to its syntactic properties. Additionally, the radiation therapy facility and the administrative part show characteristics of good accessibility. However, the functional space of diagnostic imaging is difficult to access and isolate. The staircases in the diagram are shown as isolated (difficult to access); however, it should be assumed that they are natural places that concentrate users due to their function of combining floor accessibility vertically. The result of the VGA for Model 2 analysis (Fig. 12) allows us to draw similar conclusions to the result shown in Fig. 11. Each of the offices and administrative rooms are isolated, and the corridors are the best accessible spaces of the ward. However, due to the purpose of the expertise, the proposed changes will be shown on Model 1. After performing the first Space Syntax analyses, it was decided to analyze two spatial changes. This step after the analysis was to test two variants of spatial changes (variant A and Variant B). The following illustration shows the changes implemented consisting of:

- closure of one corridor (Variant A),
- closure of one corridor and a part including the radiotherapy facility (Variant B).

Variant A

The introduction of Variant A consists of closing one internal corridor connecting Part II and Part III. in order to reduce the number of alternative accesses from one place to another. The following illustration (Fig. 13) shows a model with Variant A introduced.

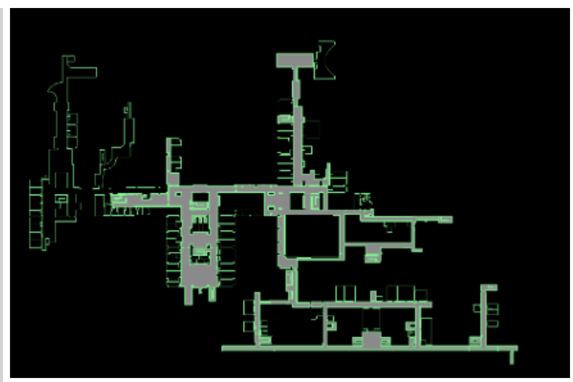

Figure 13.
Variant A in Model 1: One corridor closed to users

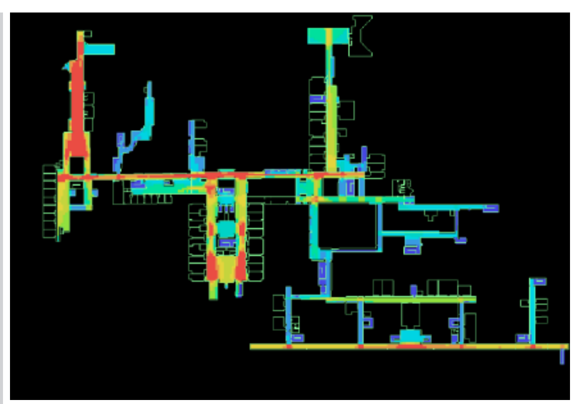

Figure 14.
VGA analysis for Variant A in model 1. Connectivity parameter (min 4 – max 629)

The introduction of Variant A in Model 1 appears to be beneficial for the legibility of the layout. The space of the longest corridor appears to be crucial in the whole system because it connects the three parts of the cancer institute. Analysis of the visibility graph shows that after the introduction of Variant A, this

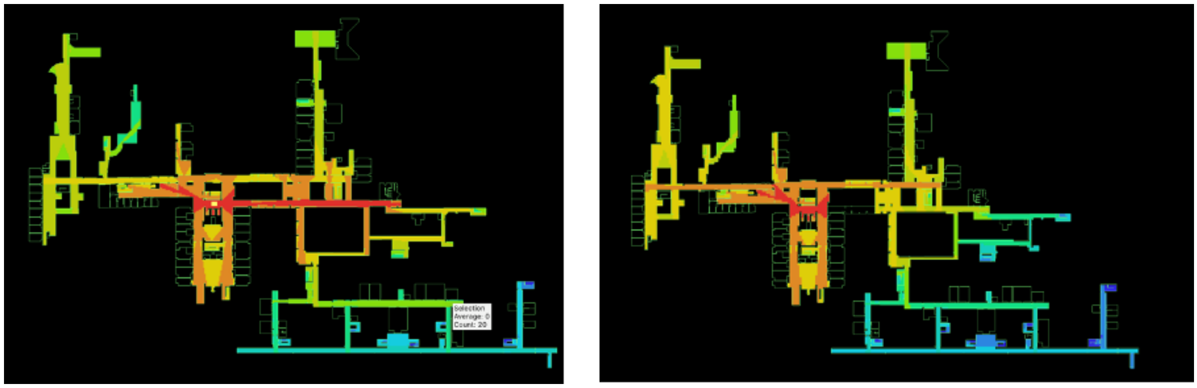

Figure 15.
Visual step depth – comparison of the situation before and after the Variant A

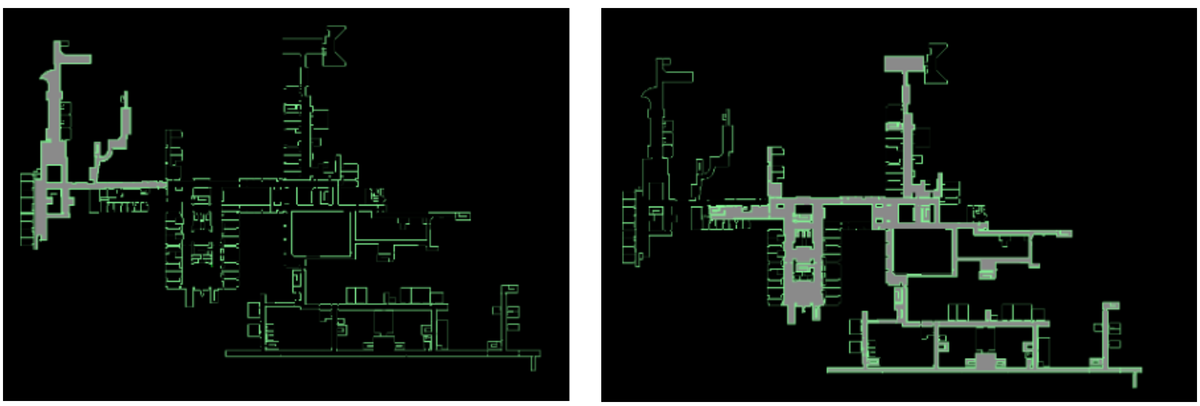

Figure 16.
Variant B in Model 1. Separate the two zones (right and left) by adding one door and closing one corridor in the section leading to the diagnostic imaging space to outside users

space is the best accessible space, and at each intersection with another corridor, it shows accessibility enhancement properties. The visual step depth analysis for the starting point (Fig. 15) also confirms the validity of Variant A. The isovist with a depth of 2 (orange) covers all the most important communication spaces connecting all three parts. This means that each orange space is in the same visual depth of 2 (from the starting point).

Variant B

The introduction of Variation B in Model 1 consists of an additional (compared to Variation A) closure of the transition from the space covering daytime chemotherapy to the space of the radiation therapy facility. This part of the analysis is to see how the visibility graph for each part will change. Figure 16 below shows the separation of the right and left parts in Variant B.

Analysis of the visibility diagram of Part I (Fig.16) and Parts II and III (Fig.17) shows a significant weakening of the accessibility of the corridor leading from Part I to Part II of the building. The analysis of Part III (Fig. 16) shows a strengthening of the accessibility of the corridor serving the administrative part, which is not advisable in the context of finding patient access routes to the various spaces of the oncology institute. Visual step depth analyses

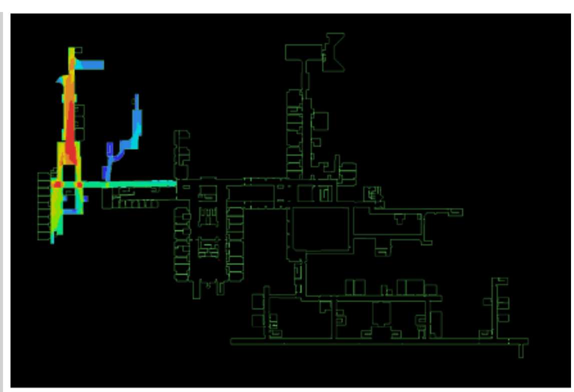

Figure 17.
VGA analysis for variant B in model 1 – part I. Connectivity parameter (min. 26 – max. 1635)

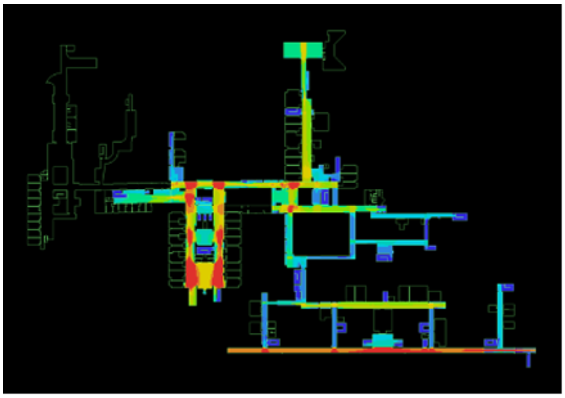

Figure 18.
VGA analysis for variant B in model 1 – part II and III. Connectivity parameter (min. 15 – max. 1605)

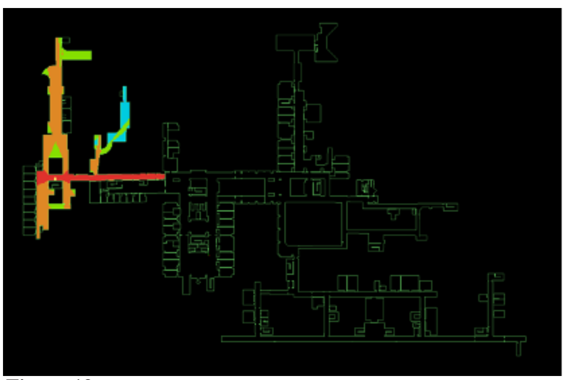

Figure 19.
Visual step depth for variant B – part I

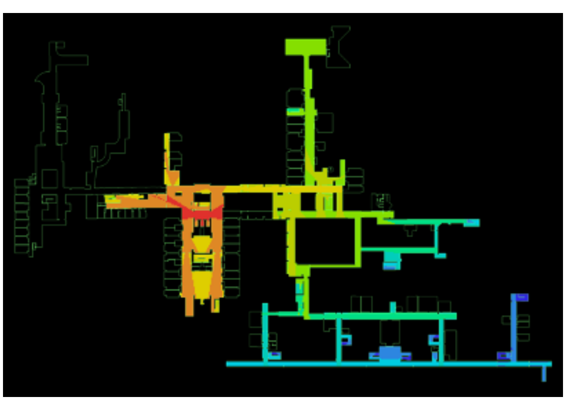

Figure 20.
Visual step depth for variant B – part II and III

(Fig. 18 and Fig. 19) also show that closing the passage between Parts I and II and III will disrupt the logical process of finding passage in both parts. For Part I, the red isovist with a depth of 1 (from the exit point of the staircase) does not lead to the offices but only indicates a corridor, which in this case loses its value. In Parts II and III, the orange isovist actually covers only the passageways in Part II without leading to Part III. Such a change would disrupt the logic of wayfinding between Parts II and III. The analyses carried out allow for a more accurate assessment of the possible consequences of the spatial changes made to the building.

4. DISCUSSION

In assessing the behavioural quality of the space, the role of factors related to the perception of the visual identity system was pointed out, which was used in the development of research criteria for the patient research stage. These included: Visibility of visual identification system, Legibility of the signage system, Characteristic signs in the circular area. Analogous to the criteria identified in the research condition, the importance of stress level, difficulty in finding their way and uncertainty in moving around were pointed out as crucial factors for patients' orientation in space. On the other hand, analysis of the location of directional signage was possible in both qualitative research and Space Syntax, based on VGA analysis. The use of the Space Syntax method provided the opportunity for mathematical analysis of space with simultaneous variation of functional changes. This allowed us to analyse possible directions of functional changes and location of key functions. On the other hand, this method did not allow to evaluate the accessibility aspects of communication layout of the building (lack of variants of routes taking into account the change of floors). The research assumed a focus on patient needs and capabilities as a key starting point. This translated into combining qualitative research techniques to record user perception and behaviour with syntactic analyses to map accessibility and linkages of key functions. This provided the basis for formulating design guidelines for the visual identity system strategy for the buildings of the Institute of Oncology in Gliwice. The presented Space Syntax analyses shows that:

- To make it easier to find the paths of access routes to the individual spaces of the National Institute of Oncology in Gliwice, the spatial accessibility of the corridor connecting all parts of the building should be strengthened by closing an alternative route leading from space II to space III.
- separating parts of the floor covering functions that could theoretically operate independently (space I from spaces II and III) will negatively influence the ease of finding the main corridor and the route from space II to space III.
- With the separation of part I from parts II and III,

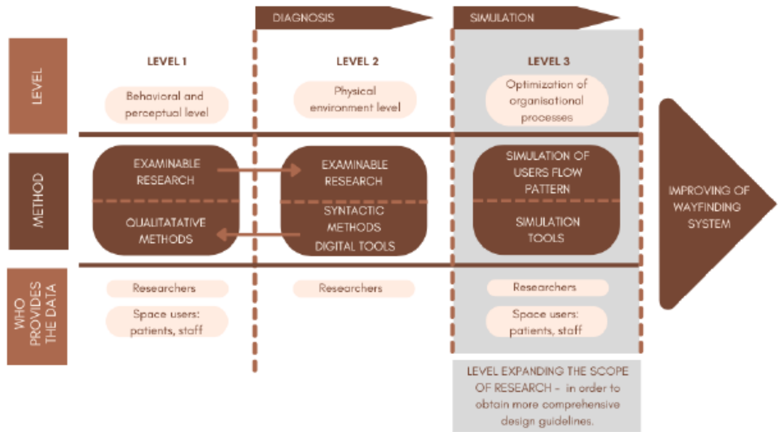

Figure 21.
A diagram of the process of examining the space of complex buildings in terms of wayfinding systems

Table 4.
The identified key issues for planning the research on wayfinding systems in hospitals

Main architectural components of wayfinding system	Exploratory walks Detected results	Space Syntax Detected results	Complementary simulation method
legibility of the communication layout	*	*	*
Characteristic elements in the space (landmarks)	*		*
Visual accessibility of the destination/ decision point	*	*	*
Zoning of the functional areas in the building, difference in areas and buildings at the site		*	*
Visibility of visual identification system	*		*
Legibility of the signage system	*		*
Number of changes in direction along each route		*	*
Overloading of distractors and obscuring elements	*		*
Characteristic points and functions in the circular area	*		*

the accessibility of the administrative part in the old oncology will be reinforced (which is not advisable in view of the objective of improving the accessibility of other spaces).

The following diagram (Fig. 21) presents a proposal for a model process for analysing complex buildings in terms of wayfinding. It takes into account both the course of the various phases of the research and the possibility of using this process in didactics for architecture majors. Although the process takes into account analytical and simulation methods using digital tools (Level 2), the key starting point is the diagnosis of the building's problems in the context of user perception (Level 1). The full conception of an effective research process requires the use of simulation tools (Level 3) to test user flow. The Table 4 illustrates the results detected using individual research tools and techniques.

5. SUMMARY

The proposed method for examining complex buildings focuses on conducting multicriteria analyses of complex spaces in public utility buildings. It assumes, among other things, the use of the syntax of space in the presented method to obtain the legibility of the transportation system recognised by means of a mathematical model of space. The mathematical model makes it possible to study the existing or designed functional layout and the consequences of possible spatial changes. Syntactic parameters indicate the number of changes in the direction of movement in the system, which makes it possible to analyse its level of complication and test possible solutions to improve movement between designated points. The described method, which is used for pre-design research for a specific type of object, can be adapted and utilized for pre-design research for various types of objects. This can include different fields such as architecture, engineering, visual identification design, or scientific research.

Furthermore, the framework of the method serves as a valuable tool fostering skills in pre-design research, data analysis, users' behaviour interpretation, problem solving and decision-making across disciplines. Imparting the knowledge and ability to use modern simulation techniques to understand the relationship between space and the users' behaviour and processes in it is crucial in view of the need to improve the quality of the products offered, which are buildings and urban spaces. The construction principle of the method is shown in a diagram (Fig. 21), which allows the tool to be applied to other types of complex public buildings. The scheme of the developed method indicates the possibility of moving at level three to the stage of simulations based on data collected in earlier phases. Once the problem has been diagnosed, the tools available to researchers allow, in successive iterations, to test in the form of simulations the behaviour of users of space, divided into groups of customer and service providers. The goal is to optimise not only the accessibility of the space but also the distances and relationships between key functional zones. Level 3 activity will be performed based on the analysis of processes carried out over time and based on available human, equipment and spatial resources. The goal is to increase patient/customer satisfaction (LoS) and rationalise organizational activities.

A key element is flexibility and the ability to tailor the method to specific needs and contexts. By identifying core concepts and processes and adapting them to different thematic areas, it is possible to utilize this method in a wide range of research applications.

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REFERENCES

[1] Morag, I., Heylighen, A., & Pintelon, L. (2016). Evaluating the inclusivity of hospital wayfinding systems for people with diverse needs and abilities. *Journal of health services research & policy, 21*(4), 243–248. https://doi.org/10.1177/1355819616642257

[2] Apelt, R., Crawford, J., & Hogan, D. (2007). Wayfinding System Audit, Copyright 2007 Icon.Net Pty Ltd.

[3] NHS. Effective wayfinding and signing systems guidance for healthcare facilities. (2005). London.

[4] Harper, C.A., Duke, T., Avera, A., Crosser, A., Jefferies, S., & Klisans, D.V. (2020). Exploring Hospital Wayfinding Systems: Design Guidelines for Wayfinding Interfaces. International Conference on Applied Human Factors and Ergonomics.

[5] Ahmed, S., Muhammad, I. B., Isa, A. A., & Sani, M. A. (2020). Influence of spatial layout on wayfinding behaviour in hospital environment in Nigeria. *Journal of Art, Architecture and Built Environment, 3*(1), 26–44.

[6] Ford, P., Fisher, J., Paxman-Clarke, L., & Minichiello, M. (2020). Effective wayfinding adaptation in an older National Health Service hospital in the United Kingdom: insights from mobile eye-tracking. *Design for Health, 4*(1), 105-121.

[7] Bubric, K., Harvey, G., & Pitamber, T.,(2021). A user-centered approach to evaluating wayfinding systems in healthcare. *HERD: Health Environments Research & Design Journal, 14*(1), 19-30.

[8] Peponis, J. Zimring, C. Choi, Y. (1990). Finding the building in wayfinding. *Environment and Behavior 22*(5), 555–590.

[9] O'Neill M. (1991). Effects of signage and floor plan configuration on wayfinding accuracy. *Environment and Behavior* 23, 553–574.

[10] Penn, A. (2003). Space Syntax and spatial cognition: or why the axial line? *Environment and behavior, 35*(1), 30-65.

[11] Ford, P., Fisher, J., Paxman-Clarke, L., & Minichiello, M. (2020). Effective wayfinding adaptation in an older National Health Service hospital in the United Kingdom: insights from mobile eye-tracking. *Design for Health, 4*(1), 105-121.

[12] Sadek A.H., McCuskey Shepley M. (2016). Space Syntax Analysis: Tools for Augmenting the Precision of Healthcare Facility Spatial Analysis. *Health Environments Research & Design Journal 2016, 10*(1), 114-129. DOI: 10.1177/1937586715624225

[13] Hedhoudh, A., Cherif, F., Bouguetitiche A. (2015). Wayfinding in unfamiliar environment based on Space Syntax. URL: https://www.researchgate.net/publication/263799663_Wayfinding_based_on_space_syntaxacces (visited on 05/01/2024).

[14] Greene, M., Reyes, J., Castro, A. (2012). (EDIT) Proceedings of the 8th International Space Syntax Symposium, Santiago de Chile, Chile.

[15] Emo, B., Hoelscher, C., Wiener, J., & Dalton, R. (2012). Wayfinding and spatial configuration: evidence from street corners. Proceedings: Eighth International Space Syntax Symposium, Santiago de Chile, Chile.

[16] Hölscher, C., Brösamle, M., & Vrachliotis, G. (2012). Challenges in Multilevel Wayfinding: A Case Study with the Space Syntax Technique. *Environment and Planning B: Planning and Design, 39*(1), 63–82.

[17] Peyvastehgar, Y., Heidari, A. A., Kiaee, M., & Kiaee, M. (2017). Wayfinding process analysis using Space Syntax in the Museum of Contemporary Art. *Hoviatshahr, 11*(2), 43–52.

[18] Chen, M.-S.; Ko, Y.-T.; Hsieh, W.-C. (2021). Exploring the Planning and Configuration of the Hospital Wayfinding System by Space Syntax: A Case Study of Cheng Ching Hospital, Chung Kang Branch in Taiwan. *ISPRS Int. J. Geo-Inf*., 10, 570.

[19] Geng, S., Chau, H., Yan, S., Zhang, W., & Zhang, C. (2020). Comparative analysis of hospital environments in Australia and China using the Space Syntax approach.

[20] Sari, D.P., and Alhamdani, M. R., (2021). Spatial and behavior analysis for improving the Siantan Hilir health center into a Type-D Hospital. IOP Conference Series: Earth Environmental Science. 780 (012055), DOI 10.1088/1755-1315/780/1/012055.

[21] Jamshidi, S., Parker, J. S., Hashemi, S. (2020).The effects of environmental factors on the patient outcomes in hospital environments: A review of literature, *Frontiers of Architectural Research, 9*(2), 249–263. https://doi.org/10.1016/j.foar.2019.10.001.

[22] Koch D., Legeby A. (2022). Equal living environments: Universal design and (un)equal access from a syntactic perspective, Uppsala, Sweden. *Proceedings 13th International Space Syntax Symposium*, 466,1–26.

[23] UCL Depthmap 7: Basic Usage (https://archtech.gr/varoudis/depthmapX/LearningMaterial/depthmapbasics.pdf)

[24] Turner, A. (2001). Depthmap: A Program to Perform Visibility Graph Analysis. Proceedings of the 3rd International Symposium on Space Syntax, p.9. URL: http://www.ucl.ac.uk/bartlett/3sss/papers_pdf/31_turner.pdf.

[25] Benedikt, M. L. (1979). To Take Hold of Space: Isovists and Isovist Fields. *Environment and Planning B: Urban Analytics and City Science 6*(1), 47–65. ISSN: 0265-8135. DOI: 10.1068/b060047.

[26] Koutsolampros, P. et al. (2017). Big Data and Workplace Micro-Behaviours: A Closer Inspection of the Social Behaviour of Eating and Interacting. Proceedings of the 11th International Space Syntax Symposium, 11, 149–1.

[27] Dettlaff, W. (2014). Space Syntax analysis – methodology of understanding the space. PhD Interdisciplinary Journal. URL: https://tiny.pl/cbzsh (visited on 22.01.2024).