Barrier free visibility for staff in ICU
Focused on space syntax for circulation in Asian ICU

*Javaria Manzoor Shaikh*

Abstract—The main contribution of paper is for designers through identification of appropriate shape geometry required for care givers in a hospital by using space syntax technique. Healthcare management field is at a boom now a days, and facilitating nurse is one of the important aspect coming up in future, thus a lot of new courses in this field are also been introduced and management is in demand. Focus is on creating the optimal conditions for innovation in healthcare, which has more to do with team dynamics and mindset than standard processes and tools. Researchers are rigorously working to improve patient safety by increasing and improving interface with nurse. This study systematically analyses the Nurse Station typo-morphology, and simulates nurse vision. The visual connectivity is measured on depth map graphs. Hence the aim is to reduce staff stress and fatigue by support space distribution by increasing effectiveness in delivering care. A depth map comparative analysis of three types of the Surgical Intensive Care Unit (SICU), Medical Intensive Care Unit MICU and Critical Care Unit CCU found at hospitals Hallym University Medical Center, South Korea (HUMC), is analyzed here. Concussively, it was proved that L-Shape provides maximum visibility, where as I shape provides vast vista of a panoramic view from the Nurse Station.

Index Terms—ICU, Nurse Station, Hallym University Medical Center (HUMC), Space Syntax connectivity, Karachi Heart Hospital

I. INTRODUCTION

The hospital management team faces impossible choices to balance cost and quality of care both in Pakistan and South Korea. The Surgical Intensive Care Unit (SICU) is a 20-bed, high-acuity, fast-paced, ICU). Because of the high pace the SICU has a special task for all the 20 beds to be visible and accessible easily [1][2]. Here in this article we described the key characteristics of a successful healthcare innovation mindset and introduce the approach and a set of methods and tools used.

Clinical teams are facing increasing demand to perform more efficiently in terms of improving nurse sustenance. Thus standardization for staff and patient safely is one of the top priorities as Evidence Based Design (EBD) [3]. While EBD is applied here on nurse practice, if there is lack of visual connectivity then nurse have to do more routine route and walking has been hectic for staff [4]. The background section presents a hypothesis which provides a sense of predicted results. It is accompanied with a null hypothesis.

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The built environment influences health. As a species humans need structured for physical shelter, as manifestations of social and cultural values, and as embodiments of spiritual and emotional needs [5]. As population growth accelerates, the production of the built environment becomes more resource intensive, stressing indigenous building material and methodologies beyond their sustainable capacities.

Clinical medicine and public health do not always define health as a state which is merely depending on lack of illness. The world Health Organization, for example, defines health as a physically, mentally, and socially stable well-being. Architecture and planning can promote this broader conception of human health and well-being.

II. BACKGROUND

A. Hypothesis

The testing of Hypothesis may be described as: a procedure in which sample data are used to describe whether to accept or reject a statement or an assumption about population parameter [6]. The Hypothesis which we want to test here is “Improving the typology of nurse station and morphology of the viewing pattern from nurse station to the patient”. The alternative hypothesis may be stated as $H_1: \mu < 2$ and $\mu > 2$ or $\mu \neq 2$. If medicine and public health incorporate a view of human health as nested within a broader concept of ecological health.

Health care personnel and facilities are not evenly distributed among the world’s population. Wealthy industrialized countries have more physicians and hospital beds per person than poorer developing countries.

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Major imbalances in the amount of money spent on health care also exists. The poorest developing countries spend very little per person per year on health, compared to most of the developed countries.

Public health is the science and art of preventing disease, prolonging life and promoting health through the organized efforts and informed choices of society, organization, public and private, communities.

The health care services are offered by the medical, nursing, and allied health professions. The patient forms the main ring in a long chain, where all efforts of the hospital employees are involved in its treatment, to curb or restrain the abnormal state of body resulting from the harmful effects of pathogenic organisms, injuries accident etc. The overall combined effort takes place on a special platform, called “Hospital”.

Pakistan is ranked second in terms of child mortality (under 5-years) with 97 per 1000 children dying, following Afghanistan (257 per 1,000 children, 2007) in West Asia.

Sindh Province has the highest mortality rate among the provinces of the country. To reduce mortality as the 4th item of MDGs (Millennium Development Goals)1 presented by the UN in 2000.

**B. Capturing care context**

Understanding people’s experiences and needs demands ways to also capture their environmental context and conditions. This includes the pace, rhythm and flow of activities and behavior as well as specific contextual qualities of multi-sensory experience [3].

Recently outpatient clinic in Korea general hospitals are changing from the department store type, which is gathering an individual clinics with their own departmental territory. Now as interdisciplinary outpatient clinics and specialty centers are emerging, outpatient layout is required to support joint treatment of multiple departments [22]. The conventional ‘individual clinic’ type, which assigns the size and location of each clinic first and then its layout, has problems with its incoherent layout, limited flexibility for future change and even poor fire safety [7].

In the ‘modular outpatient’ type, the basic overall layout is set first and then each clinic area is assigned within this modular layout. This gives more coherent and standardized exam room layouts along with more flexibility for future change or growth of outpatient clinics [9].

**III. METHODOLOGY**

A. **EBD, HRDoL Health related quality of life and POE**

EBD can be regarded as a natural progression of “healing environment”[7], here nurse walking progress towards patients is aimed to be improved, three month research analysis was conducted by author on sites, there is a HRDoL Health related quality of life, which is a multi-dimensional concept is applied where POE includes a combination of quantitative analysis as well as qualitative technique is applied [6].

A three month quasi experiment was conducted, on site by the authors after survey, a pre-occupancy inauguration session with nurse artificial simulation was conducted at Sacred Heart Hospital, Hallym University Medical Center Dongtan (HUMC) in collaboration with the Korean institution of HealthCare Architecture. The nurse round route was then compared with the similar I-Shaped, L-Shaped and U-Shaped ICU, MICU [3], SICU and CCU configurations. On the second stage nurse’s suggestion was taken with the efficient vision and calculates healing acceleration process in staff. The study was approved by the Korean institute of Healthcare Architecture and hospital’s Public Relations Committee for Medical and Healthcare Research Ethics and the privacy ombudsman for the research at these hospitals and Data Service for facilitating the data collection [8].

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1 MDGs (Millennium Development Goals): The Millennium Development Declaration for sustainable development and detailed 8 goals by 2015 were unanimously adopted by 189 government delegates in the UN Summit in 2000.
B. Patient care unit

Developing new hospital campus in urban site ideas of therapeutic landscape merge with sustainable site planning principles in developing healing gardens, green roofs, and native planting for the landscape design of HUMC hospital, was developed with a series of roof gardens using native and adopted planting strategies, permeable paving, water features in the campus forecourt, and an intimate healing garden on a rooftop nestled between inpatient wings [17].

One of the client’s goals for the new hospital is that it should function together with the existing context, as a operational facility. It was essential to connect lower podiums as close as possible so that, the service zone of the two buildings can operate as a single department. It became crucial to secure a wide space which is uninterrupted by “cores” such as elevators, stairways, and mechanical shafts, and large enough to accommodate the size of surgery or ICUs on the same floor. Among many massing options, the “Central Spine Linear Street Core” [24].

IV. LITERATURE REVIEW

On the other hand EBD can be regarded as a natural progression of ‘healing Environment’ as more and more research evidence has become accumulated and available. EBD focuses on measurable outcomes in designing a healing environment [8][9][10]. Although the current concept of “healing Environment” emphasizes on reducing patients stress, EBD has been proven to have a positive impact not only on patient outcomes but also on quality and safely, staff satisfaction, operational efficiency and even financial performance. If the nomenclature of “healing environment” becomes a cliché found for every healthcare project, EBD can rejuvenate the meaning of “healing environment” with more clear guides that will allow us to continue our quest towards better design [11][12][13].

In the recent project of HUMC design we applied EBD theory as far as we could. However it was difficult to implement into real project because it is rather a new concept in Korea[14][15].The main reason is that, in Korea, there is little existing research on EBD, or even POE (post occupancy evaluation) of existing hospitals which is the most basic material for EBD research[16]. Though we as researcher planned to design based on resources and available research. Moreover evaluating the research based on the adoptability into Korea’s unique culture and medical environment.

Scheme was opted for because, with its recessed main core, it gives the best functional efficiency and flexibility not only on its own but also with its flanking service building

A. Site: Key building performance strategy

Mold free environment safeguard sensitive patients Green roof

The aim is if the healthcare industry become a model for the larger world in developing an ecological approach to these environmental and health challenges? Central to these approaches to medicine is the axiom: “first do no harm”.

B. Energy

The benefits of providing a healthy indoor healing environment for patients, families and staff are well documented in fig. 5 and 6 an environment that reduces stress and increases health benefits.

V. CASE STUDY ICU PLAN TYPE

The pattern based ranking of the general plan type is similar, for example linear, L-Shape, U- Shape, parallel, or hybrid complex combination. Although a considerably compact concentric plan is usually more systematic and efficient [17]; though exterior shape is less an indicator than the internal Nurse Station core organization and layout [18]. Currently very methodological plans have been achieved with combination of concentric pods, and with upcoming bedside computer aided software e.g. Space Syntax. Healthcare trends research for this article has groomed to be more interactive and participatory, often combined with author’s insight research and innovation design activities to make better sense of complex trends [19].

Following is plans and analysis to further give a complete understanding of the entire hospital Hallym University Medical Center, South Korea (HUMC). The paper compares various space schemas for health care facilities in Korea and suggest an optimal scheme to ensure barrier free visibility for Nurse to Patient. The findings of this study would be useful for architects and health care managers to design new or retrofit existing healthcare facilities for creating best healing and safe environment for the patients [4].

The floor comprises of emergency department, having all the essential rooms, and their size, along with the facilities of X-Ray and ECG, working around the clock by managing in three shifts. The numbers of beds are 13 with 1 isolation room. Averages about 1200 patients come here, most men as shown in Figure 2.

Fig. 2. Shows I-Shaped, L-Shaped and U-Shaped ICU, MICU, SICU and CCU configurations at Sacred Heart Hospital, Hallym University Medical Center Dongtan (HUMC).

The benefits of providing a healthy indoor healing environment for patients, families and staff are well documented. Extended the healing concept to the landscape and the site- as shown below an environment that reduces stress and increases health benefits – will provide a healthy physical [5]
environment that nurtures the human spirit. To start, the facility itself must not pollute, contaminate, or destroy the site on which it is built [20].

A. Plan type

Hallym University Medical Center (HUMC), was inaugurated in the premises near Seoul, in 2012. It covers 21,000 m².

The ranking of the general plan type are similar, although a considerably compact concentric plan is usually more systematic and efficient; although exterior shape is less an indicator than the internal core organization and layout.

Currently very methodological plans have been achieved with combination of concentric pods, and with upcoming bedside.

The typical double loaded corridor was the standard design for several years due to the cross ventilation and natural lighting. But the drawback includes very long distance between the nurse station and the last room of the layout [21][22][23]. 4 dialysis beds are also provided, among with their necessary equipment. The operation theatre is in front of the ward, having facility for two beds at a time. Separate Operation Theaters (OT) are provided near the wards of Eye, Ear Nose Throat (ENT) and Gynae.

Magnetic Resonance Imaging (MRI) facility is also there with a separate entrance, which then leads further to the heart related activities. Heart care, with blocks of Cardiology, Cardiothoracic and for critical care, the C.C.U. The CCU provides 15 beds along with an Echo room ultra sound, and E.T.T (exercise tolerance test) facility. OPD and emergency work efficiently. A setup of the operation theatre, with ICU and separate wards for male and female is also there depending upon the amount of care required.

B. Configuring for daylight

The three large plan enclosed courtyards to daylight its diagnosis and treatment area. The plan enclosed courtyard has been the strategy of choice to achieve both density and daylight for centuries [24][25].

Plan enclosed courtyards allow a simple overall diagnosis and treatment shape to be retained as shown in the following typo morphologies.
These forms allow nurses to have visibility around corners, (as shown in space syntax Fig. 1, 3 &6) now nurse can see front and back; thus allowing services zone and treatment to be connected even at the back of ICU as shown in Fig. 3. A matrix of space syntax analysis of sixty-foot wings accommodate most caregivers work path, adding a minimal amount of travel for caregivers[26][27], Figure 7 and 9 shows the path on depthmap analysis. The college of Physicians and surgeons of Pakistan has recognized many of its departments for post-graduate training such as Medicine, Surgery, Obstetrics and Gynecology, Oral and Maxillofacial Surgery and Pathology. The Royal College of Obstetricians and Gynecologists of Britain has granted recognition to the Department of Obstetrics and Gynecology at AMC for the clinical training of the MRCOG candidates.

A second diagnostic and treatment daylight configuration strategy articulated the diagnostic and treatment footprint as shown below. However this strategy is surprisingly ineffective in increasing daylight level. Partnership and collaboration between designers and medical practitioners is fundamental to instilling a public health-inspired ethic in twenty-first-century healthcare facilities.

Because it is a sensitive scenario, there is a proposed approach for a post occupation and pre occupation comparison to further enhance this paper.

The bed distribution for each ward is half of the male and half of the female, which in numbers is 24 male / 24 female and 1 side room for male and 1 for female. The placement of the washrooms, at the entrance of each ward is a definite mistake. There are 3 Medical wards, 3 Surgical, 3 for Gynae 1 ENT, 1 Eye, 1 Gastro, 1 Pulmonary, 3 Peads, 1 Nursery, 1 Neurology, 1 Urology, 1 Cardiology, 1 Oncology, 1 Endocrynology, 1 Dermatology, 1 Cyeatry, 1 Orthopedics and 1 Burn unit of 25 beds.

C. Spatial organization

The compact rectangular unit as shown above in Fig. 4 and 5 is much more flexible that the circular layout in terms of the ratio between patient rooms to amount of support space as shown in Fig. 1 and 2, due to the facility of exchanging the exterior dimensions on all sides at the same time maintaining the equal amount of bed count.

Moreover evaluating the research based on the adoptability into Karachi’s unique culture and medical environment. We applied the selected model of syntax thoroughly to achieve and evaluate results. Thus we proposed the solution for future upcoming research.
The strength of paper is the use of space syntax technique in an interior environment.

Plenty of compact rectilinear plans have an efficiency rating similar to the circulation plans and provides a better degree [28][29].

Here the public and staff circulation is been bifurcation to allow better thoroughfare for communication both verbal as well as non-verbal. Fig. 10 shows the connections of neuro-center, sugary, cancer center and Emergency at macro level.

D. Circulation

A complete bifurcation of these multiple circulation may not be practical though it is not essential if the distance is not huge. Her design for the ideal ward- a long rectangular space with fifteen beds arranged along long walls and single entrance adjacent to the nurse’s station- was widely adopted and christened the “nightingale ward”. Privacy was entirely sacrificed for nursing efficiency and the ability to regulate entry to and exit the ward. Nightingale advocated plans that eliminates small spaces, including closets, sculleries, and lobby areas.

While there are the OT’s of Orthopedics, General surgery, Gynecology and Peds. All the relations are well-established

They have good relation with ICU and wards, but away from the Emergency department. The beds are parallel to the window. Also, there is sufficient space for circulation inside the wards. Nursing station has visual contact with patients. The door openings are wide and stretcher can enter or leave the wards easily. All rooms are heated and cooled by central heating and cooling system.

For inpatient units, the only strategy to achieve day-lighting and visibility in all staff workplace is by revisiting the double loaded corridor plan that the racetrack unit replace. As the evidence from clinicians suggests, by distributing caregiver workstation and support rooms within single room-double-loaded corridor pods, more patients will be in view as they stir to rise from beds, so fewer will be attended and at risk of falling. With supplies in hand and fewer unnecessary trips, nurse travel time of 30 percent will drop towards 20 percent.
organization minimizes vertical circulation travel time.

E. Use of state-of-the-art software Bubble diagram

Built on the site of the public amenity, the project is an expansion of the social cultural center, into developing a healing environment. The developer of Secret hospital wanted a sustainable design that could minimize operation budget, reduce consumption of natural resources, and improve occupant comfort, health, and productivity. As shown in the bubble diagram the multidisciplinary integrated design process facilitated the development of building components that serve multiple functions.

VI. COMPARISION WITH PAKISTANI ICU

Here planning approach places the impatient units opposite parking areas, and develops a therapeutic garden between and around the twenty-four-bed units. Patient rooms provide views of the gardens and more distant vistas of the downtown Karachi skyline.

Fig. 10. The post occupancy evaluation of hospital in Karachi U shape waiting for visibility

Source: used with permission from Quarterly review Medicare

The problem which sometimes arises in the peak hours is the “Time”, which it takes to transfer the patient to the OT’s in the inpatient department. All are linked by the well illuminated natural lighted corridors. The ducts running through are visible clearly, distracting the visitors.

In our research, separation of public and private circulation became one of the major issues to resolve, for it will be uncomfortable and inefficient for both patients and staffs if all these circulations pass in a single corridor.

More patient bed head will be seen with each nurse step. Families will have more opportunities to meet and support each other. It will be found, coincidentally, that these determinants, day lit L-Shape and T-Shape nursing units will join together rather well around courtyards, either off to the side or above Diagnosis and Treatments [31].

Fig. 11. The inauguration session of hospital in Pakistan Source: used with permission from Quarterly review Medicare Jinnah Medical Care Hospital

In the recent project of heart hospital design we applied EBD theory as far as we could. However it was difficult to implement into real project because it is rather a new concept in Karachi while it is prevalent in the practice of North American healthcare design. The main reason it that, in Karachi, there is little existing research on EBD, or even POE (post occupancy evaluation) of existing hospitals which is the most basic material for EBD research. Though we as researcher planned to design based on resources and available research.

One of the client’s goals for the new hospital is that it should function together with the existing context, as an operational facility. It was essential to connect lower podiums as close as possible so that, the service zone of the two buildings can operate as a single department. It became crucial to secure a wide space which is uninterrupted by “cores” such as elevators, stairways, and mechanical shafts, and large enough to accommodate the size of surgery or ICUs on the same floor. Among many massing options, the “Central Spine Linear Street
Scheme was opted for because, with its recessed main core, it gives the best functional efficiency and flexibility not only on its own but also with its flanking service building Free heart camp with screening facilities for ECG, BP, Blood Sugar, Cholesterol and BMI held on March 07. Medicare Cardiologists, Interventionist, Cardiothoracic Surgeons, Medical Specialists, Dietitian and Cardiac Rehabilitation expert examined more than 200 patients.

VII. RESULTS

It was proved that U-Shape provides minimum walking and maximum visibility (as shown in Fig. 4) as nurse is focal point surrounded by patients with two 90o junctions; whereas L shape provides visibility as the nurse is at pivot with one 90o configuration. Lastly, I shape provides vast vista of a panoramic view from the Nurse Station but on the other hand very rigorous walking route for nurse.

A. Limitation and future work: Nurse Circulation in ICU

There is an array of horizontal circulation such as patient (Inpatient and outpatient), staff, visitors and materials. A complete schematic pattern to bifurcate these multiple layers of overlapping circulation may be practically achieved since it is essential in ICU in Korea where the distance is not very high. This research focuses on nurse walking only other overlapping circulation is out of scope. However in the future research author plan to study the overlapping of several set of nursing and separation of public activity and private activity circulation as the major issues that could be resolved.

NS Design is a method that can let nurse see around corners [26], thus design thinking is the upcoming management methodology.

The paper compares various space schemas for health care facilities in Korea and suggest an optimal scheme to ensure barrier free visibility for Nurse to Patient. The findings of this study would be useful for architects and health care managers to design new or retrofit existing healthcare facilities for creating best healing and safe environment for the patients.

B. Findings

Korea is the upcoming field in research and technology especially in healthcare, and ICU is most sensitive and delicate field where there is a demand for an improvement and a scope for incorporating artificial intelligence. This paper has strength of a case study from Korea near Seoul where a hospital is analyzed based on author’s own perception.

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Table III

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<th></th>
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Conclusively we proved that the defined vision is suitable for enhanced communication and reduction of error.

VIII. CONCLUSION

The paper addresses a unique topic where not much research has been done. This topic would be especially useful for architects and healthcare managers in Pakistan.

The subject of the case study was four ICU from three general hospitals in Korea with ICU that has relatively clear layouts in terms of NS and bed positions. Among them two were direct view type i.e. L-Shape or I-Shape and two were lateral or side view i.e. U-Shape. A Conclusively we proved that the defined vision is suitable for enhanced communication and reduction of error.

In Asian culture I-shape is highly appreciated by 76% from the Nurse of the hospital in Karachi. Since the results acquired were acceptable therefore we took into consideration the categorization methods, and then repeated the steps stage 3 till 6 to decide on the optimum of the case study based on the pediatric patient and position on the space syntax map.

IX. ACKNOWLEDGEMENT

The study was arranged by the Korean institute of Healthcare Architecture. It was supported by Higher Education Commission grant for HRDI-UESTP for South Korea. The author performed internship at Jungnim under Director Park the study was patronage. The author thanks the INAUGURATION MEDICARE CARDIAC & GENERAL HOSPITAL Medicare Cardiac and General Hospital was inaugurated on 15th February by Professor Dr Pirzada Qasim Raza Siddiqui, Vice Chancellor Ziauddin University. Chairman, S.M.Sohail Trust, Prof. Dr Tariq Sohail, Ex. Director, Syed Adnan Sohail, renowned Doctors, Corporate sector representatives and Faculty members of the Jinnah Medical and Dental College present on the occasion. Thank you Medicare Management for arranging visit to CICU specially patient Mr. Sheikh Riaz.
Ahmed. He was admitted on Feb 15 for CABG (Medicare 2nd CABG). Photo shows, Mr. Riaz with family members, Cardiothoracic, CICU & Nursing & Management staff celebrating the occasion.

X. NOMENCLATURE

Intensive Care Unit ICU
Surgical care Unit SICU
Medical Intensive Care Unit MICU
Critical Care Unit CCU
Hallym University Medical Center, South Korea (HUMC), ASAN Medical Center AMC
NS Nurse Station,
Space Syntax
Karachi Heart Hospital
EBD Evidence Based Design
Analysis of variances ANNOVA

REFERENCES