IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Review of the Fundamentals of Wayfinding and Circulation Principles for a Hospital Design in Nigeria

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Abstract : Pathways can be conceived as the perceptual thread linking spaces of a building or series of interior and exterior spaces relative to where we are, and where we anticipate going. Studies have shown significant relationship between circulation and the ease of wayfinding, especially in hospitals. This paper reviewed the fundamental ideas associated with the wayfinding process and formally linking them with circulation configurations in buildings. It further presented the layers of circulation that define the paths of movement in buildings as essential elements notable in architectural design which can improve wayfinding performance. This is followed by a review of potential concepts that enable accessibility and spatial circulation effectiveness derivable from theories of axial space, convex space and isovist fields. These theories were eventually applied in the conceptual design of the Baze University hospital (BUH) in Nigeria. An analysis of the BUH circulation system using visibility graphs showed the significance of larger carriage pathways for better visibility fields in indoor wayfinding. The significance of this study is the application of fundamental architectural principles in the Hospital circulation design process.

***Keywords* - Wayfinding design, wayfinding principles, circulation design, circulation configuration, circulation efficiency, hospital circulation design**

1. INTRODUCTION

Wayfinding can be defined as a process of identifying locations and navigating to destination using spatial and environmental information. This definition is synonymous with such statements as 'Every person acquainted with an environment possesses a simplified cognitive structure of the environment' [1]. Likewise, it does not signify that there exists a region in the physical brain to which the entire environment is physically mapped, however it connotes that there will be a correspondence between the products of input and output behaviors relative to functions of cognitive exercise [2]. In the case of hospital environments, the idea of modern hospital building connotes an immense, highly sophisticated institution with diverse location points where care, treatments and administration are carried out. Studies indicates that excessively institutionalized environments in large medical centers are responsible for a number of negative effects on patients and users with resultant episodes like stress, anxiety, wayfinding difficulties and spatial disorientation, lack of cognitional control, and stress associated with inadequate access to nature. This created a rise of patient-centered and evidence based movements in healthcare planning and design, giving rise to the current quality of hospital physical environments [3]. The impacts of environmental organization on way-finding performance as well as user-cognitive representation of real-time spatial information are fundamental components of the spatial cognition process. According to Edward Tolman, 'every individual utilizes cognitive maps for wayfinding'. Cognitive maps are mental representations which are utilized to acquire, store, recall, code, and decode information about the relative locations and traits of phenomena in the environment [4]. In the book 'Image of the city', Lynch emphasized that images of spatial environments can be achieved only if they are configured as patterns of high continuity with a number of distinctive but interconnected parts, otherwise referred to as pathways [5]. Since Pathways are defined as routes to locations thence psychologically, recognition and navigation of pathways to destinations is vital element of the wayfinding process. Studies on the human cognition values suggest that the configuration process of any environment possesses significant cognitive consequences. More so, spatial configuration on its own could become constraints on spatial experience because its elements may improve or impede aspects of human activities through spatial cognition and behaviors [6]. The spatial configuration of every built environment influences the accuracy of cognitive representations of real world spatial information. Furthermore pathways or network structure used in our everyday spatial navigational behaviors eventually becomes critical elements of the image of a spatial environment [7].

In buildings however, patterns of circulation define the intrinsic systems for wayfinding. In order to understand the concept of wayfinding in hospital buildings, the process of circulation must be comprehended. Circulation in buildings occurs in layers, each

layer representing a significant process in the structure of way finding. Circulation in other words, can be defined as the ways and modes of flow through and within a building [8]. Buildings are not experienced statically but dynamically via circulation space; hence spatial layouts reflect the dynamics of motion. Following the ideals of the constructivist approach, circulation spaces can be seen not only as enablers but also as a product of movement.

In architectural terms on the other hand, circulation is defined as the ways people move and interact within buildings. It is common knowledge that humans by nature and behavior ultimately define their paths through spaces by way of choice and convenience. The natural human behavior in built up environments is often determined by the building form and layouts. Hence, as the form and space in buildings are distinguished according to the function and structure, so is the flow within the building. Subsequently, paths of human movement within buildings are actually the element that links different spaces together. In reality however, the occurrence of circulation in architectural design is a combination of the natural tendencies of people to flow in one direction or another. It is realistic to summarize then, that the fundamental principle of design is to guide flow patterns in Architecture towards achieving the course of navigation, orientation and wayfinding. Thus the interdependent interactions between the building itself and the people who move within it, creates the dynamic flow that is referred to as Circulation.

Spatial configuration in buildings influences human movement flows, which impacts on the behaviors of the users within the building space and the level of decisions they make. In the case of hospital designs, circulation and easy of wayfinding plays a significant role in defining the efficiency of hospital services [9]. Architects and designers of hospitals, employ different layouts and configurations for improving flow efficiency. Study shows that the quality of care and patient health has links with the physical attributes of the healthcare environment [10].

Significance of Study

This paper presents the fundamental principles of active wayfinding and contexts of circulation adoptable in hospital design, with the objective of identifying architectural design approaches for building circulation configurations channeled towards improving the wayfinding processes. In this study, the objective is to showcase the result of adopting fundamental theories on circulation design. Designers are often tasked with the challenge of producing functional spaces and the success of these tasks depends largely on the design implications. Therefore, this paper presents the basic principles for achieving circulation design in architecture. Firstly, it looked at the principles of movement, flow and circulation which affect indoor wayfinding. By identifying the significant layers of circulation, it utilized the identified elements in devising a design approach for Hospital building design. The eventual identified elements and layers of circulation were carried through the design process for the Baze university hospital (BUH) building.

2. BACKGROUND OF THE STUDY

The value of effective wayfinding and its function in buildings cannot be overemphasized. The ease of circulation within a building is associated to efficiency of functions. Review of hospital designs reveals that circulation and ease of wayfinding are associated with improvements in patient wellbeing as well as functional and administrative effectiveness. Likewise, for general building safety and post occupancy experiences, the values of wayfinding play key roles in problem solving experiences, be it associated with emergency evacuations, or with simple spatial orientation attitudes. The concept of wayfinding has been in existence with the contexts of spatial problem solving [11].

2.1 Wayfinding Principles

In building design, wayfinding performance can be formally linked with circulation configurations. Circulation efficiency often deals with the ability to navigate through different configurations of spaces with less difficulty. Successful wayfinding on the other hand, is said to have occurred when the navigator can make correct navigation decisions that take him or her from a present location to a destination that fulfills the intended purpose of movement [12,13]. The major principles that enable successful wayfinding can be defined as follows:

1. Location Distinctiveness
2. Landmarks and Orientation
3. Pathways or circulation configuration
4. Zoning (areas of different visual characters)
5. Signage with decision points
6. Sight lines for visibility

2.1.1 Location distinctiveness

This refers to an individual's sense of his setting's uniqueness. This unique attribute may be vital in empowering a psychological influence on users of a place [14]. Every location in an architectural space deserves distinctiveness. This has to do with place familiarity, which in turn aids in creating significant cognitive memory that essentially assists in wayfinding process. Location distinctiveness assists a place navigator answer the question "*WHERE AM I*?" Building designs as such present characteristic scenarios that enable users make distinctive judgments of their location with ease. By giving every location in a navigable space a unique perceptual identity, the navigator can associate the immediate surroundings with a location in the more universal space. This principle objectifies the element of wayfinding function by giving building designers the task of making landmarks of every space to some extent, by recreating a recognizable point of reference to the larger space.

2.1.2 Landmarks and Orientation

Landmarks are defined as feature used for navigation and to indicate a position. They are often the application of elements that stands out from the near environment and made visible from afar. More often than not, landmarks are used to provide orientation

cues and memorable identifiers for place cognition. In design application, a system of landmarks can be used to organize and define a general space, while serving as an Orientation symbol which assists a place navigator answer the question "*WHICH DIRECTION AM I FACING*?"

2.1.3 Pathways or circulation configuration

Pathways are regarded as distinct areas (carriageways) for movement and flow to and from destinations. The nature of circulation carriageways created by well-structured paths is a significant part of the wayfinding process. Different circulation configurations are applied for different building functions. Fundamentally, all paths of movements appear linear in nature. Equally, all paths emanate from a starting point, from which we navigate through a sequence of spaces to a destination. However, pathways can also be segmented or curvilinear in configuration, they can also intersect or branch out into other paths, or form a loop. In architectural design application, the type of configuration of a path influences and is impacted by the organizational pattern of the spaces it is made to link. The configuration of a path often reinforces a spatial organization by reiterating its pattern. It may also contrast with the form of the spatial organization and serve as a visual counterpoint to it. By so doing, users are able to cognitively decode the overall configuration of the paths in a building or their orientation within the building and eventually the understanding of its spatial layout. When a path cuts through a space, it creates possibility for flow and points of rest within the space. Equally, when a path terminates in a space, the path is established by the location of the space itself [15].

2.1.4 Zoning

This involves the creation of areas with different visual characteristics defined by distinctive features or functions and given unique identity. Appropriate zoning design together with building flow charts are significant elements generated by building designers during the design process, intended to guide both owners (administrators) and users (visitors) in navigating a building complex. Single zones or group of zones may be collected by a designer and assigned potential cognition identity. This may be by way of appropriate signage or orientation indicators positioned at visible locations with primary emphasis on differentiating functions in the larger/universal space. The use of directories (located at places like entrances and lift lobbies) can be employed to make identification and decision easier for visitors and other users.

2.1.5 Signage

Signages are utilized in buildings as a critical component of space identity and wayfinding process. They are often employed to announce the identity of a room, zone or bay and signify the destination point for navigators. Signs are usually, but not limited to door signs, corridor signs, entrance signs etc., designed with significant font types and setting created with consistency in order to maximize legibility. Some of the critical consideration adopted in signage design and location includes clarity of information, heights of placement for general visibility, consistency of graphical font types (typography), layouts, characters and symbols for vivid legibility and distances from nodes or circulation intersection points. Designers often employ the use of symbol related signage in public buildings in order to minimize lengthy information display. Symbolized signage can be Object related, Concept related or Abstract related [16].

2.1.6 Sight lines for visibility

A Sight line can be easily defined as an unobstructed line of sight (or view) extending from a viewer to an object of interest or a landscape in the distance. The sight lines provided in a building design or environmental landscape makes it possible for the viewer to see some object in the distance [17]. In architectural design, Sight lines are significant outcomes of circulation carriage configurations. A linear configuration will provide an unobstructed straight line of sight, while a curvy configuration will give several obstructions to direct visibility. In public Buildings like hospitals where stress-free navigation is required, the application of Linear (straight or direct) sightlines are vital for ease of navigation judgments by patients and other users. Sight lines are vital concepts in the context of wayfinding and circulation designs. The concept of sight lines can be subdivided into Vertical and Horizontal components. Both components are necessary in the process of place navigation and wayfinding. Visibility of distant horizontal destinations and landmarks or vertical objects like signage hanging from a ceiling or wall may become a good assistance to navigators if their sight lines are unimpeded

2.2 Circulation Principles

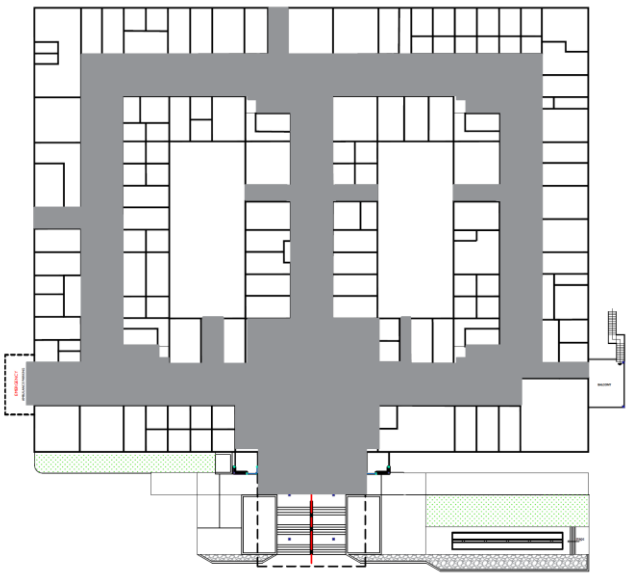
Building Circulation planning is a fundamental element in wayfinding performance. According to Le Corbusier, to experience an architectural space truthfully, it is essential to walk about and through the building itself. This literally suggests that building layouts and its organization are critical to the communication (circulation) interactivity within it [18]. Spatial configuration of architectural spaces and visual accessibility between locations within it, are fundamental factors that influence the ease of identifying paths within the building [19]. Likewise, spatial configuration and visibility is largely attributed to effective movement and wayfinding decisions [20]. Studies tend to suggest that building circulation types affect the ease or difficulty of wayfinding. In architectural practice, there is no finitely established circulation typology. While some studies suggest that simpler layouts improve way-finding cognitive process, others believe in the combination of patterns from various geometric rules or elements for navigation [21]. In the words of Passini (1996), "geometric forms have to be relatively simple in order to be effective in wayfinding. More so, interconnected buildings, are generally not understood as forms". A good form of a circulation system like simple geometrical forms as Squares, Cruciform or an L-shaped form aid in understanding the complexity of layouts, as soon as the cognitive response of a person recognizes or notices the specific shape as an underlying principle in the order of its configuration. This action in turn can inform and consequently support way-finding performance [11]. Studies on the perception of architectural spaces also recognize that building layouts and its organization can be fundamentally represented using information graphics. Most commonly adopted in graphical and mathematical representation and analysis of space is the Space syntax theory. In spatial studies, mathematical graphs are one of the most popular representations that allow for systemized spatial relationships [22]. Space syntax incorporates a set of theories and techniques used in the analysis of spatial configurations. This encompasses both exploration of the applications and extension of the analytical techniques and theoretical ideas associated with the syntactic analysis of architectural spaces. The major significance of Space syntax theory introduced by Bill Hillier (1996) is to provide a systematic and quantitative account of building configuration in order to support the understanding of how buildings

function. According to Bill Hillier, space must be translated into graphical measures. But in order to apply graph theoretic measures, the geometry of a space must firstly be read and translated into a pattern that supports the type of analysis to be performed [6]. This involves the formation of spatial networks that invokes syntactic properties of global and local systems with the aid of syntactic axial and convex maps. Space syntax applications involve three fundamental concepts that enable assessment of spatial circulation effectiveness.

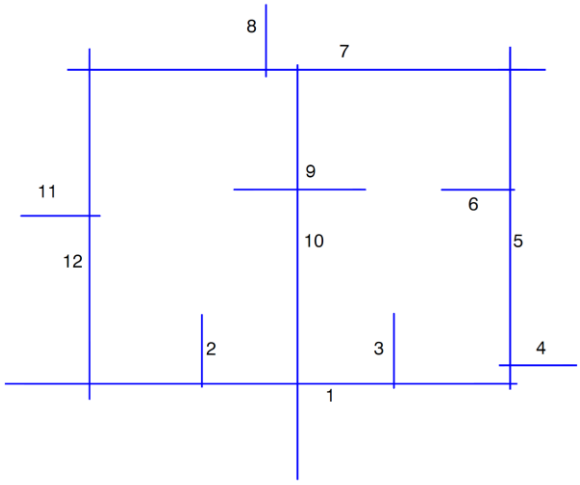
1. Axial line, which is mostly a straight sightline and possible path.
2. Convex space, which is an inhabitable void where (if imagined as a wireframe diagram), no line between two of its points goes outside its perimeter.
3. Isovists field referred to as viewsheds or visibility polygon. This is the field of view from any particular point in a space. The space syntax axial map, convex map, and visibility graph are related to the visual accessibility of the circulation layouts.

2.2.1 Axial Line

In architectural design, an axial line is the longest sightline indicating a movement path in a space within a building [23]. The axial map is built from unrestricted lines of sight, and the corresponding axial description of the building which consists of the fewest and longest lines of sight that pass through every configured space.



(a) Typical hospital floor plan

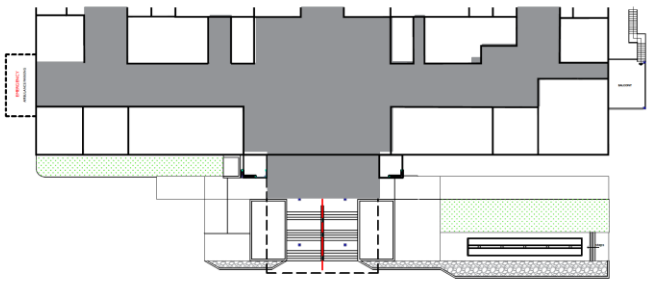


(b) Axial map of the hospital layout

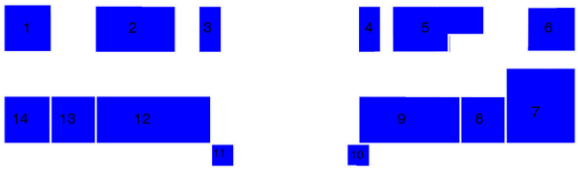
Figure 1. Baze university hospital building layout showing (a) Ground floor plan with shaded circulation pathways, (b) the axial map of the carriageways (corridors) configuration

2.2.2 Convex Space

The convex map consists of space as unconnected spatial units, with bounding polygon that contains internal corners without reflex angles. Consequently, all points within such a space are visible from all other associated spaces [23].



(a) Typical hospital floor plan

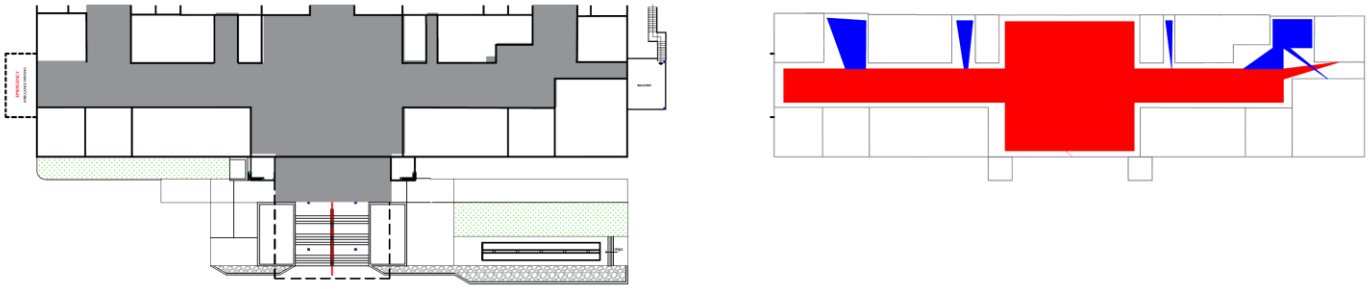


(b) Convex map

Figure 2. Baze university hospital layout showing (a) Ground floor plan, (b) the Convex map indicating the convex spaces.

2.2.3 Isovist field

An isovist field can be explained as a visual record of what can be seen in a 360-degree or a 180-degree view from a given point [24]. The isovist of sight generated through the Visibility graph analysis (VGA) imposes a grid of points on the layout of a building, thereby extracting visibility relationships between graphical points using each point as a node, while utilizing visibility as the connections that links all [25,26].



(a) Typical hospital floor plan (b) Isovist map

Figure 3. Baze university hospital layout showing (a) Ground floor plan, (b) the Isovist map indicating field of views in carriageways (corridors)

3. Application of the fundamental principles of Wayfinding and Circulation in developing the Baze University Hospital design

Fundamentally, our normal experience of buildings is affected by the way in which spaces within are connected to each other. The changes of direction imposed by the circulation system, the creation of room sequences, the distribution of branching points, the availability of alternative routes, and the relations of visibility between and across spaces all sum up the define the final configuration and the ease of wayfinding around the building [27].

The complexity of hospital circulation configuration is compounded by the variety of users/traffic (movements) with interweaving paths of flows. Volume of circulation activities in hospitals are determined primarily by the following category of traffic:

a. People
b. Material Supply and distribution
c. Ancillary Services

Table 1 below presents the groups of activities considered under these major traffic categories and the generalized frequency of flow within the Baze university hospital building. Hospital designers factor these activities in the design criteria for zoning and positioning of functions, as accessibility, connectivity and safety considerations must be met in ensuring the provision of efficient logistics systems.

Table 1. Generalized flow frequency of various activity groups in hospital buildings

PEOPLE MOVEMENT		MATERIALS/DISTRIBUTION		ANCILLARY SERVICES	
Patients	■	Medicine	■	Evacuation	■
Caregivers	■	Supplies	■	Emergency	■
Visitors	■	Equipment	■	Catering	■
Administrative staff	■	Accessories	■	Maintenance	■
Service staff	■			Teaching and academics	■
Medical/Diagnostic staff	■			Financial	■
Cleaning staff	■			Nursery	■
				Shopping	■
				Religious	■
Traffic Frequency:		High ■	Medium ■	Low ■	

Out of the categories mentioned above, it is understandable that the most critical flow category is the Patient flow category. Since hospital designers are often faced with the challenges of minimizing patient travel distances, the Baze university hospital layouts are configured to ensure the reduction of operational time, which impacts on the delays in patient care/patient flow. Studies identified that the most common circulation design layouts employed in modern hospital designs especially in the wards and patient care zones are the Linear and Radial configurations [3].

The development of an architectural project is often regarded as an extensive process, which must consider numerous factors that integrates the process of site utilization/layout planning and finally culminates in the completed building. More so, in the case of hospital designs, circulation configuration is paramount among the design considerations. For the design of the Baze university hospital, the author primarily considered the use of a circulation configuration concept that will impact the entire hospital layout which occupied a gross floor area of about 15,000m2. The proposed hospital is conceived as a 150 bed capacity health care facility that will function as a teaching hospital. Table 2 shows the functional zoning concept of the facility derived through the review of hospital accommodation and management requirements. The hospital design comprised of majorly Outpatient, Inpatient and Emergency service units that interface with the Clinical and Para-clinical departments. This table is critical in identifying the basic components that will form the individual convex spaces, their zoning principles and eventual configuration giving the spatial distribution and the flow patterns within.

Table 2. Functional zoning concept for the Baze university hospital design

OPD LEVEL (Outpatient Admin & services)	**IPD LEVEL (Inpatient Admin & services)**	**ACADEMIC**	**ADMIN.**	**GENERAL SERVICES**
Ground Floor	**First Floor**	**Ground/First Floors**	**Ground Floor**	**Basement Floor**
• Radiology and Diagnostics • Laboratories • Treatment • Emergency • Surgery • Medicine • Dental • Otolaryngology • Ophthalmology • Obs/Gynaecology • Paediatrics • Pharmacy	• Surgery and Orthopaedics • Anaesthetics • Patient care admin. • Surgical wards • Medical wards • ICU wards • Staff on call lodging	• Research • Teaching • Demonstration • Library • Virtual learning	• H.R. Management • Accounts • Records • Admissions • Patient services • Staff welfare • ICT services	• CSSD • Medical Gas process plant • Laundry • Kitchen • Water treatment • Stores • Utility services units • Security/access control • CCTV/monitoring • Morgue services

The spatial distribution and zoning concept presented in Table 2, represents the preliminary level of circulation planning and wayfinding principle for the BUH project. The process of connectivity and management of circulation/wayfinding is presented in Figure 4, showing the Circulation flow chart. This flow system demonstrates the conceptual idea for movements and interactivity within the hospital. The application of the principles of wayfinding like location distinctiveness, landmark and orientation, zoning, sightline application and circulation configuration formed component of the final layout produced.

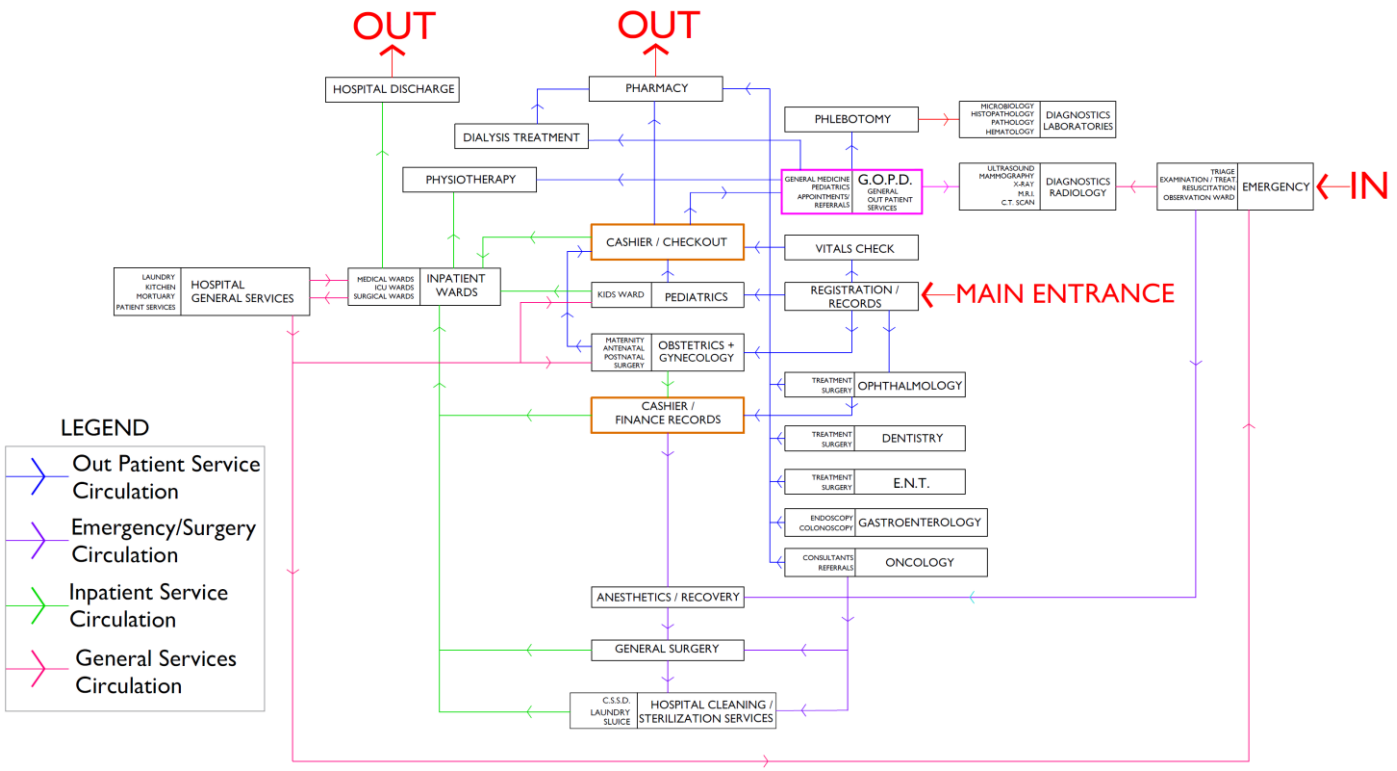


Figure 4. Baze University Hospital Flow Chart, showing major circulation paths

3.1 Organization of flow and wayfinding in the BUH design using circulation principles

In architectural theory, circulation in buildings is believed to transition in layers, each layer representing a significant process in the structure of wayfinding [15]. There are certain specific elements that make up the layers of building circulation, which can be listed as the approach to a building, the entrance, pathways and connectors and passage structure

3.1.1 Approach

The first layer of circulation and way-finding process begins with the "Approach". For the BUH design, the oblique or indirect approach was adopted as seen in Table 4. The impact of this type of approach, lies with the element of delay in reaching the building entrance, thereby permitting the visitor the chance to catch the views of the building from a distance. With this type of approach, the Entrance of the BUH is projected beyond the façade to enable clearer visibility as one approach the building. Visitors/patients coming by foot or car can easily view the parking area as well as the driveways leading to the entrance canopy and across the parking lot as shown in the BUH Site Plan in Table 4.

3.1.2 Entrance

Through the approach, one arrives at the second layer of circulation, which is the entrance level. In the BUH design, the entrance is treated as a preview of the form of space being entered, by the use of the centralized symmetrical balance of the projected entrance elements (Entrance Canopy) as shown in number 2 of the order of flow in Table 4. The main entrance hall (Registration Hall) is likewise centralized, providing a view to the left, right and center wings of the hospital which is furnished with signage for easy identification of destinations.

3.1.3 Pathway configuration

The Path configuration adopted in the BUH is the linear type. Since Straight paths are considered as primary organizing elements for series of spaces due to its proclivity to sightline, it thus represents the most basic form of way-finding and flow. The BUH design also utilized the Looped Corridor Layout for distribution of spaces and functions. The significance of the loop lies in the possibility of arriving at the starting point if lost, by simply walking in continuous line.

3.1.4 Path to Space Connectors

In order to achieve effective sightlines and visibility function, the design also adopted the fundamental straight path system for connection to spaces. Visitors/patients and staff will find easier link to activity points by simply passing through the paths (corridors) and identifying the connectors (doorways, etc.) as shown in Table 4. Rather than passing through functional spaces which may cause disruption in activities and congestion, the option of "Passing by Spaces" is utilized in order to isolate Flow from Activity points. By so doing, restrictions can easily be implemented and separation of staff zones, patient zones and visitor zones is achieved in the BUH design. Connections to activities on other floors via elevators and stairs are provided in the BUH by means of passing-by-circulation spaces (corridors) to the lift and staircase lobbies.

3.1.5 Form of Circulation system

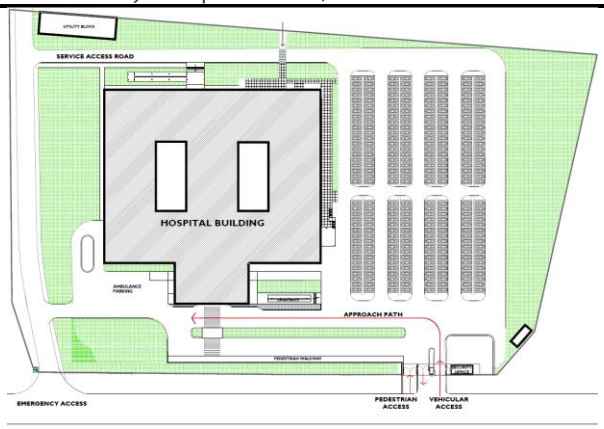
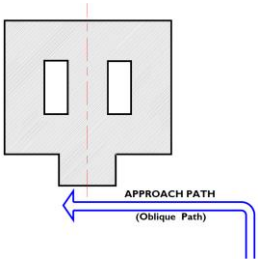
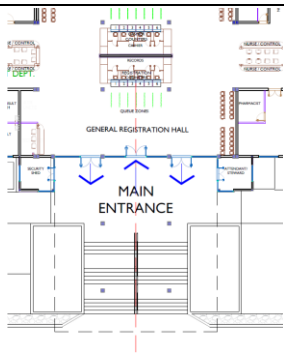
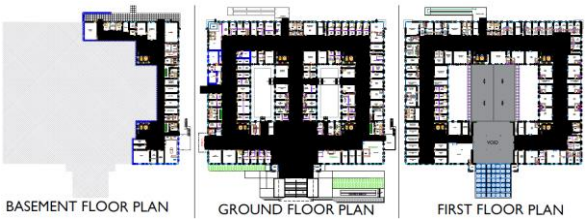
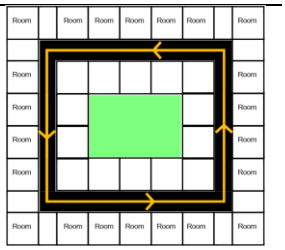
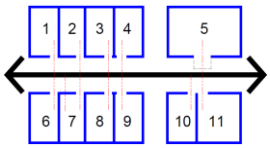
The configurations, location, shape and feature of the circulation element is significant in improving the ease in identification of destinations (wayfinding), flow of staff and visitors. In the design of the Primary circulation element, the BUH design adopted the

double loaded corridor as seen in Table 4. The circulation corridors are thus "Enclosed" at all ends as it travels across its looped form. The secondary circulation systems adopted in the design are stairs and elevators. Strategically located at the 4 corners of the square loop, the elevators and staircases are attached to each other, hence making it easy for identification via the wide corridors. Further classifications are given to the elevators in order of assignment to critical functions like movement from Emergency to Operating theatres to Radio-diagnostics or to the Morgue, Wards to Physiotherapy floor, Wards to Radio-diagnostics and Theatres/Treatment rooms to Central Sterilization unit etc. To further enhance flow in the hospital, the design adopted a wide-corridor-form. With an 8 meter wide corridor system, visibility and flow is enhanced, while congestion and obstruction of flows will be minimized. Figure 5 shows the typical ground floor plan of the BUH showing the size and form of the corridors.

Figure 5. Baze University Hospital Ground floor plan

Table 4. Layers of Circulation Elements in order of progression as adopted in the BUH for organization of flow and way-finding

ORDER OF FLOW	LAYERS OF CIRCULATION	BUH DESIGN OPTIONS

1st	**Approach**	 BUH SITE PLAN	 Path Option = Oblique
2nd	**Main Entrance**	 Entrance option = Projected + Centered along Plane of entry	
3rd	**Path Configuration**		 Path Configuration option = Linear Path with Looped corridor layout
4th	**Path-Space Connector**		 Path Space Connector option = Pass by spaces
5th	**Circulation Element**	 	 Circulation element type = Enclosed corridors (double loaded)

3.2 Analysis of way-finding performance of the BUH circulation system using visibility graph

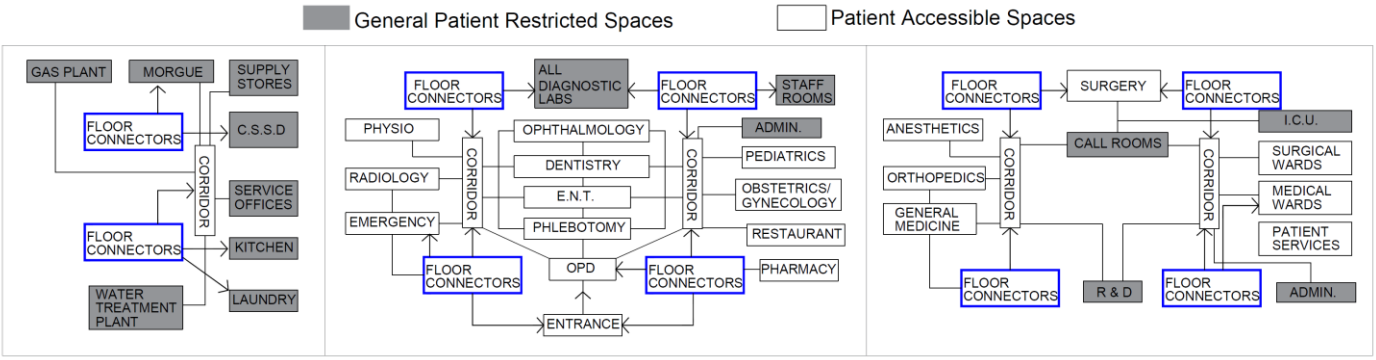
Wayfinding, is seen as a major design issue that deals with the potential spatial organization of a setting, the circulation system and the applied architectural and graphic communication. While the design layout and the circulation paths outline way finding challenges, applied architectural solutions and integrated graphic communication towards good visibility provide users with the information to solve these imposed problems [11]. The ease of wayfinding and circulation within a building contributes immensely to building efficiency and has both mental and psychological impacts on users especially patients as discussed earlier. This also affects productivity of operators who must function within the facility while traversing other functions and users. Curtailing these challenges entails adopting unsophisticated building forms, layouts and circulation elements that allow for

visibility of activity points. In the design of the Baze university hospital, a three phased circulation element is implemented for improving circulation and wayfinding:

a. In the first phase, the activities are set in a 3 level building unit with each floor/level operating as a separate functional zone as shown in Figure 6. The aim of the separation is to minimize the conflicts and interruption that occur owing to interweaving movements of the hospital users and hospital service personnel.

b. The second phase is the use of looped double loaded corridors as the major circulation element and architectural solution for ease of flow and effective way-finding. The sizes of the corridors are enlarged in the design, in order to improve the visibility factor in way-finding.

c. Thirdly is the location of secondary circulation elements, which are the Level connectors (Elevators and Stair cases) at visible intersections along the corridors for vertical flow across the floors.



(a) *(b)* *(c)*

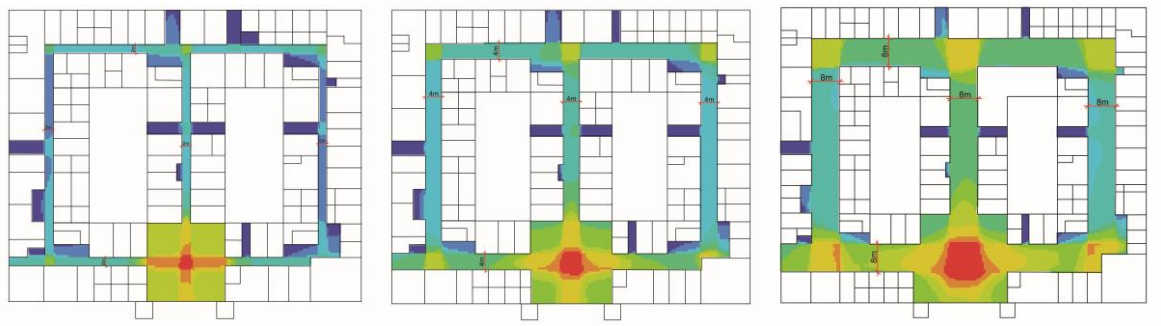
Figure 6. BUH functional and major activity-flow layouts. (a) Basement floor layout, (b) Ground floor layout, (c) First floor layout

Studies show that the first stage in the process of the wayfinding and movement is Visibility. Finding one's way around public buildings often proves to be exasperating, however this is made easier by the visual accessibility within and around buildings. Hölscher and Brösamle (2007), suggests that if large parts of a building is immediately visible with mutual intervisibility (or vistas) connecting the parts of the building, then people have to rely less on stored spatial knowledge and can rely on information directly available in their field of vision [21]. Calculations based on this impression expresses the connective structure of rooms and circulation areas in a building and these are strongly associated with route choices of hospital visitors, both in unguided exploration and in directed search based tasks relative to wayfinding behaviours [28].

To analyse the efficiency of the circulation system adopted in the BUH, a space syntax study using fundamental principles of circulation is performed. Visibility graphs are carried out in this study, in order to ascertain the wayfinding factor relative to visibility in the double loaded/looped system. The essence of this is to establish the impact of pathway configuration in wayfinding.

Visibility graphs are used to represent the spatial configuration. They are spatial representations based on isovists, often used to illustrate the visible areas around generating points in space occurring in 360 degrees. Visibility graphs work by overlaying a human-scale grid spacing on top of an architectural floor plan, then constructing an isovist from the centre of each pixel of the grid, and connecting every pixel to the pixels that can be seen within the isovist area, thus assigning values to every pixel. This graphical representation provides a description of space from the interior of the building. It also describes space from the point of view of users of a building, as they view, interact and move through it [29]. Considering the direct observation of users of circulation spaces, three sizes of circulation corridors were tested for the BUH double loaded/looped circulation design, in order to identify the best corridor width for efficient circulation flow and visibility. These sizes represent the most common carriage widths; they include the 2 meter, 4 meter and 8 meter corridor widths.

Using the software 'DepthmapX 20', visibility graphs were generate and analysed for the three sizes. Afterwards, the VGA (Visibility Graph Analysis) was constructed using solid walls modelled to represent what is visible in an open circulation corridor space. The result of the VGA graphs is shown in Figure 7, which displayed a visual colour scheme ranging from Red to Blue, where the more visible areas is highlighted in warmer colours and the less visible areas in cooler colours.



(a) *(b)* *(c)*

Figure 7. Comparison of the Visibility graph analysis of three different corridor widths considered in the design of the BUH double loaded/looped circulation corridor system.

(a) is the result of the VGA when a 2 meter wide corridor is used
(b) is the result of the VGA when a 4 meter wide corridor is used
(c) is the result of the VGA when an 8 meter wide corridor is used

From the visibility graphs presented above, the results agree with findings in Turner (2001), that design factor plays a huge role in determining the value of visibility in a circulation space [26]. The 2 meter wide system presents a lower visibility angle (illustrated by the darker cool colours) therefore making it more difficult for users to identify destinations or location nodes from a distance. The 4 meter wide corridors with brighter cool colours signify a much higher view-shed. However, the 8 meter wide corridors present the best visibility value, with warmer colours in display in the VGA. The BUH design thus adopted the 8 meter wide carriage pathways, where likewise supports a better visibility angle. The VGA analysis presents a corridor configuration with movement and flow that is dependent majorly on the openness/size of circulation spaces that healthcare workers traverse to get from one key zone to another, irrespective of the sizes of the patient service rooms. Likewise, it is also evident that the larger the sizes of the circulation area that links one major function to another, combined with the large view-shed angles on key paths it provides, then the higher the chances of running into another healthcare personnel along the circulation space and having an informal or quick conversation concerning patient information [29]. This in itself is a huge plus in the patient care service operations in large hospitals, as spaces with larger view-sheds allow for more interactivity among healthcare staff which in turn contribute to a productive workplace environment.

Through the studies conducted in the process of the design of the Baze university Hospital, the final design product presented intuitive approaches, which in implementation created a building that considered the challenges of user movement and activity flow in complex environments. To further improve the place identity aspect in the process of wayfinding and spatial cognitive experience, the option of colour coding is also adopted. In this case, significant activity zones are captioned by the colour of the doorways along major carriageways (circulation corridors) on every floor. Figure 8 below shows the colour schemes adopted in each significant zone in the BUH building.

Figure 8. The different colour schemes used on doors and entrances, differentiating the major activity areas in the BUH building. Blue in the Main outpatient zone, Green in the Main Inpatient wards, Orange in the Surgery and Operating theatres.

4. Conclusion

It is evident that wayfinding and circulation systems are essential components required in the building design process. In architectural design, the various factors that impact on these include accessibility, visibility and connectivity. These factors were discussed in this paper under the fundamental principles of wayfinding and circulation. Furthermore, the concepts of wayfinding design is outlined to factor the different layers of building circulation which includes elements like Approach, Entrance, Configuration of Path, Path-Space Relationship and Form of the Circulation Space. By adopting basic principles of location distinctiveness, zoning, application of suitable sightlines, landmarks and ideal carriageway configurations, ease of navigation is better achieved in the design process. This process has been explained as critical in the efficiency of services delivery in hospital building by achieving friendly environment for hospital visitors as well as reduction in the evacuation time in emergency services. Furthermore, by improving accessibility, visibility and people circulation in hospitals by means of effective pathways, factors such as staff performance and productivity can be improved coupled with enhancing patients' safety, privacy and rate of recovery. This paper presented the significance of the features of a Circulation space in the hospital design process using the Baze university hospital building design; it further demonstrated the importance of visibility in circulation zones and openness of flow spaces that hospital users and healthcare workers utilize to get across functional areas. Finally, these ideas can be adopted as a practical approach in layout configurations and designs with the aim of easing the challenges of wayfinding and flow in buildings.

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