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Research Article

Critical Design Factors for Wayfinding in Hospital Environment in Nigeria

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ABSTRACT: In the hospital environment, the complexity of the building configuration causes wayfinding difficulties for hospital users. This results in stress, anxiety, discomfort, loss of time, and missed appointments. This research establishes the critical factors that influence the ease of wayfinding in a hospital environment with consideration for the design systems. The study was carried out at Jos University Teaching Hospital, Plateau State, Nigeria. Also, a descriptive research design was employed with a survey questionnaire for data collection, administered on outpatients on a sample size of 96 respondents (48 males and 48 females), using a simple random sampling technique. Findings from factor analysis and multiple regressions showed that some factors have a high influence on the ease of wayfinding in the hospital environment concerning their loadings at significance value. These factors include landmarks, crowdedness in the circulation spaces, circulation intersection (nodes), and visual access. The study recommends that local landmarks should be designed to be visible from a distance at decision-making points in the hospital during wayfinding. Furthermore, circulation intersections (nodes or junctions) should be distinctive with directional signs and should have visible cues to reduce wayfinding errors at such decision points. This implies that spatial and visual factors should be considered in hospital wayfinding designs.

Keywords: *Critical factors, Hospital environment, Wayfinding, Wayfinding system designs.*

INTRODUCTION

Wayfinding involves moving from an origin to locate a destination utilizing the information in the environment (Mandel & Lemur, 2018). The navigation process involves the interconnection of decision-making, carrying out the decision (converting the decision into suitable behavior at the correct occasion and position), and meting out the information (Ekstrom et al., 2018). In a hospital environment, wayfinding is quite challenging for first-time users due to the complexity of the building configuration and evolving spaces in response to operational needs and change (Hughes et al., 2015). Furthermore, the evolved spaces are being regularly reconfigured, extended, and renamed, often resulting in a non-systematic layout, which results in confusing patients (Mustikawati et al., 2017). Consequently, people continue to get lost in such complex environments as patients may be required to find their way to multiple locations during a visit to hospitals (Morag et al., 2016). As such, patients undergo stress, anxiety, discomfort, loss of time, and missed appointments (Huelat, 2007). Therefore, this research aims to establish the factors that influence the ease of wayfinding performance in a hospital environment. The study is significant to priorities wayfinding factors in the presence of competing for architectural attributes for hospital designs.

MATERIALS AND METHODS

A descriptive survey research design was employed using a questionnaire survey as a research instrument in the data collection. The hospital has an average daily population of 129 at the general out-patients' department (GOPDs) as obtained from the Records and Information unit of the hospital. Consequently, the sample size of 96 was used as obtained in the sample size Table of Bartlett et al. (2001). The questionnaire survey was self-administered through the nurses as research assistants on a sample size of 96 respondents (48 males and 48 females) using a simple random sampling technique. Furthermore, the individual respondent was considered as a sample element. The scores on the questionnaire survey

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range from 1 to 4 (Strongly Disagree to Strongly Agree). The data obtained from the survey questionnaire was evaluated through the Statistical Package for the Social Sciences (SPSS) version 23. Also, users' demographic and more linked data were analyzed descriptively by computing the frequencies and percentages on gender, age in years (20-34; 35-49; 50-64; 65 and above), level of familiarity with the hospital, language, and the educational level attained (primary, secondary, graduate, and none).

Besides, inferential analysis such as factor analysis, and multiple regressions were carried out to establish the critical factors for wayfinding in Jos University Teaching Hospital, Jos. As such, a dependability test was performed via Cronbach's alpha to determine the adequacy of the items, to decrease the arbitrary basis of errors, and to ensure that the constructs used represent the wayfinding factor concept adopted in the study (McIver & Carmines, 1981; Nunnally & Bernstein, 1994). Furthermore, Principal Component Analysis (PCA) was utilized to decrease highly correlated factors. The extracted attributes were further subjected to multiple regression to assess how well the set of variables extracted from the factor analysis (Principal Component Analysis) was able to predict wayfinding performance design indicators.

Research Background

Contextualization of Wayfinding

The study of Dogu and Erkip (2000) in a shopping Mall in Turkey asserts that apart from signage, other spatial factors had no significant impacts on the wayfinding and orientation of individuals. However, the study did not establish the degree of influence the signage and other- spatial factors have on individuals' needs in the setting. Tom & Denis (2004) established that landmarks give vital data at position in a route where alterations in direction are probable to happen and add to making a visual model of crucial components of a setting in wayfinding. Similarly, Farr et al. (2012) suggest a model that integrates individual demographic features and spatial factors such as building arrangement, circulation paths as significant attributes that influence people considerably during navigation within structures. However, Farr et al. (2012) argued that there are limited studies that determine the factors that are most important in the multifaceted procedure of wayfinding.

Furthermore, the study of Mustikawati et al. (2017) in the hospital shows that legibility decreases in situations in which there are fewer environmental cues. However, not much is known on the number of cues that increase legibility and their extent of influence on wayfinding performance. Also, Mollerup (2009) revealed that the majority of the difficulties in wayfinding within healthcare facilities arise from environmental factors, owing to inadequate data, and architectural factors due to the design and numbering scheme. The study of Baskaya et al. (2004) recognized spatial differentiation as an architectural factor that affects wayfinding recital while spatial shape and configuration were identified by Anacta et al. (2017), Tzeng, & Huang (2009), and Pati et al. (2015). The paucity of knowledge and understanding of the degree of importance of these factors calls for further examination. Consequently, this study is focused on determining the degree of influence of factors that is significant in hospital wayfinding.

Getting lost in a hospital is an indication of a poor wayfinding system rather than inadequacy on the part of the Wayfinder (Baskaya et al., 2004). As such, designing wayfinding systems needs a strategy that allows people to use their abilities, which includes perception, language, knowledge, memory, and problem-solving competencies to successfully navigate from one location to another (Morag et al., 2016). Accordingly, successful wayfinding in an unfamiliar setting increases the users' comfort, safety, and satisfaction with the quality of the facility in the environment (Brunye et al., 2018). Besides, where there are competing attributes to consider in the design of hospital wayfinding systems, it becomes pertinent to determine the most important of these factors and prioritize them accordingly.

RESULTS AND DISCUSSIONS

Reliability Measure

Cronbach alpha method was utilized to compute the dependability of all items in the questionnaire. The measures are given below: Cronbach Alpha (Wayfinding performance)=0.751 (See Table 1). According to Paul (2013), similar reliability properties of the wayfinding scale of Cronbach's alpha were established to be 0.80 and 0.78 respectively. DeVellis (1991) affirmed that the reliability scores between 0.70 and 0.80 are deduced as good, while scores over 0.80 reflect extremely good dependability. The validity of the questionnaire was verified with the face validity technique and was established to be high.

However, the PCA was employed to decrease the factors. The PCA was to identify and reduce the factors underlying highly correlated variables. To ensure the appropriateness in the use of PCA, Kaiser-Meyer-Olkin (KMO), Bartlett's test of sphericity (BTS), and Scree Plot were used to identify significant correlations between items and sample adequacy respectively. Consequently, the Kaiser-Meyer-Olkin (KMO) had a value of 0.710, which was greater than the criterion of $\geq$ 0.6 (Pallant,

Table 1: Reliability statistics

Cronbach's Alpha	Cronbach's Alpha based on standardized items	No. of items
0.751	0.779	48

Table 2: KMO and Bartlett's Test for environmental factor

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.710
Bartlett's Test of Sphericity	Approx. Chi-Square	1064.665
	Df	153
	Sig.	.000

2011), and Bartlett's Test of Sphericity (BTS) which was statistically significant at 0.000 less than the p-value criterion of ≤ 0.05 (See Table 2). Therefore, factor analysis was apt for the information based on the result in Table 2.

Factor Analysis

The criteria for determining the number of parts to retain includes the combination of Eigenvalues greater than one, and break in the curve of the Scree plot. All significant associations were evaluated at alpha = 0.05. The spatial factor in wayfinding received a high Eigenvalue of 3.322 to 1.033 with a percentage of variance explained as 56.34 cumulative, seven statements were retained (See Table 3). This suggests that the seven components extracted were likely to be more appropriate to predict wayfinding. The rotated variable demonstrates a simple structure with relatively high factor loading on only one component and near-zero loading on the second component. The variables in the first component were on Lynch's (1960) 'image-ability' concept of wayfinding.

Furthermore, the architectural factor established a high Eigen Value of 2.827 to 1.028 with a percentage of variance explained as 58.87 in which six statements were retained. This suggests that the extracted and retained components were more strongly correlated and had a coefficient value above the criteria of 0.4 (See Table 3).

Subsequently, the wayfinding experience factor received

Table 3: Factor Analysis (PCA) of wayfinding performance

Factor No	Eigen Value ≥ 1	Factor Name	Variable no/Variable statement	% of Explained Variance	Loading
1	to 1.033 3.322	Spatial factor	B3 Important trees (Landmark)	56.34	0.854
			B4 Important shrubs (Landmark)		0.814
			B13Districts (Area)		0.753
			B12 Edges (path boundaries)		0.718
			B11 Path of circulation		0.610
			B10 Important building (Landmark)		0.589
			B14: Circulation junction (Nodes)		0.524
2	to 1.028 2.827	Arch. Factor	A6: Patients around the circulation space	58.87	0.812
			A12: Corridor intersection (nodes)		0.739
			A1: Visual access from the building entrance		0.655
			A13: Seats in circulation		0.591
			A2: Floor plan configuration		0.548
			A3: Circulation spaces		0.412
3	to 1.056 3.016	Wayfinding experience	W10: Directional signs at decision points,	63.68	0.866
			WF5: Stopped to read signs,		0.791
			WF8: Missed the way to destination		0.777
			WF13: Visible circulation paths		0.685
			WF11: Directional signs		0.586
			WF4: Stopped to ask for direction		0.533
			WF3: Difficulty in finding a way		0.468
			WF12: Destination signs,		0.429

a high Eigen Value of 3.016 to 1.056, with a percentage of Variance Explained as 63.678, eight statements were retained (See Table 3). Table 3 shows that eight items were retained with high factor loadings of Eigenvalue ≥1, which correlate weakly near-zero loading on the second component with a negative value and was used to confirm the rotated retained items.

Regression Analysis

The multiple regressions were used on the extracted variables from the Principal Component Analysis (PCA) to predict the most critical data for wayfinding performance. The analyses were separately carried out based on variables under each factor, such as spatial, architectural, and wayfinding experience factors.

Table 4 shows the relationship between spatial design factors and landmarks for wayfinding. The model indicated that R Square was 12.3% (R2 = 0.123), which was the percentage of the degree of the difference in the dependent variable explicated in the model for a spatial factor. Where B2 is the use of important buildings (landmarks) for finding a desired destination in the hospital. However, the R-squared was low, but the P-value of 0.000 (i.e. less than the threshold of 0.05) shows that the data fit well with the model (See Table 5).

Furthermore, the R-squared was low because it predicts human behavior, which is harder to predict than physical processes, but adding more data and calculating the effect size could improve the R-squared and provide a better fit for the model (Hoyt et al., 2006). Therefore, it suggests that irrespective of the R-squared value, the significant coefficients can embody the connotation of alteration in the response for a single unit of revision in the predictor. Accordingly, it suggests that the model was relatively a good predictor of the wayfinding performance (B2), the dependent variable (see Table 5). The model utilized for the regression has an excellent fit as specified in Table 5 (ANOVA) by F-value 7,366=7.36, which

Table 4: Model Summary for Spatial factor

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.351[a]	**.123**	.107	.787
a. Predictors: (Constant), B14, B4, B11, B10, B12, B3, B13 representing independent variables				
b. Dependent Variable: B2 (Building as landmark for wayfinding)				

Table 5: ANOVA for spatial factor

Model		Sum of Squares	Df	Mean Square	F	.Sig
1	Regression	31.882	7	4.555	**7.361**	**.000[b]**
	Residual	226.460	366	.619		
	Total	258.342	373			
a. Dependent Variable: B2 (Building as landmark for wayfinding)						

Table 6: Regression Coefficients [a] for spatial factor

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig
		B	Std. Error	Beta		
1	B2 (Constant)	1.157	.257		4.494	.000
	B3	.251	.056	**.254**	**4.499**	**.000**
	B4	-.011	.052	-.012	-.212	.832
	B10	.095	.063	.083	1.526	.128
	B11	.081	.062	.073	1.319	.188
	B12	.096	.059	.093	1.624	.105
	B13	.001	.066	.001	.017	.987
	B14	.109	.058	.102	1.864	.063
`a. Dependent Variable: B2 (Building as landmark for wayfinding)						

is significant at 0%, sig. value p = 0.000, less than the threshold of P-value of 0.05. The outcome suggests that the regression shows a highly significant relationship and predictability of the model for wayfinding performance to determine the weight of every unit and factor of wayfinding, a reference is made to the regression coefficients using the standard beta coefficients, constant, t, and significant value. The coefficient for spatial factor in Table 6 shows that with the column labelled 'B' was the value of the dependent variable, B2 = 1.157, Std error estimates = 0.257, t = 4.494, Sign. 0.000. In the final model, as shown in the coefficient Table 6, only one variable made a unique statistically significant contribution less than 0.05 in the spatial factor for wayfinding, which was B3. This variable was stated in the order of Sig. (p-value) and the beta values, such as B3 = ($p < 0.000$, $\beta = 0.254$). The standardized (beta) value was used for the application. Where B3 = Use of trees to identify direction. Therefore, the model obtains the form of a numerical equation where: $Y = \beta0 + \beta1B3$. Thus, Y symbolizes the result variable; wayfinding performance with the use of landmark, B3 represents the predictor variable. The implication of the result is that landmarks such as important trees could be used to identify direction are a major design factor influencing wayfinding in the study area.

The model summary for the architectural factor in Table 7 shows that R Square was 16.5% (R2 = 0.165), which was the percentage of the extent of the difference in the dependent variable clarified in the model.

The model employed came up with a good fit for the regression as indicated in Table 8 (ANOVA) by F-value 14.492 = 14.49, which is significant at 0%, sig. value p = 0.000, less than the threshold of P-value of 0.05. The result suggests that the regression shows the goodness of fit of the model to the data, indicative of an elevated inevitability of the model for wayfinding performance.

The coefficient Table 9 shows the value of the dependent variable, A2 = 0.737, Std error estimates = 0.231, t = 3.195, Sign. 0.002.

In the final model, only four variables made a unique statistically significant contribution less than 0.05 in the architectural factor for wayfinding, which was A1, A3, A6,

Table 7: Model Summaryb for architectural factor (Source: SPSS version 23 software, 2020)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.406^a	.165	.153	.715

a. Predictors: (Constant), A13, A6, A3, A1, A12

b. Dependent Variable: A2 (Floor plan configuration)

Table 8: ANOVAa for architectural factor (Source: SPSS version 23 software, 2020)

	Model	Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	37.082	5	7.416	14.492	.000b
	Residual	188.322	368	.512		
	Total	225.404	373			

a. Dependent Variable: A2

b. Predictors: (Constant), A13, A6, A3, A1, A12

Table 9: Coefficients a for architectural factor (Source: SPSS version 23 software, 2020)

Model	Unstandardised Coefficients		Standardised Coefficients		
	B	Std. Error	Beta	t	Sig
(Constant)	.737	.231		3.195	.002
A1	.219	.048	**.228**	4.569	**.000**
A3	.222	.050	**.219**	4.480	**.000**
A6	.087	.044	**.100**	2.002	**.046**
A12	.110	.043	**.128**	2.553	**.011**
A13	.055	.048	.052	1.058	.291

and A12. These variables were stated in order of Sig. value (P-value) and the beta values from the standardized (beta) value, such as A1 = ($p < 0.000$, $\beta 1 = 0.228$), A3 = 0.000; $\beta 2 = 0.219$; A6 = ($p < 0.046$, $\beta 3 = 0.100$), and A12 = 0.011; $\beta 4 = 0.128$ as shown in Table 9. The result implies that visual accessibility of building entrance, good circulation network, crowdedness in the circulation space, and junctions (nodes) in the pathways are major factors influencing wayfinding in the study area. Where, A1 was the easy identification of building entrance in the hospital; A3, was easy direction finding in the circulation space (pathways); A6, was that too many patients (crowd) around the circulation space disturb the ease of wayfinding; and A12, states that corridor intersection makes wayfinding difficult in the hospital (nodes). Therefore, the model gets the shape of a numerical equation, where: $Y = \beta 0 + \beta 1A1 + \beta 2A3 + \beta 3A6 + \beta 4A12$. Thus, Y symbolizes the result variable, floor plan configuration to execute wayfinding in the hospital.

In Table 10, the model indicated that R Square was 2.8% (R2 = 0.028), which was the percentage of variance explained in the model and shows a weak relationship. The model utilised for the regression has a good fit as shown in Table 11 (ANOVA) by F-value 1.33 and 0.226 = 0.23.

As a result of the significant value of 0.23, this is above the threshold (i.e. $P \leq 0.05$). This suggests that the predictors, the independent variables, in the model were relatively are bad predictors of the wayfinding performance of the dependent variable (WF2). Where WF 2 was to get lost on the way to the desired destination in the hospital. To establish the weight of every component of wayfinding in the factors, also, reference is made to regression coefficients using the standard beta coefficients, constant, t, and significant P-value.

The coefficient for wayfinding experience factor in Table 12 shows that on the dependent variable WF2, B value = 3.226, Std error estimates = 0.284, t = 11.377, Sign. 0.000. In the final model, only two (2) variables created a distinctive statistically important input to the forecast of the dependent variable, this

Table 10: Model Summaryb for wayfinding experience factor (Source: SPSS version 23 software, 2020)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.168[a]	.028	.007	.801

a. Predictors: (Constant), WF13, WF8, WF12, WF3, WF4, WF5, WF10, WF11
b. Dependent Variable: WF2

Table 11: ANOVAa for wayfinding experience factor (Source: SPSS version 23 software, 2020)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.839	8	.855	**1.333**	**.226[b]**
	Residual	234.094	365	.641		
	Total	240.933	373			

Table 12: Coefficients a for wayfinding experience factor (Source: SPSS version 23 software, 2020)

Model	Unstandardised Coefficients		Standardised Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	3.226	.284		11.377	.000
WF3	-.117	.049	**-.139**	**-2.368**	**.018**
WF4	.099	.048	**.119**	**2.048**	**.041**
WF5	.027	.053	.031	.514	.607
WF8	-.012	.043	-.015	-.268	.789
WF10	-.001	.049	-.001	-.011	.991
WF11	-.079	.053	-.094	-1.493	.136
WF12	.013	.048	.016	.279	.780
WF13	-.022	.049	-.026	-.442	.659

a. Dependent Variable: WF2

was less than 0.05 in the wayfinding experience factor for navigation performance. The result implies that wayfinding difficulty and stopping behavior during navigation are major design factors influencing wayfinding in the study area. Consequently, hospital design should be made simple in spatial configuration and circulation network.

The Table 12 (Coefficient) shows that the variables which were stated in order of importance of the beta value and the P-value, this includes: WF3 = ($p < 0.018$, $\beta = -0.139$), and WF4 = ($p < 0.041$, $\beta = 0.119$). The standardized (beta) values were used for application. Where, WF3 = having difficulty in finding the way in the hospital, WF4 = Stopped more than twice to ask for direction in the hospital. Therefore, the representation obtains the form of a mathematical equation where: Y (Getting lost during wayfinding) = $\beta 0 + \beta 1 WF3 + \beta 2 WF4$. Thus, Y symbolizes getting lost during wayfinding.

Accordingly, the established decisive factors for wayfinding in the hospitals obtained from the analysis based on their factor loadings and significance values show the significant relationship and predictability with wayfinding designs. These are highlighted as follows: B3 is the use of trees as landmarks to recognize the direction in wayfinding, (0.854; sig value = 0.000); A6 is crowd in the circulation space disturbs wayfinding (0.812; sig value = 0.046); A12 is the corridor intersection (nodes) makes wayfinding difficult in the hospital (0.739; sig value = 0.011); and A1 is Visual accessibility of the building entrance (0.655; sig value = 0.000) ; A3 is easy direction-finding in circulation spaces (0.412; sig value, $p = 0.000$); WF3 is having difficulty in finding the way in the hospital (0.468; $p < 0.018$); WF4 is stopped more than twice to ask for direction in the hospital (0.533; $p < 0.041$). These established attributes can be classified into spatial (A12-nodes, A3-Easy circulation spaces, WF-finding direction, WF4-stopping behavior) and visual (B3-Landmarks, 6-Crowd in circulation, A1-Visual accessibility) factors.

CONCLUSION

The study was conducted towards determining the critical factors for effective wayfinding that could be prioritized among competing attributes in hospital design in Nigeria. The study revealed that spatial and visual factors such as landmarks, circulation spaces, crowdedness, junctions (nodes), and visual access greatly influence wayfinding. Additionally, the complexity of the building layout which caused difficulty in wayfinding and stopping behavior equally significantly controls wayfinding in the hospital environment. This research mirrors the eminent extent of connection among the established critical factors and wayfinding performance in the hospital. This implies that there should be well-designed and precise directional circulation spaces with large waiting areas in hospitals to avoid patients following the crowd to wrong destinations particularly at emergencies and GOPD's. Accordingly, wayfinding design should incorporate spatial with visual factors to enable the new hospital users to reach destinations in a safe, comfortable, effective, efficient, and satisfactory manner. The study recommends that local landmarks should be designed to be visible from a distance at decision-making points in the hospital during wayfinding. Furthermore, circulation junctions should be distinctive with directional signs and should have visible cues to reduce wayfinding errors at such decision points. This suggests that the design professionals should consider the critical spatial and visual factors established in the study for hospital wayfinding designs.

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