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## Healthcare Architecture In Post-COVID Pakistan: A Multi-stakeholder Perspectives On Resilient And Patient Centered Hospital Design

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### Abstract

The COVID-19 pandemic showed that Pakistan's health care infrastructure was already facing challenges, such as chronic overcrowding, lack of isolation beds, lack of ventilation, and the almost complete absence of architects in emergency response planning. Though the relationship of the built environment with patient's outcome has been well documented in international literature, however, the lived experience of healthcare professionals and architects has not been explored in Pakistan in post pandemic era. The study is based on in-depth, semi-structured interviews with three key informants, who represent the three different aspects of hospital planning, namely, design, clinical and administrative, senior government architect with more than 20 years of experience designing public-sector hospitals, an infectious disease specialist and a pediatrician, and a hospital administrator at a large tertiary care facility. The interviews were coded and analyzed using constructivist grounded theory methodology, which uncovered themes of infrastructural challenges, infection control, patient centered design, sustainability and interdisciplinary teamwork. Results indicate that Pakistan's hospitals are mostly reactive rather than proactive in design approach and that flexible and convertible space, natural lighting and ventilation, and architect-clinician collaboration are the most pressing problems that need to be addressed. The study attempts to present a contextualized approach for resilient patient centric healthcare architecture, inspired by the World Health Organization (WHO) guidelines and grounded in the resource, cultural and policy settings of Pakistan. The results have implications for architects, administrators of healthcare facilities, and policymakers who wish to design hospital facilities that will be future-proofed for subsequent public health crises.

**Keywords:** healthcare architecture, post-COVID hospital design, patient-centered care, infection control, Pakistan, resilient infrastructure, interdisciplinary collaboration.

### Introduction

#### Background

The built environment in a hospital isn't usually a silent partner in providing services. Many international research studies have been undertaken and documented, which demonstrate that the physical design of a building, the location of windows, corridor width, clean/dirty room divisions, access to natural light, have a measurable effect on infection rates, recovery times, staff performance and how patients feel (Ulrich et al., 2008). Over the last 20 years it has established itself as a discipline of its own in health related design and institutions like the World Health Organization have published specific information on infection prevention and control standards that hospitals should adhere to (WHO, 2020).

The architecture of health care delivery has, however, been the periphery in the policy debates and practices of health care in Pakistan (Bhatti et al., 2023). The design process for hospitals has focused on incremental growth and convenience of administration instead of a clear, evidence-based planning philosophy. Most of the large public-sector tertiary care hospitals have been built decades back and subsequently extended in a piecemeal manner, which is often not accompanied by a corresponding architectural critique of the effects of the new departments, equipment or patient flows on the existing structures (Bhatti et al., 2023).

This gap was put under a harsh spotlight during the COVID-19 pandemic. Hospitals, from the biggest tertiary care centers in the country, were faced with handling an influx of infectious cases in spaces they had never planned for isolation, surge or airborne infection control (Bhatti et al. 2024). Makeshift isolation wards were created in existing wards, expo centers and other non-healthcare facilities were used as temporary field hospitals and clinical staff very often did not have any specific

area to don, doff or rest away from active wards (Bhatti and Ghufuran 2020). Since that time, the immediate crisis has passed and a critical question arises for architects, administrators and policymakers: "What should be changed the next time?" This study takes a different approach than the one taken in policy documents and top down planning frameworks and asks the question by capturing the first-hand experiences of the people who lived through the pandemic as they experienced it within Pakistan's healthcare system, an architect designing major public hospitals, a pediatrician who continued to treat patients during the pandemic, and a hospital administrator who had to deal with the operational consequences of an inadequately prepared building stock. Their stories, collected by detailed interviews, provide the empirical foundation for a grounded discussion on the possible form of resilient, patient-centric healthcare architecture in the context of Pakistan.

### **Problem Statement**

Even though there are international standards on the design of healthcare facilities and infection prevention, Pakistan's healthcare facilities, especially in the public sector, remain overcrowded, not planned, have poor ventilation and lack any separate infrastructure for isolation facilities. These deficiencies were not new to the COVID19 pandemic, but were revealed and amplified during it, with isolation wards in large tertiary hospitals being filled into single figures dozens of times while these workers continued to work in converted rooms with no separation from infected patients which, however, housed many thousands of beds, and with the clinical teams working in these rooms for weeks without access to natural light or outside views. Add to that a lack of understanding between architects and the staff of the hospitals they design, with architects rarely being involved in the administrative planning of hospitals during crises, and health care professionals receiving little training in hospital planning and rarely being consulted when hospitals are being designed. What has emerged from the process is a built environment that does not fully reflect the clinical facts nor is sufficiently prepared for the crises that are, and are not, likely to confront Pakistan, given its disease burden and climate vulnerability. This study thus examines ways in which the healthcare structure in Pakistan can become more resilient, patient centered and responsive to the challenges of everyday life and future health crises, through the voices of the people who work there: architects, clinicians and hospital administrators.

### **Research Objectives**

The study is guided by the following objectives:

1. To investigate the attitudes of the key stakeholders (Architects, Clinicians and Hospital Administrators) towards the present state of healthcare architecture in Pakistan, focusing on infrastructural gaps and their impact on patient care, operational efficiency and healthcare outcomes.
2. To look at COVID-19 experiences of stakeholders and how the built environment of Pakistan's hospitals performed in the pandemic, key architectural deficiencies and how they were resolved or not during the pandemic.
3. To identify the architectural features and design principles which stakeholders consider most essential for the creation of patient centered, infection resilient environments; and establish a framework for resilient healthcare architecture that is contextualized to Pakistan and aligns with local priorities around flexibility, sustainability and interdisciplinary working, informed by international guidance.

### **Research Questions**

1. What are the perceptions of hospital administrators, clinicians and architects of Pakistan concerning the relationship of built environment of hospitals and the quality of patient care and hospital efficiency?
2. How did COVID19 pandemic expose certain weak points in the architectural and infrastructural performance of healthcare facilities in Pakistan and how did the weaknesses either get resolved or were not resolved at the time?
3. What are key attributes, design elements and interdisciplinary collaborations stakeholders recognize as critical to the design of hospitals that will better serve patients, infection prevention and control, and pandemic preparedness?

### **Research Significance**

The findings of this study have implications for several reasons. First, it focuses on different perspectives from across the design care administration spectrum, enabling the architectural, clinical and operational aspects of hospital planning to be considered alongside each other, and not as separate entities as is often the case in studies that examine only one of these aspects. Second, the study's focus on the reality of COVID-19 pandemic has left a legacy of heightened consciousness among healthcare professionals regarding the impact of architectural neglect, which could be lost from institutional memory as the immediate crisis moves further back in time but is still relevant to current construction and renovation projects in hospitals in Pakistan. Third, the study is one of a scant few studies in the field of context-specific literature on healthcare architecture in low and middle income countries. The majority of the evidence-based design literature comes from high-resourced healthcare systems but hospitals in Pakistan are in a very different context with budgetary, cultural and climatic conditions. This study does not aim at bringing in the international standards and expecting them to be implemented unless they are adapted to the local context, rather it aims at basing the recommendations on what stakeholders say is feasible and necessary. Lastly, the study has practical significance for several audiences including Architects and Design Firms, Hospital Administrators for renovation or expansion projects and Policymakers for providing guidelines and approvals in the planning of hospital building projects in Pakistan.

### **Review Of Literature**

#### **Evidence-Based Design: Theoretical Foundations**

Many of the ideas in the modern discourse on health care architecture are rooted in the research literature on evidence-based design (EBD), which was most thoroughly summarized by Ulrich, Zimring, Zhu, DuBose, Seo, Choi, Quan and Joseph (2008). The review summarizes the results of hundreds of empirical studies and categorizes the outcomes into three general headings: patient safety, other patient outcomes and staff outcomes. Single patient rooms, not multi-bed wards, effective ventilation systems, favorable acoustic environments, daylight and views of nature, appropriate lighting, design for the caregiver, and acuity adaptable rooms, which are able to be reconfigured as the patient's condition changes, are among those design characteristics that have been shown to be present in most instances with improved outcomes (Chandir et al. 2020). Improved floor layouts that reduce unnecessary staff travel around the bed are also shown to be present in most instances with improved outcomes (Dil, Dil, and Maken 2020). The main finding of the review was that the physical environment of a hospital is not a passive factor, but is a dynamic factor that influences clinical outcomes, and this has become an essential component of future research and practice in the field (Qasim et al. 2020).

Continuing this research, Ulrich, Berry, Quan, and Parish (2010) developed a theoretical model for the field of evidence-based design which views the hospital environment as a system in which elements of the architecture combine with the organizational culture and actions of employees and patients to create outcomes that are measurable in terms of health. They have made a point of highlighting that a checklist of "good" design elements isn't enough for EBD, but it's about a process whereby decisions about the design are based on research evidence, post-occupancy evaluation, and refinement over time. This process-based understanding of EBD is relevant to the current study because several participants report that in Pakistan hospital design is often determined early in a project and not reviewed, re-designed, or adjusted as the project progresses, and, as Ulrich and co-authors emphasize, is contrary to evidence-based hospital design (Atif and Malik 2020).

The ability to see nature and have natural light has been a recurring theme in the EBD literature and is one that is strongly related to the findings of the present study. Several early studies in this tradition, such as Ulrich's own work on the healing benefits of a natural view to the hospital garden on recovery from surgery, have demonstrated that even the small amount of sight of green spaces or daylight can lead to a decrease in the need for pain medication and recovery times in patients (Sandesh et al. 2020). The principle of direct connection to natural light and the outdoors, in hospital wards especially those with long-stay hospital patients, which is now widely accepted and has been clearly demonstrated in this line of research, is not present in the current hospital stock in Pakistan as the findings of this study have shown (Majeed and Bashir 2021).

### **Infection Control, Ventilation, And International Standards**

Infection prevention and control (IPC) is at the heart of the architectural literature on the healthcare facility and it is no different when it comes to the World Health Organization's recommendations for natural ventilation for IPC in health care environments (WHO, 2009). This guideline, designed specifically for architects and engineers working in the design and operation of the healthcare facilities, has concluded that proper ventilation, mechanical or natural or a combination of the two, is one of the most effective environmental interventions available for reducing the transmission of airborne and droplet-borne pathogens in hospitals. The guideline sets design parameters including air changes per hour (ACH) for airborne infection isolation rooms, recommends specific configuration of the corridor and windows to provide effective cross-ventilation, and makes explicit the point that no one, the guideline suggests, can be as effective at infection control as the designers, the facility operators or the healthcare workers are.

Important in this context is the fact that WHO guidance explicitly states that in resource limited areas, natural ventilation can be used in place of mechanical ventilation systems without mechanical equipment, provided that buildings are designed from the beginning to include suitable orientations, window height and placement, and corridor configurations. This suggests that natural ventilation is not only a viable option for non-HVAC installed facilities, but also a viable design feature on its own merits, supporting the perspective of the architect and clinicians interviewed for this study (Salama et al. 2020).

Spatial zoning (the physical separation of "clean" and "dirty" pathways) is also a common theme throughout the broader infection control literature, as is the use of anterooms or buffer spaces to preserve the separation between infectious and non-infectious rooms and spaces; and the design of isolation rooms with anterooms or buffer spaces to prevent the direct transfer of air between these two spaces. These principles are well known in the international literature but rely heavily on good design from the beginning of the project which incorporates the zoning from the outset rather than trying to implement strict zoning in an existing building with a high occupant density, which is recognized throughout the literature as being more difficult and expensive (WHO 2020).

### **Healthcare Infrastructure In Pakistan: A System Under Strain**

Although there has been considerable research on governance, financing and human resources in the healthcare system in Pakistan, built environment as a determinant of the quality of care has received much less attention (Bhatti and Ghufraan 2020). However, there are certain strands of this literature that are of direct relevance to the understanding of the context in which the Pakistani healthcare architecture functions. However, the health system definition in constitution, which makes health responsibility a provincial government affair, is implemented in a peculiar manner where the private sector is responsible for serving a significant percentage of the population. The health system in Pakistan is defined in three tiers, Primary health care (Basic health Unit, Rural health Center), Secondary health care (Tehsil and District Headquarters hospitals), Tertiary health care (Hospitals). Underfunding of the system, as evidenced through the proportion of health expenditure to GDP compared to other similar countries, is a recurring theme in research and analysis, and a key driver of a range of downstream issues such as overcrowding, obsolete facilities and the lack of qualified staff. The recommendations from this literature have been mainly around governance reform, capacity development of hospital managers and the adoption of e-governance systems to ensure transparency and accountability in the planning and delivery of healthcare infrastructure projects (Safdar and Yasmin 2020).

A smaller but growing body of work has also begun to investigate Pakistan's healthcare problems from the perspective of post graduate medical education and professional training, pointing out that the next generation of healthcare administrators are lacking in any meaningful interaction with architects, planners, and the built environment during the design of new healthcare facilities, and are therefore poorly equipped to be a part of meaningful discussions with these professions when it comes to the commissioning of new facilities (Ali et al., 2020). This is in line with what the clinicians interviewed for this study indicate: Very few of them felt they had any single mention or lesson on the design of a hospital in their undergraduate training. Importantly, even in the existing literature on the healthcare infrastructure of Pakistan, the focus has been on the quantity, i.e number of beds, hospitals and healthcare workers per population size, rather than on the quality of the design (Khan et al. 2021). Spatial planning, zoning, ventilation, natural light and role of the architect in the clinical workflows are issues that have not been much emphasis in health systems research in the Pakistani context so far and the present study, which is based on an architect's viewpoint, a pediatrician's and a hospital administrator's perspective, can help to address these issues.

### **The Covid-19 Pandemic As a Stress Test For Healthcare Architecture**

While the EBD literature confirms the importance of the hospital design in normal circumstances, in the wake of COVID-19 the literature shows that these designs are being tested and the results are dramatic when the hospital is under acute and sustained stress. The American Hospital Association (AHA) compiled reflections from lessons learned during the pandemic that were realized through facility planning that must be designed to be flexible. Facilities that adopted the concept of modular construction, had "flex" spaces (rooms that could be converted to normal or surge operating modes), and had infrastructure systems (medical gas lines, electrical capacity, telecommunications, etc.) that could be expanded without adjacent areas having to be shut down were better able to respond to the pandemic than facilities designed around fixed, single-purpose room configurations. In particular, the construction of the Huoshenshan and Leishenshan field hospitals in Wuhan using prefabricated, modular, container-based building techniques and building information modelling (BIM) to coordinate design and construction in real time have been widely cited internationally as architectural responses to the pandemic (Wang, 2023). These projects proved the feasibility of building scale and speed of purpose-built infectious disease facilities that feature depressurized isolation units, separate clean and dirty routes of air flow, and speed of negative-pressure room deployment that would have previously been unimaginable given traditional procurement and construction methods. The amount of resources used to carry out such projects is not directly comparable to that available in Pakistan (Ullah et al. 2021) but the design principles of modularity, prefabrication and preplanned "surge" capacity are a body of accumulated knowledge that has been not fully utilized during the Pakistan pandemic response as mentioned by several participants in this study (Rizwan et al., 2023).

Other smaller-scale international responses provide further models that can be more easily transferred. Building a scalable modular isolation ward from prefabricated shipping containers in an open air car park to provide over 50 purpose-built isolation rooms within a few weeks, is a testament to how modular construction with shipping containers can be implemented to introduce purpose-built isolation capacity on to an existing hospital campus without disrupting existing services (Saeed et al. 2024). This type of incremental, site-specific, modular expansion of a field hospital might provide a more realistic template for resource-constrained environments than the large-scale field hospital model, as it is constructed off or onto existing infrastructure (utilities, staffing, supply chains) instead of being a new hospital. What is common in this literature is that people realize that flexibility cannot happen "on the hoof", that is, at the last minute; it must be planned ahead (Ashfaq et al. 2023). Here, those facilities which did not have modular wall systems that could be reconfigured quickly, or reserve space in basements or rooftops were forced to use ad hoc conversion of non-clinical spaces, a practice experienced by participants in this study while describing the experience in the context of dealing with the pandemic in Pakistan, where expo centers and other non-clinical spaces were converted into temporary isolation facilities with minimal architectural input.

### **Sustainable and Smart Hospital Design**

Another aspect of the international literature is around the topic of sustainability, energy efficiency and "smart" technology in health architecture, which is becoming increasingly relevant in the context of the climate emergency and high operating costs of healthcare systems worldwide. Recent assessments of pathways to energy efficient healthcare buildings have highlighted the potential for solar energy as a practically accessible source of renewables for hospitals, due to its low levels of complexity for retrofitting on existing buildings, as well as its operational resilience in settings where electricity from the grid is not reliable (Khan et al. 2022). These reviews also emphasize the need for maximizing occupant comfort while minimizing energy, the need for involving a variety of stakeholders in designing energy systems (including clinical staff), and the ability of locally-sourced materials to lower costs and carbon footprints (Han et al. 2022). The "green hospital" literature in general does not separate out sustainable elements from the design and placement of hospital buildings, but rather treats sustainable design as a whole, including the use of green roofs, creation of internal courtyards, use of landscaping views, energy-efficient building envelope, creation of renewable energy systems, and recovery and recycling of water (Navaratnam et al. 2022). International experience shows that sustainable design features can be implemented to healthcare buildings without compromising, if not improving, infection control and patient comfort, such as combining natural ventilation strategies with on-site PV generation and water recycling.

The literature on solar energy adoption in primary healthcare facilities, such as efforts to solarize rural health facilities and implement solar hybrid systems in several districts, shows that even small-scale, individual facility solarization can make a substantive contribution to the reliability of essential services in primary healthcare, particularly vaccine refrigeration, night-time emergency lighting and diagnostic equipment power (Boby, Sugga, and Dewan 2022). The solar power, biometric entry

systems, and paperless record-keeping are smart and sustainable and have been seen in other countries or they believe they could be implemented in Pakistan, but the financial considerations mentioned by the participants have so far prevented their widespread use.

### **Patient-Centered Care, Healing Environments, and Cultural Context**

The idea of the "healing environment", a physical space intentionally structured to minimize patient and family stress and enhance healing for all patients, families, and staff — has grown to be one of the key organizing ideas for patient-centered healthcare design (Makram and El-ashmawy 2022). It is rooted in the EBD evidence on daylight, nature elements, noise control and room configurations, which help to reduce disorientation and provide a sense of control for patients. It is important to note that the healing environment concept is not culturally neutral; the concept of what is a supportive, dignified, and comfortable environment is based on the local social norms, religious practice, and family structure, which means how spaces are organized depends on it (Capolongo et al. 2020).

Where gender-segregated care is an important cultural and religious factor (as it is in most parts of Pakistan) then the design implications are not confined to the designation of separate wards for male and female patients. They include space arrangement, setting and privacy of consultation and examination rooms, the flow of staff in and out of these rooms, and the availability of prayer rooms and family spaces to meet the extended-family visiting pattern that occurs in the South Asian healthcare environment (Akhtar and Ramkumar 2023). The international EBD literature increasingly recognizes the value of cultural responsiveness in design, and many of the empirical evidence bases are grounded in North American, European and East Asian healthcare systems, with a relative lack of documented, context-specific design solutions for South Asian and Muslim-majority healthcare environments, an area where qualitative, stakeholder-led research like that conducted in this study can help fill gaps.

### **Interdisciplinary Collaboration and the Implementation Gap**

Lastly, a recurring theme across all of the literature examined in this study is the disconnect between the knowledge available of successful healthcare design, and its actual implementation in practice, and this disconnect is often blamed at least in part on the lack of interaction and communication between a building's architect, clinicians, and healthcare administrators throughout the planning and design process (Shedid and Mokhtar 2023). The framing of EBD as an iterative process is based on an assumption that there are continuous conversations between designers and healthcare staff, and that there are planned opportunities to share clinical feedback with the designers to inform design decisions and for review of completed facilities to assess the outcomes for which they were intended (Ahmed Zahran et al. 2023).

However, in practice, the literature on healthcare facility planning, and the post-pandemic related facility planning literature mentioned above, shows that architects are often only introduced into the hospital project once important decisions on the scope, budget and even the basic structuring of the spatial layout have already been made, without the architects having said a word voiced their perspectives in any structured way (Kropf and Zeitz 2022). This pattern seems to be particularly prevalent in public-sector health care systems in low and middle-income countries, where investments in infrastructure projects are often determined by administrative and budgetary requirements rather than by design or clinical workflow (Aidarova and Aminov 2021). This study's findings, as reported by some of the international sources analyzed here, indicate that there is a clear divide between the existing evidence base on what makes hospitals safer and more healing and the buildings that are actually constructed, a disconnect which has been evident ever since the evidence started to grow.

### **Conclusion – Review of Literature & Gap Identification**

Combined, the literature reviewed in this section, makes three points very clear. First, there is a solid and expanding international evidence base supporting positive outcomes such as improved patient outcomes in terms of safety and recovery, and improved staff wellbeing that relate to specific architectural characteristics: ventilation, daylight, spatial zoning, modularity, and systems of sustainable operations. Second, the COVID-19 pandemic was a global stress test that revealed the impacts of planning hospitals that lack flexibility, surge capacity or a robust infection control system, and created a wealth of practical experience in how these shortcomings can be met in the future, from large scale modular field hospitals to smaller units such as container-based isolation wards. Third, much of this evidence base is inaccessible in countries such as Pakistan due to structural barriers that hinder the translation of international evidence into local practice, such as lack of proper professional training, centralized and non-collaborative approval processes, budgetary restrictions and others. What is still not well captured in this literature, however, is the firsthand experience of those who work in the healthcare system in Pakistan, including architects who have created its hospitals, clinicians who have served in its hospitals during a public health crisis, and administrators who have experienced the day-to-day functioning of hospitals. The present study, which employed a constructivist grounded theory analysis of interviews with an architect, a pediatrician and a hospital administrator, aims to close this gap.

### **Research Methodology**

#### **Research Design**

The research design used in this study is a qualitative research design that is based on the Constructivist Grounded Theory (CGT) approach developed by Charmaz (2006). There were two main reasons for using CGT instead of other qualitative methods. The research questions in this study, first of all, do not aim to test an existing theory but to explore and discover how the built environment is comprehended by the various actors in the Pakistani healthcare system, especially in the context of the experience they had during the COVID-19 period, which makes them best suited to an inductive, theory-generating process rather than deductive, hypothesis-testing process. Second, CGT also makes explicit the role of the

researcher in the construction of meaning: he is not a "neutral observer" who extracts "facts" from data. This is important because of the present researcher's own disciplinary perspective (architecture) that inevitably colours the way questions are asked in the interview process and the way the participant's answers are interpreted; the reflexive approach of CGT provides a methodologically honest structure for this kind of cross-disciplinary dialogue, where the researcher from an architecture background interacts directly with the clinical and administrative perspectives from outside their own professional training.

### Participants and Sampling

Participants were purposively selected to represent the three principal stakeholder groups identified in the literature as central to healthcare facility planning and operation: design professionals, clinical staff, and hospital administration. Purposive sampling of this kind is well suited to small-N qualitative studies where the goal is depth of insight across a deliberately diverse range of perspectives, rather than statistical generalizability across a larger, more homogeneous sample. Three participants were selected on this basis, summarized in Table 1.

**Table 1: Participant Demographics**

| Participant             | Role                                                                                       | Institution                                                            | Relevant Experience                                                                                                                                                                                                                                                                      |
|-------------------------|--------------------------------------------------------------------------------------------|------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ar. Zahid Javed Raja    | Architect; former Chief Architect, Government of Punjab (Communication & Works Department) | Government of Punjab; private healthcare architecture practice         | Nearly three decades of experience designing public-sector hospitals across Punjab, Khyber Pakhtunkhwa, Islamabad, and Balochistan, including specialized facilities such as kidney hospitals; personal experience as a COVID-19 patient in an ICU during the pandemic                   |
| Dr. Mohammad Faheem     | Professor of Pediatrics and Programme Director, Pediatric Infectious Diseases              | King Edward Medical University (Government Medical University), Lahore | Over 15 years of clinical experience in pediatric care, including direct management of infectious disease cases and isolation protocols during and after the COVID-19 pandemic                                                                                                           |
| Dr. Abdul Mudabir Rehan | Associate Professor, hospital Pharmacology; administration role                            | Services Hospital, Lahore (Postgraduate Medical Institute network)     | Extensive experience in tertiary care hospital administration, including direct responsibility for patient flow, infrastructure utilization, and pandemic-period facility management, with comparative exposure to internationally consulted hospital designs (e.g., Nishtar 2 Hospital) |

This mix of participants was specifically selected to enable the triangulation of the three aspects of the architecture of hospitals: the design, the clinical and the operational. The architect's perspective provides a technical, regulatory and professional viewpoint of the dimensions of hospital design from within a public sector; the pediatrician's perspective provides a view of the day to day clinical consequences of design, in particular for a population whom the discussion of hospital design is often lacking (children); the administrator's perspective provides a view of how design decisions or the lack of design input relates to operational consequences of patient flow, infection control and resource utilization.

### Data Collection

In-depth semi-structured interviews of 20 to 40 minutes were used to gather data. A semi-structured approach was selected to give enough structure so that all the participants covered a similar set of thematic areas relevant to the study's research questions, but give enough flexibility to enable participants to expand on those areas of particular relevance to their own professional experience, and for the interviewer to follow up on unplanned lines of inquiry that occurred during the conversation.

The interview protocol was structured into six thematic areas: (1) understanding current challenges in health care facility in Pakistan; (2) perspectives on patient centered care; (3) integration of sustainable and smart design; (4) lessons learned from COVID-19 pandemic; (5) evidence-based design and multi-user (architect-clinician) integration; and (6) future directions in health care architecture. This format aimed to help participants to move from a general discussion on the problem diagnosis, to specific design and sustainability insights, to a structured reflection on the time of the pandemic, and then to address future questions regarding the connection and future design requirements. All interviews were audio-recorded with participants' consent and transcribed verbatim to keep the full texture of the participants' responses—including the conversational back-and-forth between interviewer and participant, which often indicated a point of clarification, disagreement, or elaboration that would have been lost in the heavily edited transcribed version.

### Data Analysis and Coding Procedure

Data analysis was conducted using grounded theory methodology which has three steps of coding and analysis, namely initial (open) coding, focused coding, and theoretical coding. In the initial coding, each transcript was read line by line and short descriptive codes were triggered for phrases or subsections of text that expressed the participant's own language and framing, as much as possible: for instance, codes generated from the participant's own description of their experiences included "lack of isolation wards," "dark corridors," "natural light reduces infection," and "no architect involved in COVID wards. A great variety of granular codes was identified at this stage in all three transcripts, allowing the authors to capture

the potential issues raised by participants without imposing an external thematic structure or attempting to reduce the responses to a limited number of themes.

A focused coding approach was used to compare the initial codes between the transcripts and to classify the codes that were cited by a number of participants, or, in the case of a single participant, but were considered to have conceptual significance relative to the study's research questions, as higher level codes. The resulting codes were targeted, for example: "overcrowding and spatial constraints," "infection control and zoning," "natural light and ventilation," "pandemic-driven architectural adaptation," "sustainable and smart design integration," and "interdisciplinary collaboration gaps. Of particular interest here were points of convergence and divergence between participants, such as the architect's focus on the lack of architectural involvement in space conversions over the COVID era, which was explored in connection to the pediatrician's and administrator's perspectives on space conversions from a clinical and operational perspective, which in turn enabled triangulation of a single phenomenon (the architect-clinician disconnect) from three different angles.

In this theoretical coding phase, focused coding was expanded to smaller number of overarching theoretical categories and relationships among these categories were analyzed to provide an explanatory grounded framework. The focused codes are presented in the proposed Healthcare Architecture for Resilience and Patient-centric Healthcare in Pakistan in the Discussion section. Throughout this process, analytic memos were created to record the changing interpretations the researcher had of the data, to note inquiries that the data raised for further consideration, and to define the thinking processes that underlie each step in the development of theoretical syntheses that is demanded by CGT.

### **Ethical Considerations**

The purpose of the study was explained to all participants, as well as the use of the interviews for doctoral research and their right to not answer any question or to withdraw from the study at any time. In this article care has been taken to present findings in a way that is accurate in capturing participants' perspectives on their roles within their institutions and to avoid attributing statements that could be interpreted as institutional criticism that might cause professional difficulty for the people referred to, given the relatively small number of participants and their institutional roles. Specific institutions, colleagues or events were mentioned by participants when they indicated that they referred to these as examples of good design, but with discretion when they were referred to when more sensitive issues of administration and governance were raised.

### **Trustworthiness and Rigor**

Several steps were adopted in order to ensure the reliability of analysis. The first thing that was done was the use of verbatim transcription so there would not be a risk for the researcher's own interpretations to replace or become participants' interpretations during the process of coding. Secondly, the multiple coding stages, that is, from codes at a level of granularity that were generated at the start of the process, to broader level codes that were produced at a theoretical level, provided an audit trail that enabled the resulting interpretation to be judged as being credible. Third, the selection of participants, each with a different professional perspective enabled a form of triangulation in which commonalities (e.g., the lack of architect-clinician collaboration) were explored from multiple, independent viewpoints, thereby increasing the confidence that these characteristics were not idiosyncratic to the individual or the perspective of the participant.

### **Research Findings**

The results reported in this section were obtained in the three steps of the earlier coding. They are grouped in six topical areas that emerged consistently in the interviews with Ar. Zahid Javed Raja (the architect), Dr. Mohammad Faheem (the pediatrician) and Dr. Abdul Mudabir Rehan (the hospital administrator): overcrowding and spatial constraints; infection control and zoning; natural light, ventilation, and healing environments; pandemic-driven architectural adaptation; sustainable and smart design integration; and the interdisciplinary collaboration gap. For each category, the views of all three participants are stated together, and direct comparison of convergence and divergence among the design, clinical and administrative views is possible.

### **Overcrowding and Spatial Constraints**

Overcrowding and a lack of facilities in health care systems in Pakistan as a result of over demand for facilities were considered by all three participants as a key issue affecting almost all other areas of health care architecture. Dr Rehan presented this aspect most clearly in the context of patient to bed ratio, meaning that patient numbers in secondary or tertiary care establishments in Punjab are increasing while beds are not increasing as much. He said that structural changes to hospitals' facilities are needed and cannot be achieved with just the addition of beds, such as the establishment of separate corridors and entry/exit routes for patients with contagious illnesses, stable patients and those that are critically ill, and that none of these currently exist in any systematic manner.

Another, more under-the-hood, example of bad spatial planning, Dr. Rehan noted, was how the buildings were arranged within the hospital. He cited a hospital in Lahore that is using ambulances to transport patients from one block of the same building to another, as there are no proper pedestrian corridors, passenger lifts or bed lifts to manage the high number of patient transfers within the hospital. He said this sort of problem could be solved with relatively small fixes like underground tunnels or covered bridges between blocks but that a lack of those sorts of bridges and tunnels is a "very basic infrastructure flaw" that has "significant resource consequences downstream.

Dr. Faheem also looked at the problem of overcrowding in a slightly different way, and said that the government is trying to tackle it at its level best, but at the same time that the population growth and increased patient load both put it further and further behind in addressing the issue. It is noteworthy, however, that Dr. Faheem was not as forthright as the other two

participants in this regard, noting that the COVID-19 period did not reveal new vulnerabilities in infrastructure, but rather hastened a trend toward telemedicine and remote consultation that would reduce some demands on physical infrastructure — a point that complicates the single-minded focus on infrastructure failure as described in other parts of the narrative and is explored in more depth in Section 4.4.

Ar. Zahid located the overcrowding issue in a larger critique of how space in hospitals is thought and designed. He explained that there is a “zones model” used worldwide to design hospital departments based on the level of their functionality and risk level, where five zones model is present in more advanced healthcare systems, and second or third zone model exist in Pakistani hospitals. For Ar. Zahid, it is not just about square footage, it's about the lack of an institutionalized process in the Pakistani context and the development of space standards specific to healthcare buildings. He suggested the establishment of a “dedicated research and development institute” to investigate the needs of space in healthcare (for example, the size and form of space in x-ray rooms have changed significantly since the advent of digital imaging, so the institute could study and monitor these needs and return), and that it could systematically collect patient, doctor and other end-user feedback to guide the development of space standards.

### **Infection Control and Spatial Zoning**

Infection control was a recurring theme throughout the three interviews but each interviewee was considering the theme from a different perspective.

Dr. Rehan was the only one who gave the most architecturally specific account of the measures taken for infection control, referring to Nishtar 2 Hospital, which he said was designed with the input of international consultants. He emphasised three aspects of that facility of particular interest: it had an HVAC system that not only controlled temperature but actively disinfected the air it circulated; that it provided a clear physical split between “dirty” and “clean” corridors; and that washrooms were located in the corners of each of the building's floors rather than being in individual wards and offices, which he said helped to limit the spread of infection between different ward areas. He said that this experience was very different from that in most hospitals in the public sector in which “we don't even have enough resources and equipment to heat and cool, let alone the more complex zoning and air-handling systems like Nishtar 2.

Dr. Faheem's presentation on infection control was based on his clinical specialty in paediatrics with emphasis on infectious diseases. He termed the most important architectural component of the healing environment as “airborne precautions”, which he said most healthcare facilities in Pakistan do not have a specific room for implementation of airborne precautions or that the architecture of the rooms where the precautions are implemented is different and significant from the other categories of precautions. When asked if his department had any isolation wards now, Dr. Faheem agreed but declined to specify any benchmark figure of the ratio of isolation rooms to the total number of beds, a deficiency that, along with Ar., The more specific figures offered by Zahid and Dr. Rehan (per Section 4.4), indicates that even if isolation infrastructure is available, there is no common understanding among stakeholders about how many should be considered adequate.

Ar. Zahid's experiences of infection control were influenced by his personal journey as a COVID-19 patient, spending around 40 days in an IC Unit during the pandemic. The room he was in was a converted room and had no windows and two doors which were “very gloomy” and with no visual connection with the outside world, he described. He learned from this experience a wider architectural lesson that future isolation and critical care units should be designed in a way that gives patients a direct visual or physical link to the outside world so that they can see what is happening outside; and that this has a positive impact on their psychological recovery. He also argued that in the event of an infectious disease, strict sterilizations and controlled movements of staff are important, as a disproportionate number of doctors and nurses got infected during the pandemic due to their proximity to the patient and because no separation was built between the working areas of the doctors and the areas where the patient is being treated.

### **Natural Light, Ventilation, and Healing Environments**

This theme of the importance of natural light and ventilation in establishing healing environments was concurrent, but distinct from infection control, and was strongly represented in all three participants, but is also congruent with the WHO guidance on natural ventilation in healthcare facilities presented above and the wider evidence-based design literature reviewed.

Ar. Zahid was the most vocal about the need to pay attention to natural lighting and ventilation as a design consideration which is explicitly being ignored in the building of hospitals in Pakistan today. He said “most of our modern buildings, we're trying to avoid using natural lighting, natural ventilation, and instead using mechanical ventilation systems which have their own infection risk, especially for diseases transmitted via the air, because the recirculated air itself may be a transmission vector. He insisted that natural lighting should be used ‘as a medium’ (basically as a tool for design) and not just in patient rooms but also in circulation spaces, verandah areas and other patient and staff meeting areas. He also commented on the homogeneity of colour and visual environment of spaces he had visited while hospitalized and proposed that careful consideration of colour and view, in this case views of green space, is a low cost design intervention that has a positive impact on the wellbeing of patients.

Dr. Rehan's point of view on this theme was somewhat muted but still in the same direction. His emphasis was on mechanical infection-control systems (disinfecting HVAC system in Nishtar 2), but he did recognise that there is a lot of architectural literature out there on energy-efficient and climate-responsive design, which would differ greatly depending on the different climates all over the world, and that this sense of climate-responsive thinking is underdeveloped in Pakistan, and is usually limited by resource availability — not lack of awareness.

Dr. Faheem was a bit more conservative. He was asked directly about the use of landscape design as a solution to health problems faced in the region, taking the example of a dengue outbreak in the state of Punjab, and he admitted that there

was a bit of a struggle with this aspect with respect to in-hospital patient care, but that this would be more relevant in the community and household environments where mosquito breeding occurs instead of inside the hospital building itself. This is not a criticism of the two other responses as it is merely an observation of the pattern that can be seen throughout the data, that is, Architects' knowledge of architectural concepts and terms is far from uniform; and the design interventions that Architects might see as intuitively linked to health outcomes are not necessarily shared in the same way by clinical staff, which has direct consequences for the theme of interdisciplinary collaboration discussed earlier.

### **Pandemic-Driven Architectural Adaptation: Lessons from COVID-19**

All three interviews revolved around the COVID-19 pandemic and the COVID section of the results is one of the most revealing sections of the interview data.

Ar. The lack of architects' involvement in the structural changes and conversions that took place during the pandemic was clear in Zahid's account of the isolation ward shortage: "As I know, architects were not involved at all in the changes and conversions made during this period. Rather, hospital administrators used practical experience and knowledge gained from others — sometimes from observing response in other countries — to transform existing areas for use as isolation spaces as needed. Ar. He said he was himself hospitalized for 40 days, and that these were simply "reused" as ICUs without any of the factors you might expect in a purpose-built isolation space, such as windows, ventilation, or zoning.

Dr. Rehan's talk on the pandemic, highlighted the systemic repercussions of the absence of architecture. In reality, he added, public-sector hospitals do not have isolation rooms, as spaces were simply designated as such administratively, without the disinfection areas, scrub areas or buffer zones that true isolation infrastructure would need. He was clear that for the immediate crisis, temporary measures like using expo centers as field hospitals were "serving their purpose" but were not a lesson for preparedness. His idea was not improvisational, but instead structural: Hospitals need to be planned at the outset with reserve capacity available in the building's roof and basement—extra floor load-bearing capacity, extra service risers, modular partition systems—powered by the ability to quickly convert these spaces into new wards in time of crisis. He made a direct comparison with some other nations where they have pre-built modular structures or underground facilities for such a purpose, whereas in Pakistan, there has been no smart technology or architectural planning for the process and they have "just converted one building and expanded it".

Ar. When asked the same question, Zahid's answer was structurally identical to Dr. Rehan's, but was more technical in architectural terms. He noted that most of the buildings in hospitals in Pakistan are designed using flexible column and beam structural systems, which allow for the movement of interior walls within the building in principle, as long as the structural stability of the entire building is not affected. He said architects should include this flexibility in the design of hospitals from the very beginning to be able to configure the rooms of big halls in case of future hazards without having to resort to the kind of improvisation that Pakistan's response to COVID-19 had witnessed — such as the Punjab government using large halls and an expo center due to the lack of such flexibility in hospitals.

Both Ar. Zahid and Dr. Rehan also proposed to use small scale modular architecture which could be implemented to wards to enhance infection control in the event of a crisis. Ar. Zahid suggested an idea of "sanitation pods" which has been introduced as a self-contained unit containing a toilet and sterilized washing facilities placed next to every patient bed, rather than forcing patients (many of whom, he said, are physically unable to move easily to shared washroom facilities) to cover large distances to reach those facilities. He said this was part of a larger discussion about patient mobility and recovery, arguing that space should be provided for patients to move—whether in small pods close to their beds, or in larger lawns and courtyards for patients who are feeling better to walk around—to meaningfully advance "earlier rehabilitation conditions."

Dr. Faheem's own contribution to this theme, somewhat less architecturally elaborated, added an important dimension to the other two interviews: the telemedicine and the remote care as an architectural and operational adaptation, in and of itself. The impact of the pandemic on healthcare delivery has been "both ways," he said, both putting pressure on resources and providing an impetus to shift care to "resource-limited settings" via telemedicine — not just a lack but an opportunity. He also asked whether the concept of isolation infrastructure could be expanded to a community level, instead of the hospital level, to provide dedicated areas for community members to isolate family members in the event of an outbreak of dengue or COVID-19, and described this as a community-based home isolation.

### **Sustainable and Smart Design Integration**

Results of sustainable and smart design showed a greater diversity among the three participants, depending on the different extent of direct contact to such design projects.

Ar. Zahid gave the most practical example by talking about his participation in the design of a Kidney Hospital in Swat where he explained how the concepts of "smart" were being introduced in the process of hospital construction, among them the use of a paperless documentation system. He spoke about the overall value of such systems in operational terms: "It is something that can bring very quick working, very efficient working to the hospitals" and added that while considering the smart design of operating systems, it was important to take into account the exterior treatments and materials, which would be suitable for Swat's mountainous climate and should not simply be a copy of the exterior treatments of a hospital built for the plains environment of Lahore.

The experience Dr. Rehan had in the Nishtar 2 Hospital was the focus of his account again, which he said reflected the type of "purpose-built" infrastructure of which smart and sustainable design is expected to deliver. He explicitly connected the fact that smart hospital designs might become a possibility in Pakistan with the experience of China in building pandemic-specific hospitals, arguing that China's success in building pandemic-specific hospitals showcased the ability to practically

translate architectural and technological knowledge into purpose-built infrastructure tailored for the needs of pandemic COVID patients, and that Pakistan should follow suit and learn to do the same.

Dr. Faheem's answers to questions on sustainable and smart design were the most guarded of the three. He asked for clarification when he was directly asked what he meant by 'sustainable architecture' and, when given examples, (AI-based tools, solar panels, pollution-resistant paints, water reservoirs), admitted that these can be of help, but doubted whether the healthcare system in Pakistan was at the same level as other countries. He was not familiar with nor involved with any undertaking that involved any aspect of smart technologies in the hospital. On the other hand, the response given, although not as detailed in specific terms as the other two, is still a valuable discovery and one that points towards possible current focus on sustainable and smart design by architects and senior hospital leaders having access to certain exemplary projects, but not necessarily by clinical staff more broadly.

### **The Interdisciplinary Collaboration Gap**

One final finding, probably the theme through all of the others, is the relationship, or lack thereof, between architects, clinicians and administrators regarding the planning and design of healthcare facilities.

Dr. Faheem put this most clearly and notably, suggesting an institutional solution. After having spent over 15 years in the service of various hospital buildings of different ages and design quality, he expressed his confidence that "before starting any hospital, there must be a committee comprising of healthcare professionals and the architectural teams, where doctors would be asked systematically how their working environment can be improved; hospital spaces should be a heaven for the doctors at least, as they spend more time in them than any other kind of user. He also noted that hospital design and planning had been hardly addressed during his own medical training, as had been found in the medical curricular literature reviewed above.

Dr. Rehan's presentation on the collaboration gap was more of a procedural and institutional approach, and specifically highlighted the institutional framework in which hospital construction decisions are being made in Pakistan. He explained that architectural designs are often approved early without what he called a 'SWOT analysis' and that the delay from approval to construction can be as long as 20 years or even longer, which may allow for a change in the surrounding environment, the catchment area for the patients served and even the use of the building itself. As a particularly striking example he quoted a building that was originally built as a medical college and was then converted to a hospital, all the design mismatches that implies. He said that this trend was due to the lack of any formalized, continuous collaboration between the health department and the architectural/planning departments and recommended that the two be bound under a Memorandum of Understanding (MOU) where in the architectural departments should be expected to contribute their expertise on the technical design and the health department would be expected to contribute to the operational and clinical aspects of the works of the architects, but with each one operating in its own area of expertise.

Ar. Zahid's vision of collaboration was both professionally in terms of training and also in terms of governance. His observation was that the world recognizes healthcare architecture as a specialized sub discipline and he noted that this isn't the case in Pakistan, where the majority of architects have reached the profession of hospital design by accident. He suggested the establishment of a standing committee comprising doctors, engineers, and architects to discuss advancements in both sectors and to develop policy recommendations for the government – a structure that is very similar to Ar. Rehan's proposed MOU, but in the context of doctors, engineers, and architects. Zahid, not administrative procedure, was the means of professional knowledge-sharing. Strikingly, Ar. The problem with this, Zahid said, is that during the peak of the COVID-19 lockdowns, the only ones "thriving for their lives and other people's lives" were the frontline doctors, who, in Zahid's opinion, were faced with the task of coordinating emergency space conversions "without coordinating with other professionals or other technocrats who could have helped them, including architects and engineers.

### **Summary of Findings**

In all six focal categories, the three interviews yield a consistent picture. The healthcare architecture in Pakistan, at least as experienced by an architect, a pediatrician and a hospital administrator in the context of an existing public tertiary care system, is marked by chronic spatial constraints, the lack of real architectural provision of infection control measures, a shared (though not equally understood) appreciation of the value of natural light, ventilation and views of nature in patient recovery, a pandemic response which was almost exclusively improvised and non-architectural, the absence of any pre-planned flexible or modular capacity for space, and a persistent gap between those who design healthcare buildings and those who work within them, which each of the participants, from their own professional perspective, identified as a priority for change. The results of this study are the foundation for the following discussion and proposed framework.

### **Discussion**

The results outlined above suggested a list of connected healthcare priorities for the future in Pakistan: priorities, which while rooted in the individual experiences of three persons, relate very closely to the international evidence-base outlined in Section 2. This section summarizes those findings in a proposed resilient, patient-centered healthcare architecture, and then explores a series of policy recommendations and limitations of the study.

#### **Toward a Contextualized Framework for Resilient Healthcare Architecture**

The five overarching pillars that emerged were theoretically developed in Section 3.4 and were supported by the focused codes that were identified in Section 4 and by strands of the international literature reviewed in Section 2. This framework is summarized in Table 2, which assigns a key strategy to each pillar, provides background on the findings from the study, and includes an example from the participants or from the body of literature.

**Table 2: A Proposed Framework for Resilient, Patient-Centered Healthcare Architecture in Pakistan**

| Pillar                                               | Key Strategy                                                                                                                                                                                                                                                                      | Grounded In                                                                                                                                                                                                                                   | Illustrative Example                                                                                                                                                                         |
|------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Flexibility and Surge Adaptability                   | Design hospitals with reserve structural capacity (rooftops, basements, flexible column-beam systems) and pre-planned modular partitioning so that surge capacity can be activated without ad hoc conversion of non-clinical spaces                                               | Dr. Rehan's proposal for reservable rooftop/basement floors; Ar. Zahid's observation that flexible structural systems already exist but are not designed-for in advance                                                                       | Modular, prefabricated isolation wards of the kind used internationally during COVID-19, adapted to incremental, site-specific expansion rather than large-scale field hospital construction |
| Infection Control and Spatial Zoning                 | Physically separate clean and contaminated circulation routes, position washrooms and sanitation facilities to minimize cross-ward movement, and integrate air-handling systems capable of both climate control and disinfection                                                  | Dr. Rehan's account of Nishtar 2 Hospital's separated corridors, corner-located washrooms, and disinfecting HVAC; Dr. Faheem's emphasis on dedicated airborne precaution areas                                                                | WHO (2009) guidance on natural ventilation design methods and zoning for airborne infection control                                                                                          |
| Natural Light, Ventilation, and Healing Environments | Prioritize natural lighting and ventilation as primary design tools rather than relying on mechanical systems alone; ensure patient areas — including isolation and critical care units — retain visual and physical connection to the outdoors; use color and views purposefully | Ar. Zahid's first-hand account of a windowless converted ICU and his call for natural light "as a medium"; broader evidence-based design literature on daylight and views of nature                                                           | Single-side corridor natural ventilation designs described in WHO (2009); evidence-based design findings on daylight and recovery outcomes (Ulrich et al., 2008)                             |
| Sustainable and Smart Design Integration             | Incorporate climate-responsive design (local materials, orientation, passive cooling/heating appropriate to regional climate), renewable energy (solar), and digital/paperless systems where feasible, scaled to budgetary realities                                              | Ar. Zahid's Swat Kidney Hospital experience and emphasis on climate-appropriate design; Dr. Rehan's reference to purpose-built, internationally consulted facilities                                                                          | Solar-powered and climate-responsive healthcare facility models documented in the international sustainable healthcare design literature                                                     |
| Interdisciplinary Governance and Collaboration       | Institutionalize structured collaboration between architects, healthcare professionals, and administrators at every stage of hospital planning, design, construction, and post-occupancy evaluation, formalized through standing committees or memoranda of understanding         | Dr. Faheem's proposal for a joint committee before executing any hospital project; Dr. Rehan's proposed MOU between health and architecture departments; Ar. Zahid's call for a standing multi-professional policy committee of understanding | Ulrich, Berry, Quan, and Parish's (2010) conceptual framework positioning EBD as an iterative, collaborative process rather than a one-time design decision                                  |

This framework is different from the majority of the frameworks based on higher resource health care systems in two significant ways. First, it does not view interdisciplinary governance as an enabling condition of good design, but as a pillar that is as much a cause of the other four as they are of it. It is the consistency and emphasis with which all three participants, from their respective professional perspectives, came to view the disconnect between the architect, clinician, and administrator as a root cause of the other four that brought this issue to the forefront. Even where there is a good awareness of the principles of design (natural ventilation, zoning, modular flexibility), these are, as this study has shown, known but not practiced. Second, the framework takes a proactive approach to addressing resource limitations as a starting point, not an afterthought; this is evident, for instance, in the "Sustainable and Smart Design" pillar, which emphasizes that solutions must be "scaled to budgetary realities," not merely applied to systems with ample resources.

### Discussion of Findings in Relation to the Literature

There were several overlaps and discrepancies between the results of this study and literature reviewed in review of literature.

These results clearly support the major tenet of the evidence-based design literature, which is that the environment of a hospital is a dynamic element that influences the outcomes of care, not just a passive backdrop (Ulrich et al., 2008). Ar. Zahid's description of the converted ICU room in which he had to be hospitalized is the archetype of the kind of setting the EBD literature describes as having a negative impact on recovery, and his advice of "direct visual and physical connection with the outdoor" is very similar to the daylight and nature-view findings synthesized by Ulrich and colleagues. What the findings contribute to this literature is the vivid demonstration of how such environments 'happen' in practice, namely that

they are emergency spaces that are not intentionally designed to include these factors, but rather result from the spontaneous conversion of pre-existing spaces, without any architectural input whatsoever.

Likewise, the results are comparable to the WHO's (2009) stance that natural ventilation is a viable, evidence-informed infection control approach in resource-limited environments – Ar. Zahid's objections to mechanical ventilation are similar to the one in the guidance of WHO, which instead of being a last resort, is another design solution that is presented with its own set of evidence. Lungarini has explained) made it challenging to select window size and shape in the design of the new restrooms. Concurrently, the results show an un-met need that is not directly included in the guidance: the absence of any institutionalized space-standards process (as explained by Ar. Lungarini) meant that it was difficult to choose the size and shape of the windows in the design of the new restrooms. This description of Zahid's (no mechanism) means that neither there is any organized way to incorporate that as guidance when designing new hospitals.

The results in relation to the literature on COVID-19 modular hospital (Section 2.4) are more complicated. The participants were quite conscious about the Chinese experience of fast-track, modular hospital construction and they spoke positively about it (Dr. Rehan especially), but none of them mentioned any attempt to adapt or apply such principles in the Pakistani context in the course of the pandemic itself. This indicates a lack of understanding of best practice in overseas countries, not the absence of such practice, but rather the lack of the institutional structures – pre-identified surge spaces, expertise in building modular constructions and most importantly, the involvement of architects in emergency planning – that would be needed to make that best practice a reality. This is in line with the general trend noted in Section 2.7, that the literature provides little indication that the "implementation gap" in healthcare design is due to a lack of technical knowledge, but instead relates to structural and institutional barriers.

Last but not least, the results advance the body of literature on patient-centered, culturally responsive design (Section 2.6) in a limited but significant manner. Although none of the three participants in this study's final sample emphasized designing for gender-segregation as much as some did in the broader sample of interviews conducted for this research, Dr. Faheem's comments on the need to consider gender specific ergonomic issues in healthcare design, and his observation that preferences for gender treatment are less operationally relevant in the care of children than in the care of adult patients, imply that "cultural responsiveness" in healthcare design in Pakistan could be seen as a systematic conditioning of design by department and patient population, rather than as a single consistently applied design standard throughout a facility.

### **Policy Recommendations**

Based on the above analysis and the framework in Table 2, this study made the following policy recommendations, which are all directly linked to the interviewee's findings.

1. **Form a National Healthcare Architecture and Space Standards Body.** Ar. This study considers Zahid's recommendation for a special research and development institute on space standard for healthcare as the prime recommendation on which the others rely. Such a body could be asked to develop and then regularly review the space standards for various types of healthcare facility and department based on feedback from patients and staff, post-occupancy evaluations of existing hospitals and the changing nature of medical equipment and technology. Importantly, this body should be given a mandate including both new construction and the renovations of existing facilities as participants discussed the long timelines and changing needs of hospital construction projects in Pakistan.
2. **Formalize Interdisciplinary Working via Standing Committees or MOUs.** Dr. Faheem's suggestion of a joint committee of both the architect and clinician before any hospital project is undertaken, and Dr. Rehan's request for a Memorandum of Understanding between the health and architect/plan departments, both serve as indicators of the same proposal: the interdisciplinary cooperation between these two fields in designing a healthcare facility should be considered as a prerequisite. This study suggests that such collaborations should be required throughout the life cycle of a project, not at a single approval point, such as at initial space programming, design review and as part of post-occupancy evaluation, in response to Dr. Rehan's concern about designs being approved in the beginning and constructed.
3. **Implement pilot flexible and modular design elements in existing tertiary hospitals.** Instead of trying to roll out a grand international scheme like the field hospitals in China, this study proposes to test smaller interventions, site-specific to the context of Pakistani existing tertiary care hospitals: reserving structural space in the rooftops and basements (as proposed by Dr. Rehan) and modular partition systems with flexible column-beam structures (as proposed by Ar. Small-scale "sanitation pod" units, in addition to those around patient beds (Zahid), near patient beds. These interventions could be piloted in current facilities, not just in new designs, and lessons learnt and improved before these are included in the space standards for other projects.
4. **Incorporate Healthcare Architecture in Professional Education for Architects & Clinicians.** Both Ar. They found that the lack of professional training in collaboration can be attributed to two factors: architects rarely obtain hospital design expertise as part of their training, and medical students have only limited exposure to the built environment as a factor that affects the quality of care. The study suggests the inclusion of specific healthcare architecture content in both architecture and medical courses, which can be integrated into the same courses or via a case-based learning approach where architecture and medical students are made to talk to each other during their studies, thereby tackling the collaboration issue head-on, before entering the workforce.
5. **Design for natural light and ventilation as the norm, not the exception. Reflecting both** Ar. In light of Zahid's criticism of the lack of natural light and ventilation in the construction of modern hospitals and the WHO's (2009) definition of natural ventilation as an evidence-based infection control strategy in its own right, this study suggests that any national healthcare space standards (Recommendation 1) should explicitly include natural light and ventilation as a

default building requirement, not only for isolation and critical care rooms, but for all hospital spaces, and that mechanical systems should be used as an adjunct rather than a replacement for natural systems.

### Limitations of the Study

The results of this study should be considered with regard to some limitations. Most importantly, the study is based on in-depth interviews with three people, one from each institution and for the architect and administrator, one from each professional career trajectory within the public sector healthcare system in Pakistan. The purposive sampling of participants from three different professional viewpoints ensured maximum diversity of the views within the limited sample, and the results should not be interpreted as representative of the views of all architects, clinicians or administrators across the Pakistani health service spectrum, which is also very diverse, with differences between provinces, between public and private health sectors and between urban tertiary care hospitals and rural primary health care centers.

Second, interviews occurred post-acute phase of the Covid-19 pandemic and the narration of the pandemic period is inevitably retrospective reflection and therefore may have resulted in a certain level of narration blanketing and/or hindsight bias in the accounts of participants. Last, because the study was conducted by a researcher trained in architecture, the risk of architectural framings of problems and solutions being more readily elicited and more fully explored may have existed, a risk that the constructivist grounded theory approach's focus on reflexivity (Charmaz, 2006) attempts to compensate for but can never entirely prevent. Future studies with a larger and more institutionally diverse sample, including engagement of participants from outside of Punjab and the private sector, would assist in testing the generalizability of the framework suggested in this section.

### Conclusions

The aim of this study was to propose changes to Pakistan's healthcare design and delivery system to become more resilient, patient centered, and responsive to the future public health challenges, informed by the grounded views of three stakeholders at varying stages of the healthcare design and delivery process: an architect with almost three decades of hospital design experience in the public sector, a pediatric infectious disease specialist, and a hospital administrator with direct responsibility for the daily operation of a large tertiary care facility.

The images they paint that come from their stories are the same and in some ways sobering. Pakistan's healthcare settings remain resource constrained, with a history of chronic overcrowding well before the pandemic, and almost no purpose built isolation facilities, and the profession of architecture hardly involved in the emergency reshaping of healthcare space that took place as a result. The study also revealed a consistent and strong recognition of the importance of the principles of natural light, ventilation, spatial zoning and flexible, modular design, which are well documented in the international evidence-based design literature and are seldom articulated in the buildings where the participants described working with, working in, and being treated by.

That this study does not reveal new architectural principles, but rather the evidence that existing principles are not being applied and are not applied because the institutional structures (space standards bodies, interdisciplinary committees, collaborative governance mechanisms) which would make them do so simply are not present. The five pillars described in the following (flexibility and adaptability to surges, infection control, spatial zoning, natural light, ventilation, healing environments, sustainable and smart design integration, interdisciplinary governance and collaboration) have been suggested as a basis for architects, healthcare administrators and policy makers to fill this void.

This is not the first public health crisis Pakistan's healthcare system has been asked to address, nor the first challenge to test the ability of the healthcare system's hospitals, as physical structures, to respond. The common interest of the people in this study was a shared belief that the lessons of the pandemic should not be forgotten before they can be made part of the built environment. In that regard, the main recommendation of this study is procedural rather than architectural: the dialogue between health facility planners and health workers needs to be a permanent fixture in the design, construction and refurbishment of health facilities in Pakistan; and not a one-off event that happens during the next health crisis.

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