Understanding the relationship between user preference and spatial layout

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Article Information	ABSTRACT
  AISSMS IOIT RESEARCH **International Journal of TEAMS**	Hospital buildings are one of the most avoided buildings especially if you have to spend a night there. Even if it is very well designed and functions well, it might be a distressing experience for the users themselves. The time spent may vary but for longer duration stays the comfort with space definitely matters. Wards are one of the most occupied areas of the hospitals by the patients would be the wards. These wards are shared by the nurse's, the patients and also the occasional visitors. Considering this, there is always an underlying factor of encroaching the bed space privacy of any individual. There is a connection between the spaces and its occupants. This research aims to understand this connection and find out what influences this connection. The basic purpose of doing this study was to understand the individual preference of beds in wards and correlate that with the location of the bed. The research attempted to identify the preferences of the users in different existing ward layouts from a selected hospital. The study involves a two-fold methodological approach, one was using the Space Syntax theory to understand the layouts of the wards and the second was to analyse the end user preferences by conducting a questionnaire survey. The findings have then been analysed to understand the relationship between the end user's preferences and ward layouts.

KEYWORDS: hospitals; space syntax; user preference; spatial analysis

1. INTRODUCTION

Hospital Buildings have always been a very important part of any community's well-being. From taking care of the daily flu to seeing someone recover over a few months. These buildings have seen it all with the community. Over the years, the healthcare design has evolved just as much as the end users who need them. The constant need to be updated and upgraded to the latest shenanigans of the world has something that has always been a part of the process. Along with all of this is a fact that individuals have worked very hard to make a life for themselves and their comfort. There are many people who prefer being in the middle of chaos. And there are some who like their own company. All of this can be overlooked when in a shared ward with multiple patients.

The same ward size can be used for a double occupancy or converted to a four bedded ward or even six bedded ward. In each case, the individual bed space is different and the way each individual perceives this space is also different. To understand this perception, it is necessary to talk with users who have experienced this before. There are visitor hours where one patient might get five visitors and then are the nurse's rounds. The nurses play a very important role in the hospital. Out of the entire staff which includes doctors, nurses, attendants etc., the nurses spend the maximum amount of time with the patients and also in the ward. That is the reason why whenever studying the circulation of wards in the hospitals, the nursing stations become very essential.

The nurses need to monitor the patients constantly, keep updated with their vitals, do their hourly rounds and also be near-by enough to reach on time in case of any emergency. For the nurses, clear visual of their patients and closest access Is important which means that every layout has a different approach. Space syntax is a theory that deals with the layouts of a building (Saif Haq, 2012). This theory has been used to understand the layout and its statistical measurements of individual wards.

The aim of the paper was to study existing hospital wards spatially and understand the user preferences of bed locations in wards.

The scope of the study was to explore and connect the spatial layouts with bed preferences in the context of existing wards in the Indian scenario. The limitation for this study was that it is only focused on the ward layouts in specific.

The objectives of the research study are to:

- To select the wards/ inpatient areas for study
- To understand the parameters of the study
- To understand the factors influencing bed preference
- To study the relationship between bed preferences and spatial layouts

2. LITERATURE REVIEWS

According to the space syntax website (Space Syntax network), "*Space syntax is a science based, human focused approach that investigates relationships between spatial layout and a range of social, economic and environmental phenomena. These phenomena include patterns of movement, awareness and interaction; density, land use and land value; urban growth and societal differentiation; safety and crime distribution*". (Space Syntax network, n.d.) Space Syntax was pioneered in the 1970's by Prof Bill Hillier, Prof Julienne Hanson and colleagues at The Bartlett, University College London.

Space syntax is not a relatively new theory. In the journal article by Saif Haq (2012), the team has discussed the various methods of applying this theory specifically to healthcare buildings. Prior to this research, there were very few papers talking about the use of space syntax in hospital buildings. So the paper by (Saif Haq, 2012) created a new area for research. In the same article, Saif Haq (2012), mentions that *"Most articles reported empirical research that used space syntax methods to quantify the environment as a set of predictor variables for a specific behaviour such as nurse's spatial positioning in medical-surgical units (MSU's) or visitor movement in the public areas of hospital."*

In the paper by Rosica Pachilova & Kerstin Sailer (2019), the main aim was to find out the connection between spatial layout of the hospital wards and time spent on fulfilling same duties in different layouts. The study was done to understand the working from Nurses point of view. The simplicity of the layout with a main corridor that served as a spine and connected all bays and functions increased the intelligibility of the ward function. Though the study focused more on the time spent by the nurses accessing the different spaces in different case studies, the circulation was a understood by the space syntax method. In another paper, the spatial spaces were analysed using visibility graphs to examine connectivity and visual depth mean (Petros Koutsolampros, 2018). It helped focus on the centrality of the plan. There is a theory called *Visibility affordance* which has been discussed and applied in the paper by Hadi Khatereh (2014). These were defined as the visibility relations created in space by design features regardless of human presence or activities. This is something we explore in this paper. The article by (Hadi Khatereh, 2014) focused on the architectural design enabling direct physical visibility.

According to the Space Syntax Glossary (Klarqvist, 1993), certain descriptions to understand are as follows:

"**Graph** is a figure representing the relationship of permeability between all the spaces of a layout. It is possible to also use links in order to represent relationships of visibility between spaces.

Axial Map depicts the least number of axial lines (straight line/sight line) covering all spaces of a layout and their connections.

Syntactic step is defined as the direct connection or permeable relation between a space and its immediate neighbours or between overlapping isovists. In an axial map a syntactic step may be understood as the change of direction from one line to another.

Isovist space is the total area that can be viewed from a point.

Depth between two paces is defined as the least number of syntactic steps in a graph that are needed to reach one from the other.

Connectivity measures the number of immediate neighbours that are directly connected to a space.

Integration describes the average depth of a space to all other spaces in the system. The space of a system can be ranked from the most integrated to the most segregated.

Intelligibility is the correlation between connectivity and integration and describes how far the depth of a space from the layout as a whole can be inferred from the number of its direct connections."

Introduction of the Space Syntax theory is not possible without mentioning the main scientist who has had a great contribution in the development of the theory. Patrick Alasdair Fionn Turner (Alasdair Turner) did research into introducing a dynamic model that derives aggregate spatial analysis from the visual affordances of the built environment. He has also written the UCL *Depthmap* software in which he implemented space syntax methods as well as the agent model.

3. METHODOLOGY

The methodology used for this research is two-fold. The first step was analysing the selected hospital and finalizing the most frequented wards to be used for the study. These wards were then spatially analysed using space syntax for which a software called *Depthmapx* has been used. In the second step, a questionnaire survey was prepared. The survey was conducted on a random group of people who had visited the hospital. The survey led to an understanding of the user preferences and criteria that influence bed selection. The findings of the spatial analysis were combined with the conclusions of the survey and further analysed to understand the user's preference for bed locations.

SPATIAL ANALYSIS

The study has used the *Depthmapx* software to study the connectivity pattern and visual integration in the wards of an existing hospital building. The prime focus of the study is to analyse the spatial layouts of individual ward types.

The hospital selected for the study is an existing government hospital with a floor plan layout of wards cluster mirrored on both sides of the hospital corridor. As seen in the Connectivity plan, the hospital has one main vertical corridor which is connected by two horizontal corridors and two supporting ones. The main circulation core is situated at the centre of the

main lobby and staircase blocks at either ends of the corridors. All the wards are well connected and easily accessible. The corridors act like the spine of the Hospital which controls the movement across the hospital depending on the restricted status of the ward or wing. Refer fig 1.
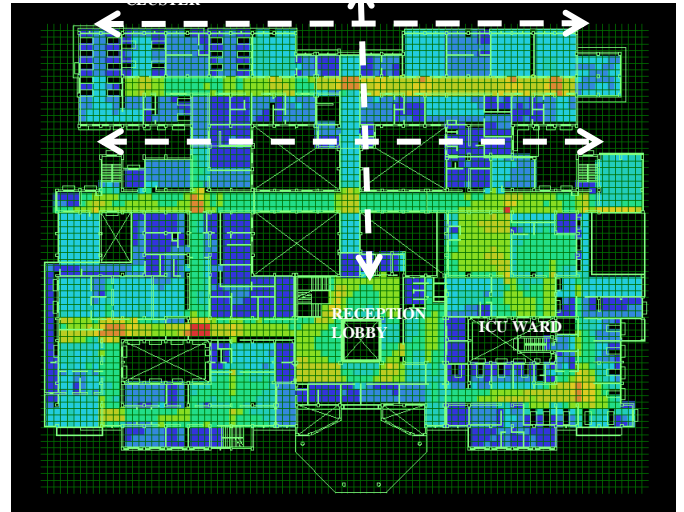

Fig 1: Image showing the typical floor plan for the existing hospital selected.

TYPICAL FLOOR PLAN:
The ward cluster has a shared Nurse's station which is monitored using call bells and alarm systems. The corridor acts as the serving spine for connecting all the rooms in the layout. Each individual room has been used for the survey keeping the layout of the existing plan intact. The connectivity can be seen from the central corridor. The farther you are from the central point, the colours change from red- orange- yellow- green- blue. For the Visual Integration, the farther you are from the visual centre, the deeper blue is the colour. The statistical measures would be seen in the Visual Step Depth map and Metric Step depth Map which indicates the actual measure of distance.

Based on the analysis, it is evident that even though the wards share a common Nurse's Station, all of them are within 15M of walking distance. Also, all the wards are in the range of Step Depth 3 from the Nurse's station. The corridor acts like the main access point and hence for the entire survey layout adapted from the existing layouts, the corridor entry shall be considered as the Nurse's viewing point for further analysis.

The nurse's station is at the absolute centre of the L shaped ICU ward, which gives the nurse's a benefit of visibility to maximum no of beds. The beds that are farther away are in the step 4 giving a little disadvantage. But all the beds are under 18M walking distance from the nurse's station. Most of the beds are within step depth 1 or 2.

The ward were selected on the basis of occupancy and existing typical layouts of the individual floor plans.

5. QUESTIONNAIRE SURVEY

To understand the user groups and their preferences, a pilot survey was conducted on a random sample survey group across India. As the Study was being conducted for General Wards in existing Hospital in India, the sample was selected at random and they were given scenarios from existing layouts rather than new designed ones. To explain the purpose of the study, an explanatory message was given beforehand so as not to get distracted and vague responses.
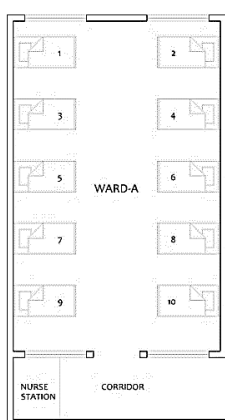
Fig 2: Layout of Ward Type – A
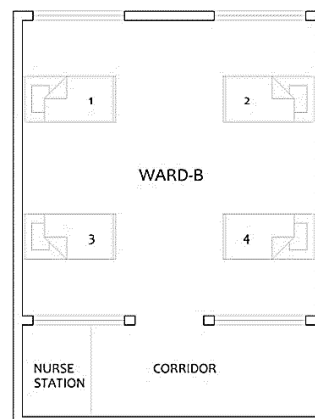
Fig 3: Layout of Type –B
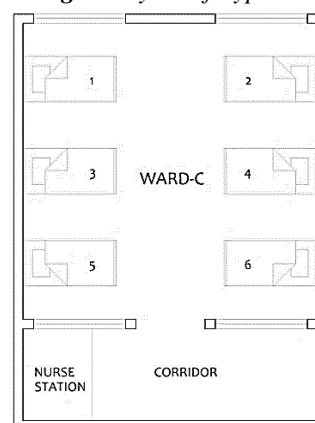
Fig 4: Layout of Type –C

Fig 5: Layout of Ward Type – D
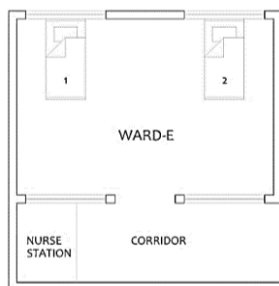
***Fig 6:** Layout of Ward Type – E*
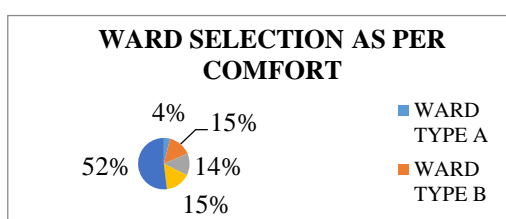
***Fig 7:** Graph showing the Ward preference.*
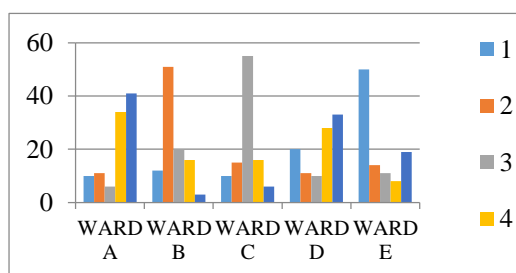
***Fig 8:** Graph showing the comparison of Ward type preference.*
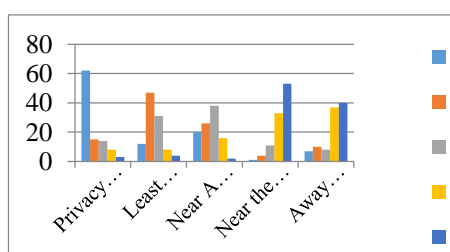
***Fig 9:** Graph showing the preference of patients.*

The total responses received were 102 out of which 73 participants were female and 29 were male. More than 85 % participants belonged to the age group 21-40. The participants were shown the following layouts of the wards which as mentioned are adapted from existing wards from a general hospital to understand their acceptance of each bed space and their reactions to each layout. From the responses, it was found that more than 50% of the participants preferred Ward type – E which is a double shared room. The Ward type A is the least preferred ward type. A ten bed ward is not really something that people like. Refer fig 7.

Now that we understood that Ward type E is the most preferred, the next step was to find out how do the other ward layouts fare. The next question was about rating the wards according to preference. The results indicate that Ward E is the most preferred ward type closely followed by Ward type B which is a four bedded ward. Ward type C seems to be the most averagely accepted ward but the main indication of people not preferring too many people in their vicinity is the response that Ward type A got. Ward Type A is a ten bedded ward, which is one of the most common layouts seen in general hospitals, but it is the least preferred layout. Refer fig 8.

Each patient is different and so are the different criteria that influence the decision making during bed selection, if given a chance. From the comparative chart, it is seen that "Privacy from other patients" is of utmost priority followed by "Least interference". Refer fig 9. This question was asked to understand the priorities that each patient or bed occupant might have that would influence their decision making. It is interesting to note that the least preference point is creating a clash of opinions between "near the door" and "away from the door".

4.1 Individual ward analysis:

Ward Type – A

Ward type A is Ten Bedded ward. It is laid out in the existing manner with access from the bottom corridor. The central point of the entrance shall be considered as the Nurse's viewing point. Both these maps indicate one common thing and that is that the farther the bed is from the door, more is the step depth and lesser is the visibility. The Beds no 1 & 2 are at least 9 M walking distance from the Nurse's viewing point. Refer fig 10. Bed no 9 & 10 have the most accessibility visibility wise and lesser step distance. Refer fig 12. Only 4 % participants preferred this ward. The most preferred beds are bed no1 & bed no 2 which are connected well with the main circulation corridor and yet the least visually integrated. Refer fig 11. These bed selections are most preferred by women. All the other bed options have an equally shared preference. It was assumed at the beginning of the study that the beds closest to the entrance would be least preferred but this theory has been proven wrong with 8 % overall

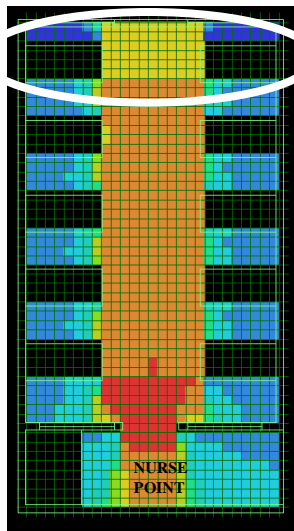preference out of which 25% are females and 75% males.
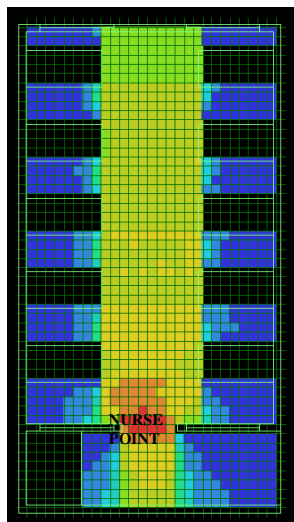

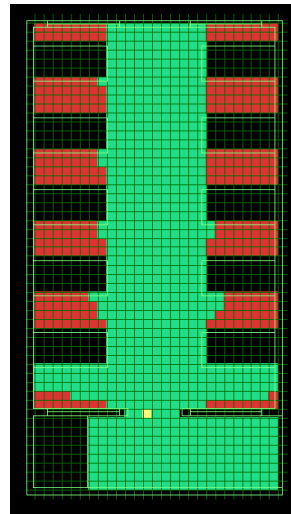**Fig 10:** *Ward A – Connectivity*

Fig 11:– *Visual Integration*

Fig 12: *Visual Step Depth*
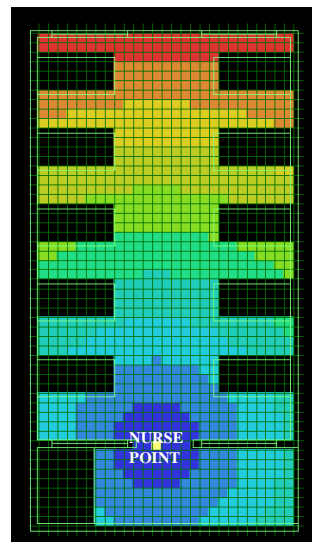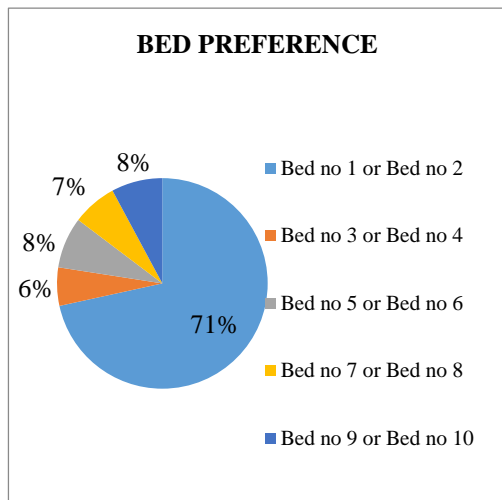

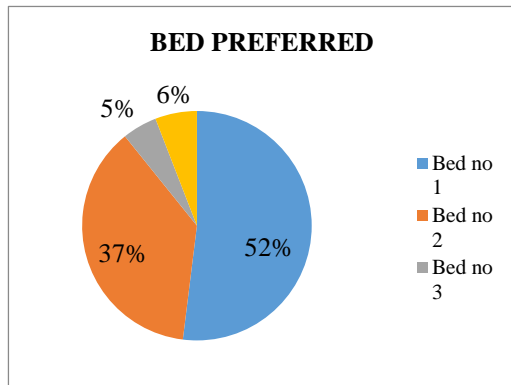**Fig 13:** *Ward type A – Metric Step*

Fig 14: *Chart showing bed preference for Ward A Depth*

Ward Type B:

This layout was circulated in the survey as the Ward Type B. It is inspired by the existing four bedded ward and planned out in the same manner. The corridor that acts as the central spine of circulation is the main access point for the Nurse's viewing point. The maps indicated that even though it is a four bedded ward, the beds on the inner side that is Bed no 1 & Bed no 2 are farther away and have a step distance of 5 M on an average. Refer fig 18.The visibility of all the four beds is under step depth 1. Refer fig 17.

This Four bedded ward gets an overall preference of 15%. Bed no 1 gets maximum preference with 52% votes and followed by bed no 2 with 37% preference. Both of these beds are the least visually integrated and well-connected but retaining their own privacy.
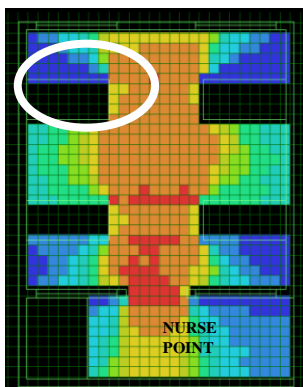
Fig 15: *Ward Type B – Connectivity*
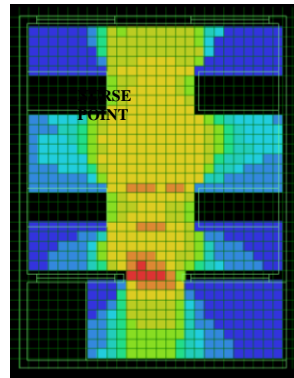
Fig 16: *Visual Integration*
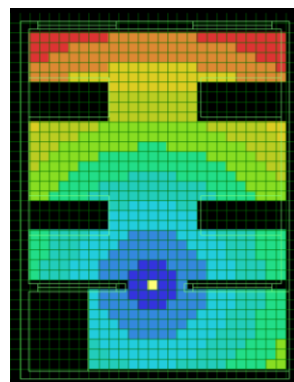
Fig 17: *Metric Step Depth*
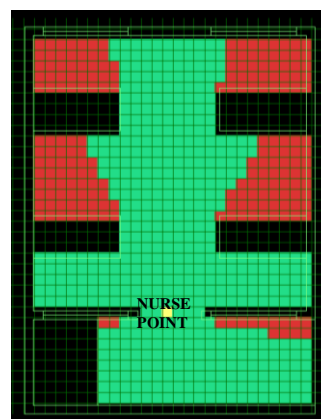
Fig 18: *Ward type B– Visual Step Depth*

Fig 19: *Chart bed preference for Ward B.*

Ward Type C:

This layout was circulated in the survey as the Ward Type C. It is inspired by the existing six bedded ward and planned out in the same manner. The corridor that acts as the central spine of circulation is the main access point for the Nurse's viewing point. This six bedded ward in in the same setting has the four bedded ward. It implies that the central beds which are bed no 3 & 4 have best of both situations. They are not too close to the door nor too far. The farthest best are bed no 1 & 2 which have a walking distance of 6M on an average from the Nurse's viewing point. Refer fig 23.Visibility wise, all the beds are in Step depth 1. Refer fig 22. It received 14% overall preference. (29-71 male-female % ratios).86% belong to 21-40. Bed no 1 & 2 have the maximum preference with 83 % selection. Refer fig 23 A. These beds have the least connectivity and the least visual integration.
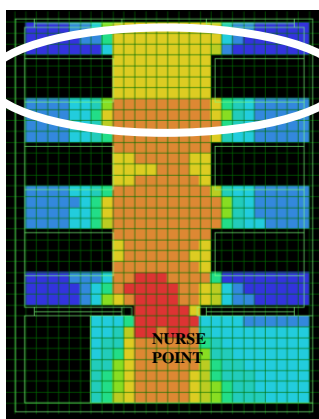
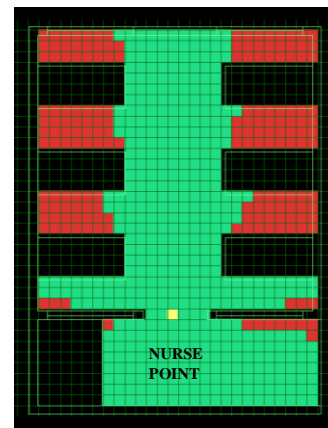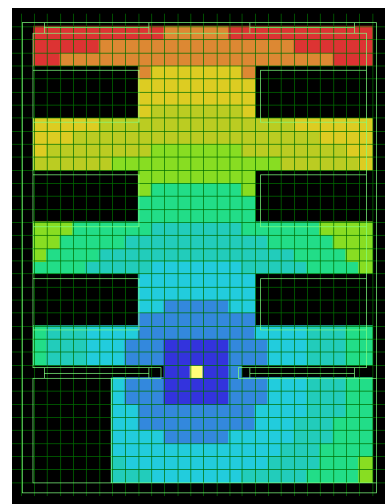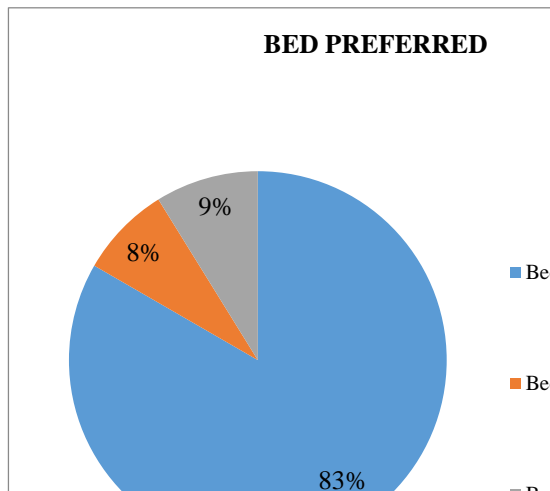**Fig 20:** *Ward Type C – Connectivity*
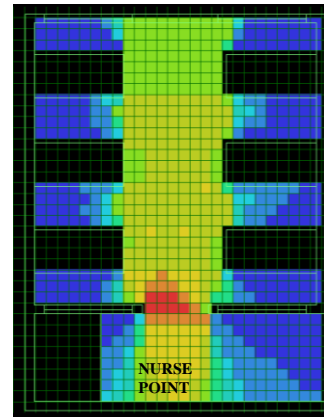
Fig 21:– *Visual Integration*

Fig 22: *Visual Step Depth*

Fig 23: *Ward type C – Metric Step*

BED PREFERRED

Depth ***Fig 23 A:*** *Chart bed preference for Ward C*

Ward Type D:

This layout was circulated in the survey as the Ward Type D. It is inspired by the existing ICU ward and planned out in the same manner. The Nurse's station is situated in the centre like the one in existing layout.From these maps, it is evident that even though the beds share a common Nurse's Station, all of them are within 8M of walking distance. Refer fig 24. Also, all the wards are in the range of Step 2 from the Nurse's station. Refer fig 27. 16% Overall preference (44-56 male-female % ratio).100% belong to 21-40. This ward which is inspired from the existing ICU ward received a very mix response in terms of bed selections. The existing ward and this ward have one thing is common and that is central location of nurse's station without individual separations or room separations. Bed no 1 & 2 received 36% priority whereas bed no 5 & 6 received 31% votes. Refer fig 28.
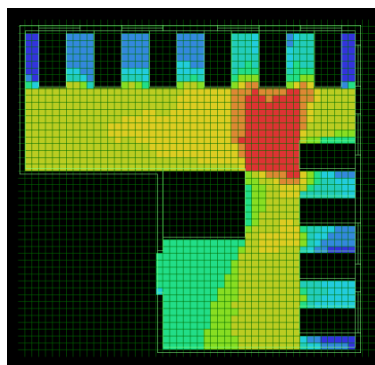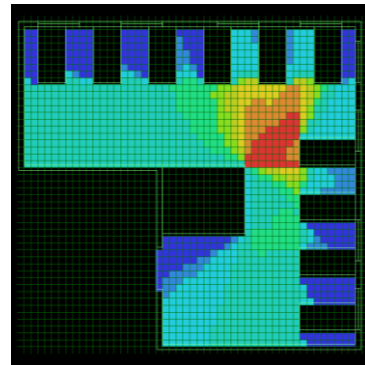

Fig 24: *Ward Type D – Connectivity*
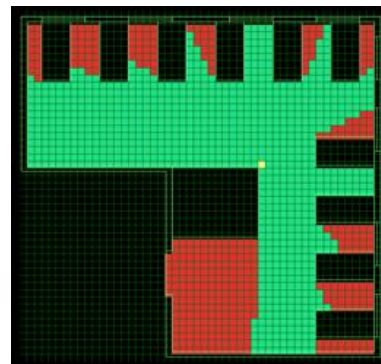

Fig 25: *Visual Integration*

Fig 26: *Visual Step Depth*
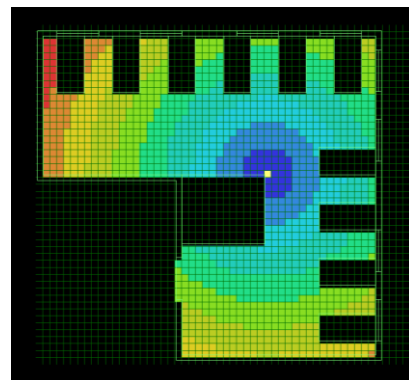
Fig 27: *Ward type D – Metric Step Depth*

BED PREFERRED

Bed no 1 or Bed no 2
Bed no 3 or Bed no 4
Bed no 5 or Bed no 6
Bed no 7 or Bed no 8
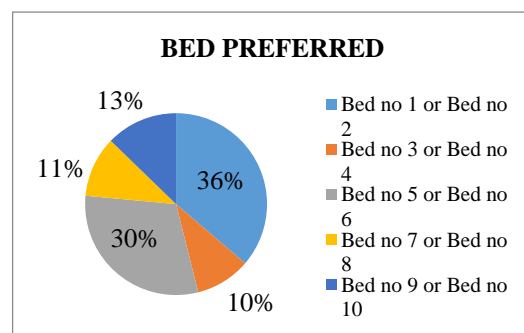Bed no 9 or Bed no 10

Fig 28: Chart bed preference for Ward D

Ward Type E–

52% people preferred this ward. Since this ward was assumed to be the most preferred ward before the survey, this layout was not given in the option for bed selection. But being a double bed ward, this ward presents the maximum opportunity of privacy for each bed. From the survey it was clear that most of the people prefer keeping their privacy intact and not sharing their bed space with more people. This layout was circulated in the survey as the Ward Type E. This ward type is a double shared bed. Both the beds are equally distanced from the viewing point. This ward is very symmetrical in visibility approach. Refer fig 30 & Fig 31.
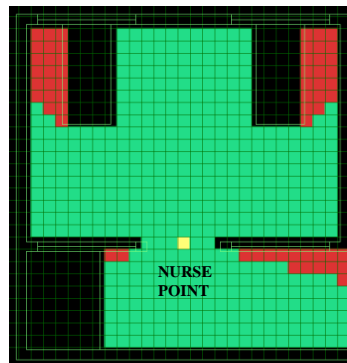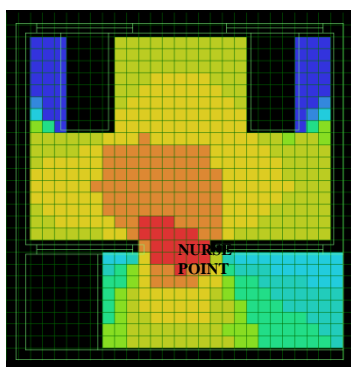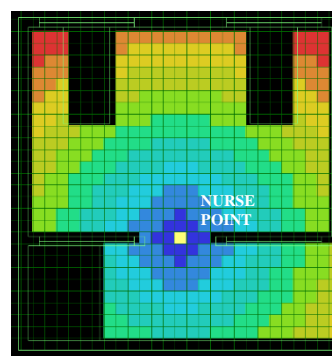

Fig 29: Ward Type E- Connectivity

Fig 30: Visual Integration

Fig 31: Visual Step Depth

Fig 32: Image showing Ward type E – Metric Step Depth

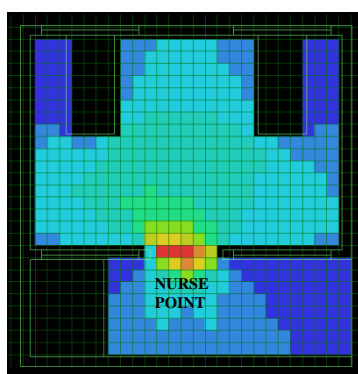**4.2 Survey Conclusion:**

The questions were formulated in a manner that were easy to answer and would not take more than five minutes of the participant's time. The survey was circulated using an online portal and the data collected has been compiled in an excel sheet for analysis. The questionnaire was administered to two kinds of user groups: the non-patient user group like doctors, nurses etc. as well as visitors and patient user group.
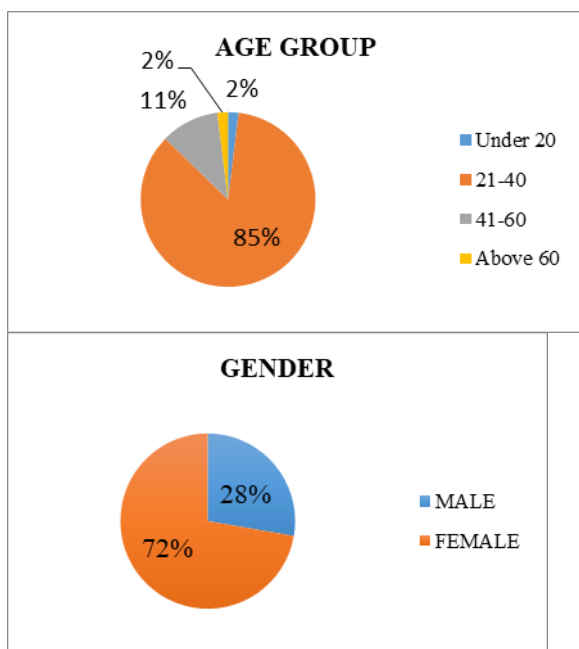
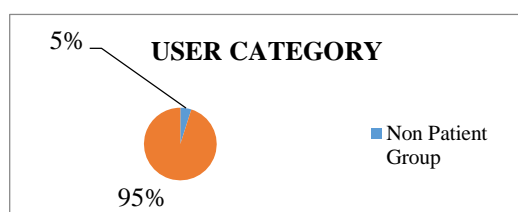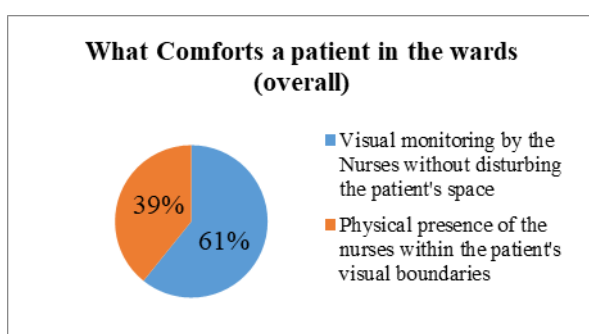*Fig 33: the Age groups of People Surveyed. Fig 34: the Gender of People Surveyed.*

Fig 35: Graph showing the User Category of People Surveyed.

5. *Fig 36: the response for Patient Comfort Question*

5.1 Understanding User Preference:

The overall response for the question as to What Comforts a patient in the wards showed a preference for the option of "Visual monitoring by the nurses without disturbing the patient's space". Refer fig 36. But on a deeper analysis it was found that all the participants belonging to the hospital staff category preferred the option of "Physical presence of the nurses within the patient's visual boundaries". This is where the difference of opinion is seen between both the user groups of the same space (Refer fig 37 & fig 38).

6. DATA ANALYSIS – COMPARATIVE STUDY - CONCLUSION

From the above studies, it can be deducted that the beds that are most preferred are all away from the entrance door in individual wards. Based on the study of all the ward types and different layouts it is safe to say that even if people share wards, they need their privacy as much as possible. It maybe from the visitors or their fellow ward mates and even nurses. Looking at all the data, the preference for the beds is seen to be more towards farther from the doors. The more step depth and more the visual integration, more we get closer to the bed preferred. Though the least populated ward, that is Ward E with two beds is more preferred compared to the others, it is the actual question of privacy and preference that makes the occupants prefer the inner most bed in the wards. This study has helped understand the various factors that influence the user's comfort while being hospital residents.
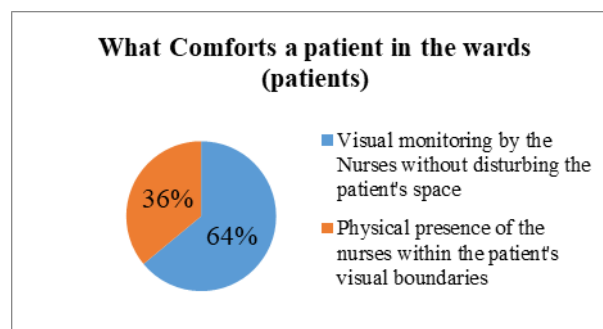

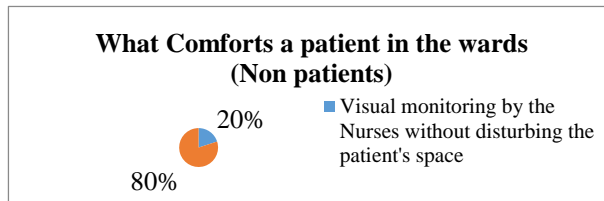*Fig 37: the response for Patient Comfort*

What Comforts a patient in the wards (Non patients)

. *Fig 38: Graph showing the response for Patient Comfort Question.*

Table 1: Conclusions for preferred bed .

Ward Type	Preferred Bed	Bed Location	Visible Step Depth	Metric Step Depth
A	Bed no 1 & Bed no 2	Extreme inner end, Near a window	1	9 M
B	Bed no 1	Extreme inner end, Near a window	1	5 M
C	Bed no 1 & Bed no 2	Extreme inner end, Near a window	1	6 M
D	Bed no 1 & Bed no 2	Extreme Inner side, away from the Door	1	7 M

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