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RESEARCH PAPER

An Architectural Study on Spatial Configuration of Emergency, Out Patient Department (OPD) and Isolation w.r.t. Infectious Diseases- Focused on Secondary Level Hospitals of Khyber Pukhtunkhwa Province

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ABSTRACT

The objectives of this study are to explore the role of spatial configuration in the possible spread and control measure of infectious disease in the secondary hospitals of the province of Khyber Pukhtunkhwa, Pakistan. The healthcare delivery system has been challenged in the world on the onset of infectious diseases since many people faced life threatening situations during the pandemic. This paper used space syntax Method, a field of study on the impact of spatial configuration and human behavior, used in more than two hundred universities of the world as research tool. The results show that in case study more spaces to be traversed for reaching isolation room as compared to case study and the least number of spaces for reaching isolation rooms were found case study 2. Case study 3 shows highest number of spaces for reaching isolation rooms, indicating more spatial interaction leading to more spatial contamination.

Introduction

A healthy and functioning medical service indicates a strong and harmonious relationship and coordinates primary, secondary and tertiary considerations. Such a mix and a few procedures could be arranged and executed to improve the medicinal services delivery system of Pakistan.

The tertiary level hospital organization in Pakistan is composed of an outdoor patient department, an indoor patient department, an emergency department, scanning and lab facilities to the public. Primitively the structures that filled in as healthcare, offices, and centers were not the same as different structures as far as space, meeting practical necessities or engineering articulation is considered. During the 1980s, the administration began to fabricate medical clinics intended to fill in as social welfare organizations. An extraordinary assortment of shape and format has been utilized among typologies in the structure of tertiary level healthcare facilities in Pakistan (Gawande 2010).

In Pakistan, a healthcare delivery system is comprised of four methods; of

1. Preventive,
2. Promotive,

3. Healing, and
4. Rehab facilities.

The Healthcare Delivery System of Pakistan is curtailed through Figure 1.

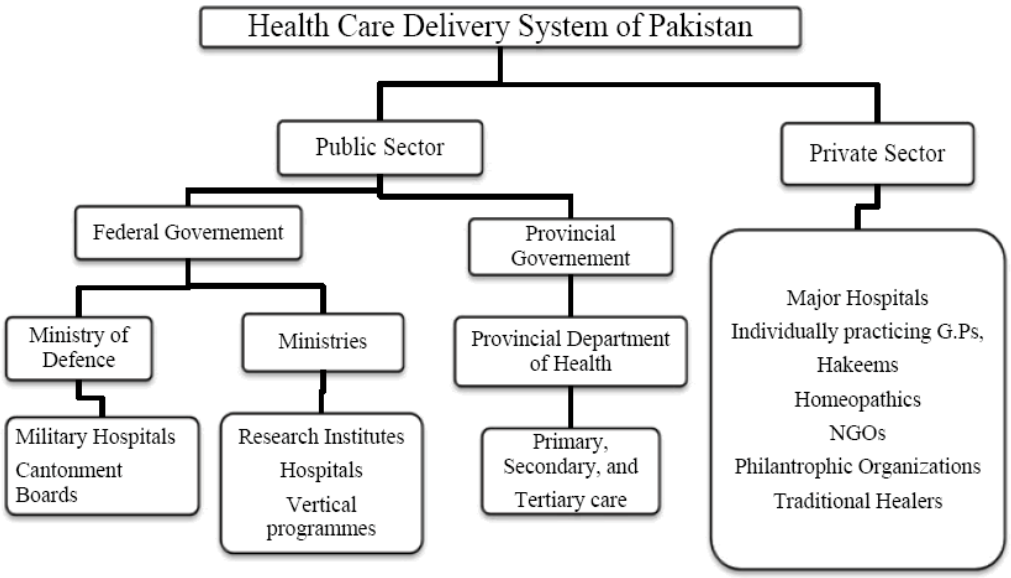

Figure 1 The Healthcare Delivery System of Pakistan

Healthcare care delivery system of Pakistan is carried by a network doctors, nurses, lady health workers etc. These personals work in the field to ensure a healthy environment. Moreover, in Pakistan, healthcare facilities are the responsibilities of the provincial government except for the federal zone.

Generally, healthcare facilities are multifaceted buildings requiring coordination in various administrations and practical units. An impeccable healthcare facility is composed of indoor and outdoor patient departments; administration; research and instructing facilities. The physical relations among these departments predominantly decide the setup of a hospital (Frampton and Charmel 2009).

Healthcare buildings are mostly very integrated buildings. All departments are composed of administrative and functional units as reflected in most of the design guidelines and building codes. Experts are required to work on the technical aspects like electrical, mechanical and communication systems. Individually it is not possible to have total knowledge about hospitals. The practical units inside the hospital can have challenging needs (Kibert 2016).

The important thing is that the range of mandatory administration is wide, for example, Emergency units need to serve and enhance a wide range of customers and employees. Ideally, the structural procedure merges the direct input of the clinic owner and key personnel at the right time. Designers should also consider patients, guests, support staff, volunteers, and workers who generally do not directly contribute to the plan. The configuration of the Great Emergency Unit tailors the actual requirements to the human needs of its diverse customers. (Jiang and Claramunt 2002). The methodology ought to consolidate the ability and experience of medicinal services organizers, modelers, attendants, specialists, and patients. It empowers the choices to be tried by tackling the learning of these partners and thoroughly assessing plan alternatives. In the fabricated

structure, bottlenecks in the process and space will be distinguished in the investigation and plan arrangements created to avoid them.

Healthcare delivery systems are based on defined setup procedures and established methods anywhere in the world.

This implies that there is a defined pattern of healthcare delivery system which cannot be seen through the naked eye but can be detected using certain methods and tools.

As the hospital is a place which responds to a patient in case of life-threating situations hence needs to be well planned by the genotype of the healthcare delivery system.

Hospitals in Pakistan are generally facing the issues of congestions, way findings and the issue of spaces contamination are alarming factors in spread of infectious diseases at hospitals. In existing healthcare system or treatment culture of Khyber Pukhtunkhwa hospitals the patient flow, in emergency-diagnostics-isolation and OPD-diagnostics-isolation w.r.t. infectious diseases, is a major source of contaminating spaces hence a major source in spread of infectious diseases.

Literature Review

The global panics associated with infectious diseases, including the publication of a letter containing anthrax spores in the United States in 2001 and the emergence of severe acute respiratory syndrome (SARS) in 2002, and highly contagious COVID-19. Emphasis is placed on ongoing efforts to contain the virus. Global readiness for new public health threats needs to be improved. As reported by WHO in Pakistan there have been 1,529,405 confirmed cases of COVID-19 with 30,378 deaths between January 2020 to May 2022. Apart of the direct deaths during the COVID 19 there have been numerous reports on indirect deaths of patients who couldn't attend hospitals during this pandemic, have been reported. This further highlights the need of reconsidering the design matrix of healthcare facilities planning w.r.t. infectious diseases (Morens, Folkers et al. 2008).

The following are the basic departments in a hospital generally;

- Indoor patient department
- Outdoor patient department
- diagnostic and treatment
- administrative units
- services
- teaching and research facilities

Physical connections between these departments are outlined below in Figure 2 and Figure 3.

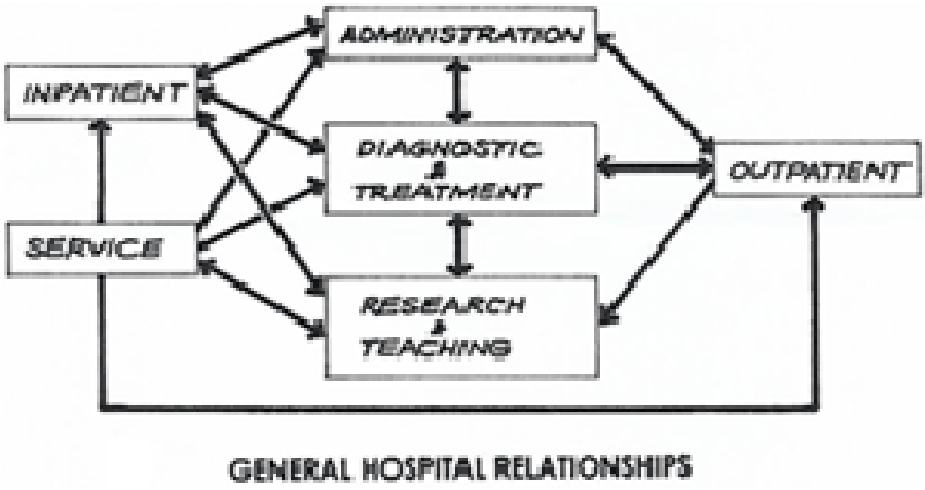

Figure 2 General Hospital Space Relationships

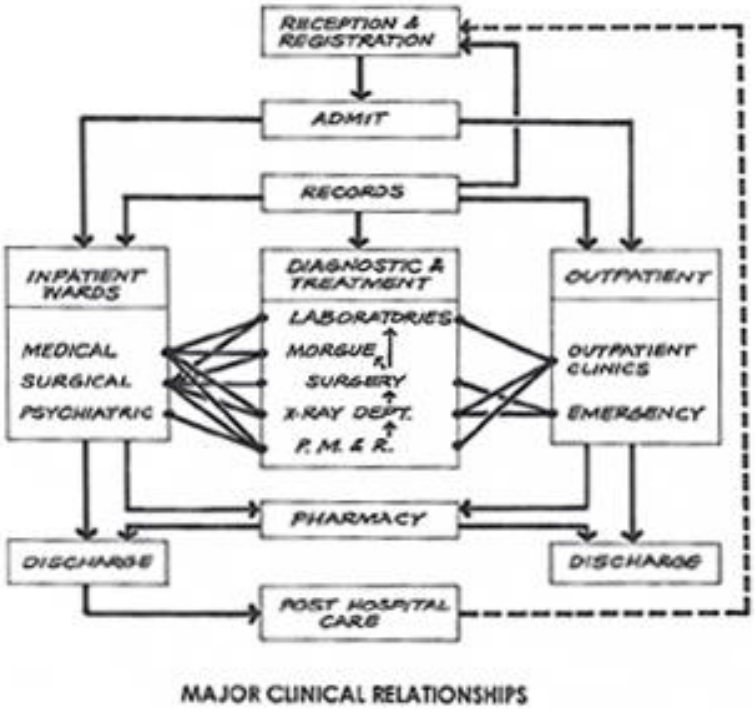

Figure 3 Major clinical relationships in hospital plan

The above pictures illustrate the interactions between a hospital's distinct areas well and indicate that distinct units are inseparably linked with their access and function. Site restrictions and openings, atmosphere, encompassing offices, budget, and accessible innovation also affect the department arrangement. New medicinal demands and fresh innovation produce fresh decisions (Prahalad and Ramaswamy 2004).

'Space syntax ' is a strategy, or several approaches, to describe, evaluate and translate spatial arrangements into constructions and settlements (Hillier, Hanson, and

Graham 1987, Hillier and Hanson 1984, Hillier 1996). It provides an accurate way to deal with the collapse of spatial structure and to see how social and cultural patterns are embedded in spatial examples. The scheme is defined in space syntax as an association of spaces that portrays the link between two spaces in the structure thinking about distinct spaces (Vaughan 2007).

Space syntax is a tool that provides quantitative measurements of space for both individual rooms (rooms, hallways, etc.) and the overall layout (e.g., clinic, emergency department, entire hospital).

Primarily, Syntax identifies the underlying spatial structure in the entire configuration of spatial complex.

This paper used the following aspects of space syntax; a brief description of each is given below:

Configuration

Space Syntax is a theory about understanding architecture and urban areas from the point of view of their configuration. "Configuration is defined in general as, at least, the relation between two spaces taking into account a third, and, at most, as the relation among spaces in a complex taking into account all other spaces in the complex."

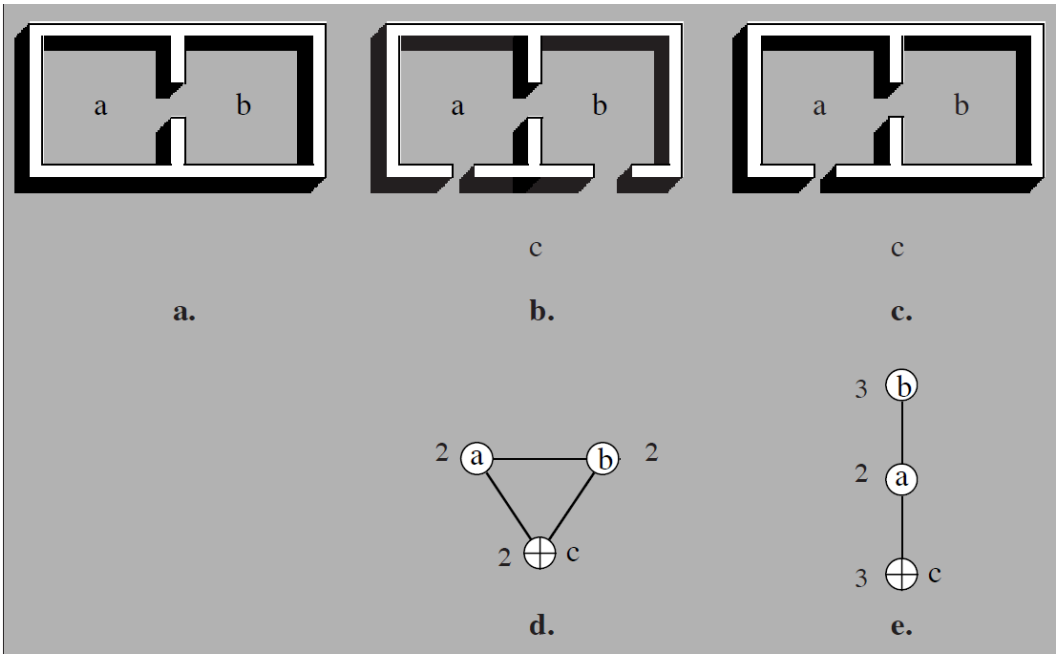

Figure 1 Configuration and j-graphs

Integration

Integration is a normalized measure of the distance from any origin to all other spaces in the system. In general, you can calculate how close the origin space is to all other spaces and use it as a measure of relative asymmetry (or relative depth) (Liao, Gu et al. 2019).

Integration is expressed by the value of Real Relative Asymmetry (RRA).

Justified Graphs:

In a justified map / graph, the node is drawn on the base, all depth 1 points from that point are placed horizontally just above it, and all depth 2 points from that point are depth. It is placed horizontally above the point of 1, until all depth levels from that point are considered (Kruger 1989).

In this study, the entry points of the secondary hospitals were considered as root. All the connecting lines were then drawn.

Control Value

Control value measures what degree of choice each space represent for its immediate neighbors as a space to move to. Each space has a certain number k of immediate neighbors (Jiang and Claramunt 2002).

Case Studies

The following case studies of secondary level hospitals were selected for analysis using spaces syntax.

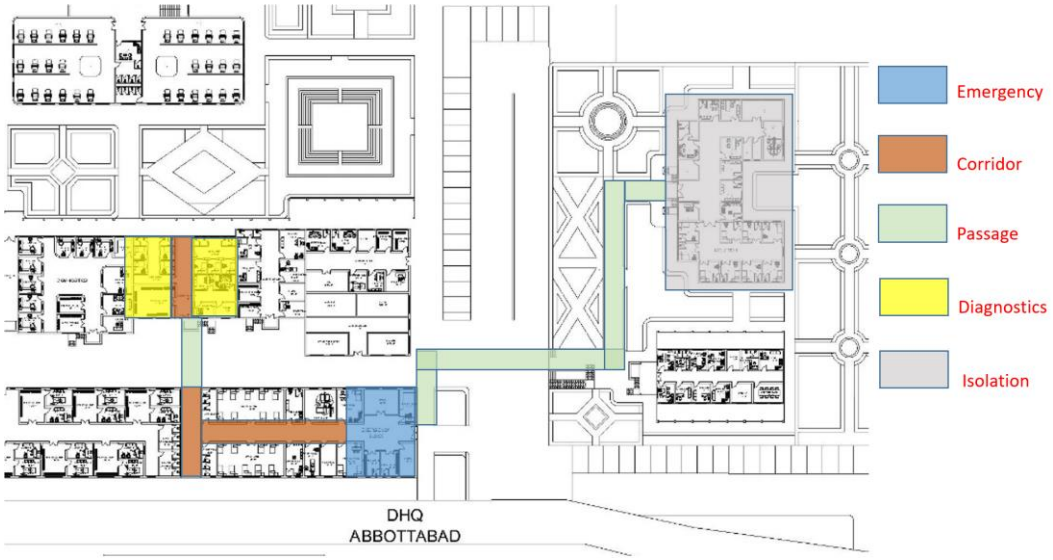

Figure 5 DHQ Abbottabad

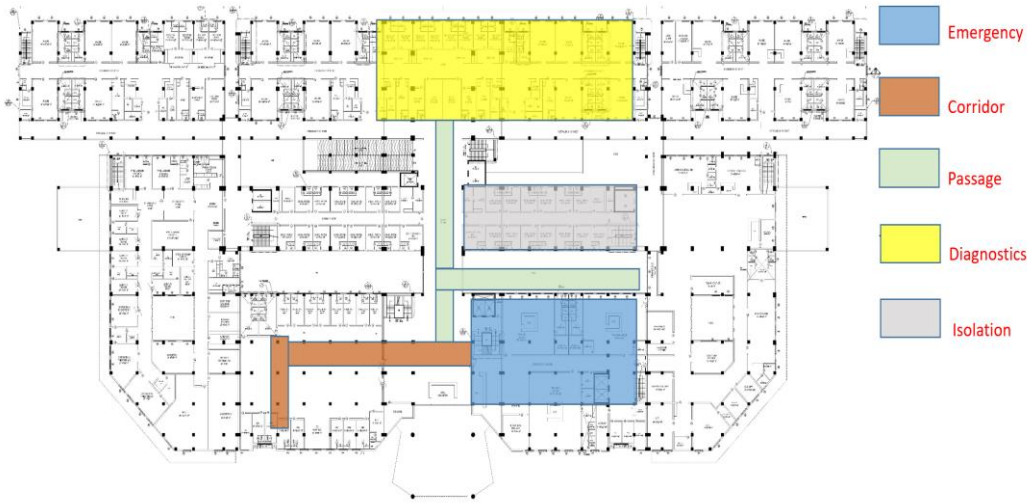

Figure 6 DHQ Peshawar

Figure 7 DHQ Hangu

Analysis

The case studies were analyzed keeping the following aspects of Space Syntax;

- Step Depth
- Integration
- Control Value

In each case study the above aspects are presented graphically and tabulated. It is shown through scientific colour coding system named VIBGYOR (Violet, Indigo, Blue, Green, Yellow, Orange and Red).

Case Study 1 (DHQ Abbottabad)

The space syntax analysis w.r.t. Step Depth, Integration and Control value of DHQ Abbottabad are shown as;

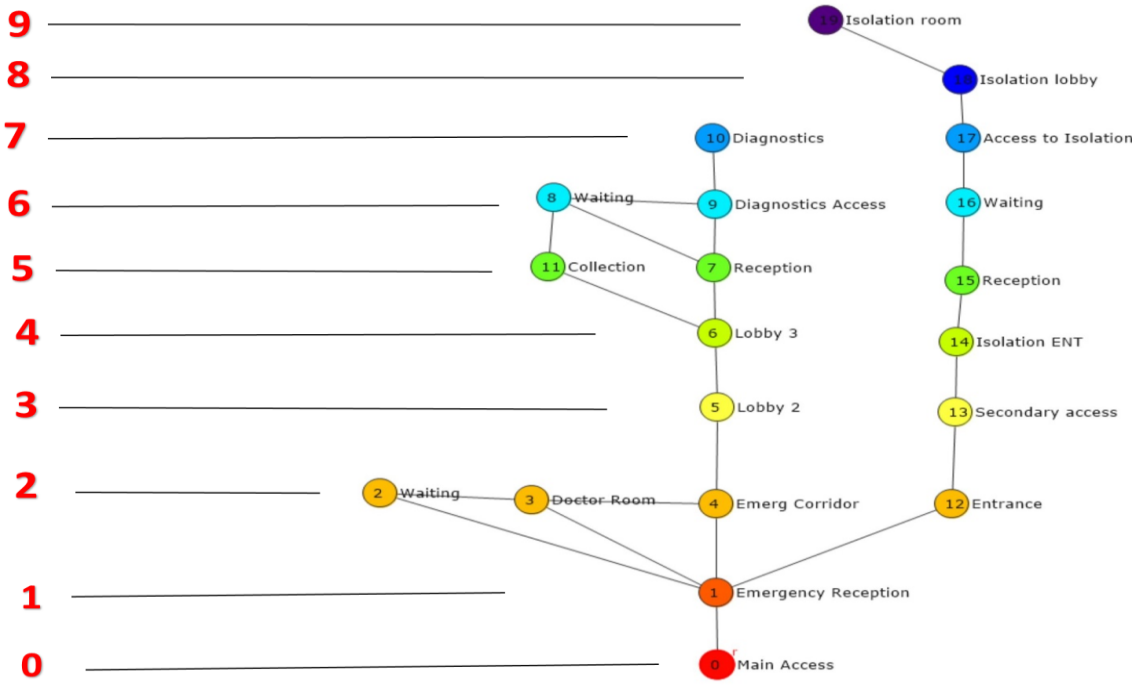

Figure 7 Justified Permeability Graph- **Step Depth** (DHQ Abbottabad)

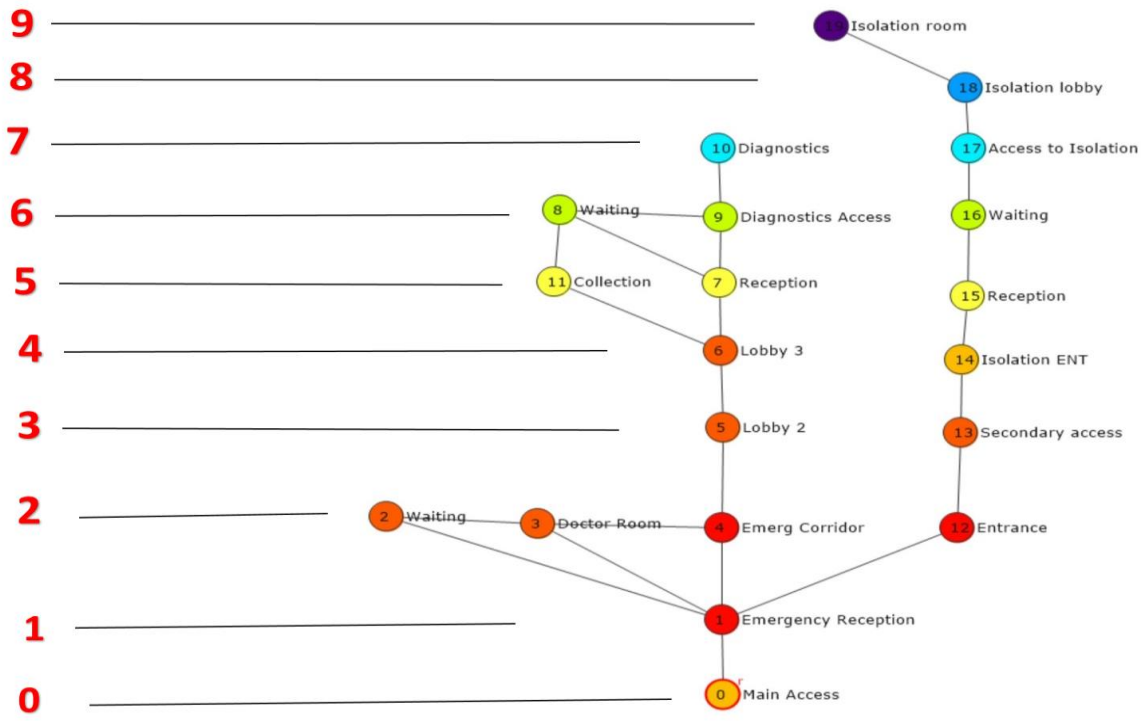

Figure 9 Justified Permeability Graph- **Integration** (DHQ Abbottabad)

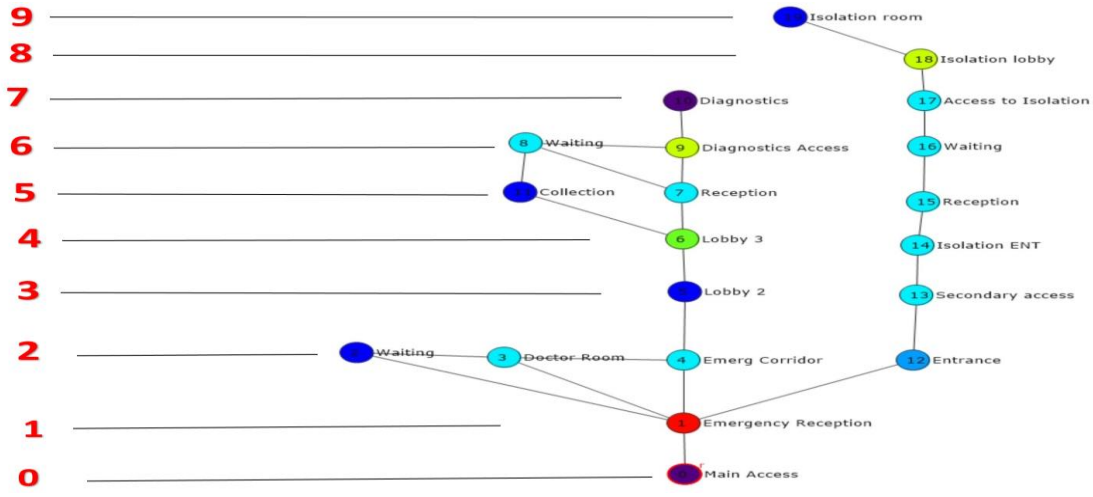

Figure 10 Justified Permeability Graph- **Control value** (DHQ Abbottabad)

Table 1
DHQ Abbottabad

Root	Space	Total Depth (TDn)	Mean Depth (MDn)	integration	Control Value(CV)
0	Main Access	87	4.57	2.51	0.20
1	Emergency Reception	69	3.63	3.42	2.66
2	Waiting	86	4.52	2.55	0.53

3	Doctor Room	78	4.10	2.89	1.03
4	Emergency Corridor	72	3.78	3.22	1.03
5	Lobby 2	78	4.10	2.89	0.66
6	Lobby 3	86	4.52	2.55	1.33
7	Reception	98	5.15	2.16	1.00
8	Waiting	112	5.89	1.83	1.16
9	Diagnostics Access	112	5.89	1.83	1.66
10	Diagnostics	130	6.84	1.54	0.33
11	Collection	100	5.26	2.11	0.66
12	Entrance	73	3.84	3.16	0.70
13	Secondary access	79	4.15	2.85	1.00
14	Isolation ENT	87	4.57	2.51	1.00
15	Reception	97	5.10	2.19	1.00
16	Waiting	109	5.73	1.90	1.00
17	Access to Isolation	123	6.47	1.64	1.00
18	Isolation lobby	139	7.31	1.42	1.50
19	Isolation room	157	8.26	1.23	0.50
	Min	69.00	3.63	0.20	0.20
	Mean	98.60	5.18	**2.32**	**1.00**
	Max	157.00	8.26	3.42	2.66

Case Study 2 (DHQ Peshawar)

The space syntax analysis w.r.t. Step Depth, Integration and Control value of DHQ Peshawar are shown as;

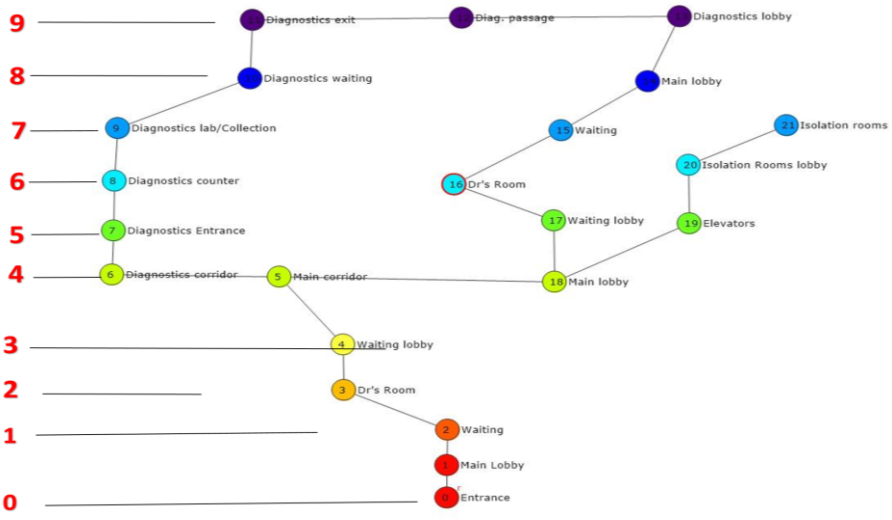

Figure 11 Justified Permeability Graph- Step Depth **(DHQ Peshawar)**

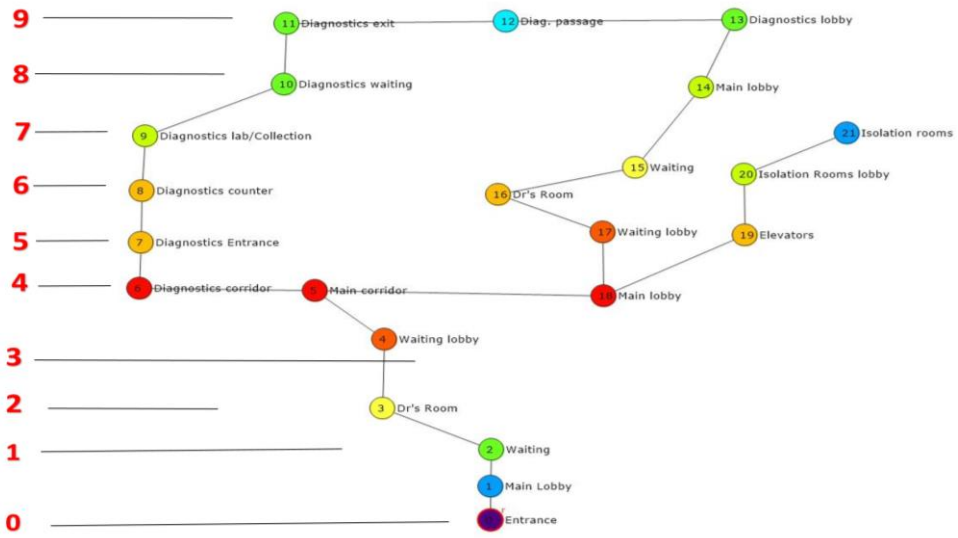

Figure 12 Justified Permeability Graph- **Integration** (DHQ Peshawar)

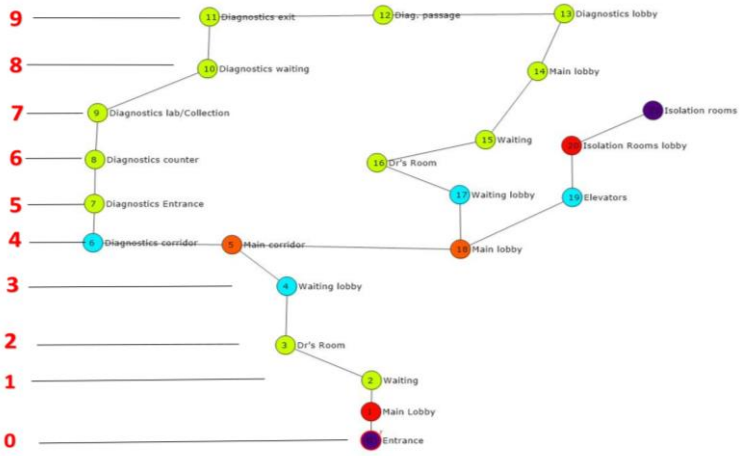

Figure 13 Justified Permeability Graph- **Control Value** (DHQ Peshawar)

Table 2
DHQ Peshawar

Root	Space	Total Depth (TDn)	Mean Depth (MDn)	Integration	Control Value (CV)
0	Entrance	153	7.28	1.59	0.50
1	Main Lobby	133	6.33	1.87	1.50
2	Waiting	115	5.47	2.23	1.00
3	Dr's Room	99	4.71	2.69	1.00
4	Waiting lobby	85	4.04	3.28	0.83
5	Main corridor	73	3.47	4.03	1.33
6	Diagnostics corridor	81	3.85	3.50	0.83
7	Diagnostics Entrance	89	4.23	3.08	1.00

8	Diagnostics counter	97	4.61	2.76	1.00
9	Diagnostics lab/Collection	105	5.00	2.50	1.00
10	Diagnostics waiting	113	5.38	2.28	1.00
11	Diagnostics exit	121	5.76	2.10	1.00
12	Diag. passage	123	5.85	2.05	1.00
13	Diagnostics lobby	115	5.47	2.23	1.00
14	Main lobby	107	5.09	2.44	1.00
15	Waiting	99	4.71	2.69	1.00
16	Dr's Room	91	4.33	3.00	1.00
17	Waiting lobby	83	3.95	3.38	0.83
18	Main lobby	75	3.57	3.88	1.33
19	Elevators	91	4.33	3.00	0.83
20	Isolation Rooms lobby	109	5.19	2.38	1.50
21	Isolation rooms	129	6.14	1.94	0.50
	Min	73.00	3.47		
	Mean	103.90	4.94		
	Max	153.00	7.28		

Case Study 3 (DHQ Hangu)

The space syntax analysis w.r.t. Step Depth, Integration and Control value of DHQ Hangu are shown as;

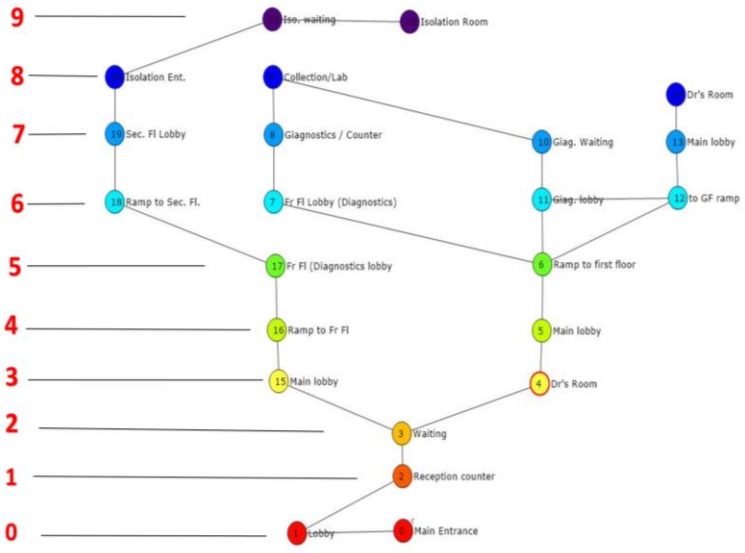

Figure 14 Justified Permeability Graph**- Step Depth** (DHQ Hangu)

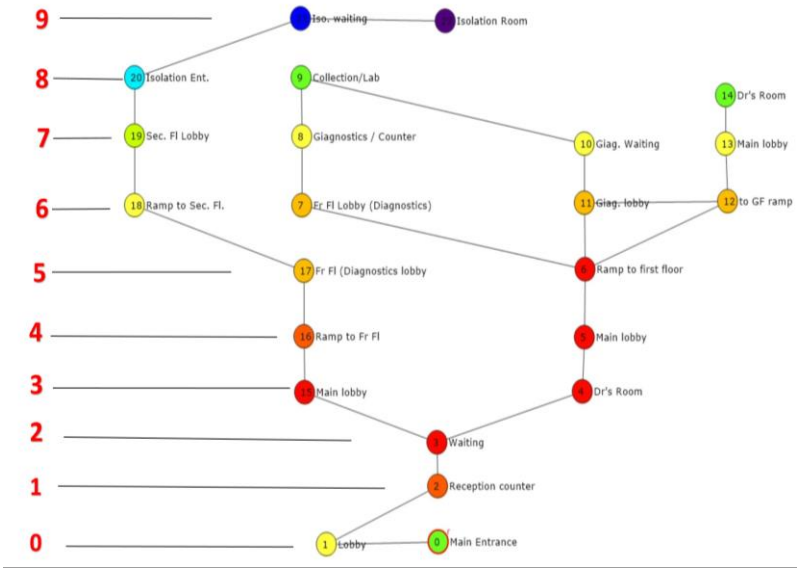

Figure 15 Justified Permeability Graph**- Integration** (DHQ Hangu)

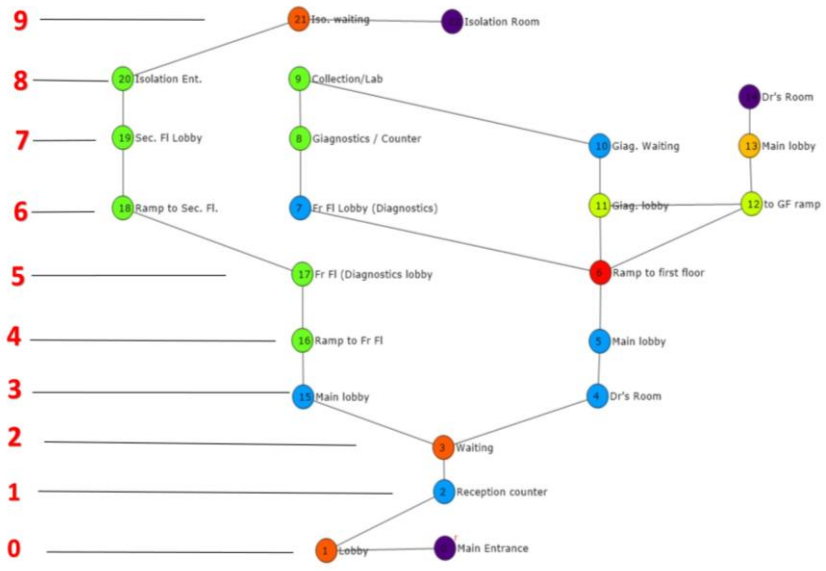

Figure 16 Justified Permeability Graph**- Control Value (**DHQ Hangu)

Table 3
DHQ Hangu

Root	Space	Total Depth (TDn)	Mean Depth (MDn)	Integration	Control Value (CV)
0	Main Entrance	144	6.54	1.89	0.50
1	Lobby	123	5.59	2.28	1.50
2	Reception counter	104	4.72	2.81	0.83
3	Waiting	87	3.95	3.55	1.50
4	Dr's Room	88	4.00	3.50	0.83
5	Main lobby	91	4.13	3.34	0.75

6	Ramp to first floor	96	4.36	3.12	1.66
7	Fr Fl Lobby (Diagnostics)	113	5.13	2.53	0.75
8	Diagnostics / Counter	130	5.90	2.13	1.00
9	Collection/Lab	144	6.54	1.89	1.00
10	iag. Waiting	127	5.77	2.20	0.83
11	Giag. lobby	110	5.00	2.62	1.08
12	to GF ramp	110	5.00	2.62	1.08
13	Main lobby	129	5.86	2.15	1.33
14	Dr's Room	150	6.81	1.80	0.50
15	Main lobby	94	4.27	3.20	0.83
16	Ramp to Fr Fl	103	4.68	2.85	1.00
17	Fr Fl (Diagnostics lobby	114	5.18	2.51	1.00
18	Ramp to Sec. Fl.	127	5.77	2.20	1.00
19	Sec. Fl Lobby	142	6.45	1.92	1.00
20	Isolation Ent.	159	7.22	1.68	1.00
21	Iso. waiting	178	8.09	1.48	1.50
22	Isolation Room	199	9.04	1.30	0.50
	Min	87.00	3.95		
	Mean	124.43	5.65		
	Max	199.00	9.04		

The syntactic values of all the three case studies are shown in Table 4 & Table 5 below.

Table 4
Summary of Syntactic values

Case Study no.	Step Depth	Mean Depth	Total Depth	Control Value	Integration
1	9	5.18	98.6	1.00	2.32
2	10	4.94	103.90	1.00	2.68
3	11	5.65	124.43	1.00	2.42

Table 5: Syntactic values of Isolation

Case Study no.	Step Depth	Mean Depth	Total Depth	Control Value	Integration
1	9	8.26	157	0.50	1.23
2	8	6.14	129	0.50	1.94
3	11	9.04	199	0.50	1.30

Conclusions

Isolation rooms in case study 1& 2 are comparatively easily accessible from entrance on a **step depth** of 9 & 8 receptively. This is also reflected in the values of **mean depth (8.26 and 6.14)** and **total depth (157 and 159)**. Furthermore the highest integration value shows that isolation rooms are easily accessible from emergency and

diagnostics which is also evident from hospital plans. The plans indicates that isolation rooms are placed in between emergency and diagnostics. There are less number of spaces to be traversed for reaching isolation rooms in case study 2 compared to the other two cases.

Syntactic values of case study 1 indicates more depth values which means increased number of spaces to be traversed to reach isolation room as compared to case 2. This is also evident from the plan of case study 1.

Syntactic Case study 3 indicates highest depth values which means highest number of spaces to be traversed for reaching isolation rooms. In this case the integration value is lowest among the three case studies indicating more spatial interaction leading to more spatial contamination.

Recommendations

Based on the above data and analysis the following recommendations are enlisted;

1. Step depth of isolation rooms need to be kept below 8 or 9 for future designs.
2. The location of isolation rooms need to be placed near to diagnostics and emergency department which in turn will reduce mean depth of isolation rooms.
3. Total depth of spatial configuration could be reduced through scattered block planning which is also a traditional facility designing strategy in this region of the world.
4. Since the scattered block planning was found syntactically shallower and least spatially convergent, therefore this provides more open spaces for better climatic performance as well as slow spread of infectious diseases.

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