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RESEARCH PAPER

Crafting Environmental Prioritization for End Users: Revamping the Thermal Comfort at Shifa Gyne Hospital, Rawalpindi

[1]Architect Omer Shujat Bhatti*, [2]Architect Wahida Akhtar Bhatti and [3]Architect Rifza Zahid

1. Research Associate, Department of Nutritional Sciences & Environmental Design, AIOU Islamabad, Pakistan
2. MSc ED Student, Department of Nutritional Sciences & Environmental Design, AIOU Islamabad, Pakistan
3. Lecturer, Department of Architecture, Lahore College for Women University, Lahore, Pakistan

***Corresponding Author:** omer.shujat@aiou.edu.pk

ABSTRACT

COVID-19 pandemic raised concerns of thermal comfort in hospitals by end users. Gynecology & Obstetrics is a major health specialty which prioritizes on thermal comfort of the patients. Lacking of such standardization was observed in Shifa Gyne Hospital, Rawalpindi and it was explored through current research. Objective was to explore, identify issues and propose interventions to address these gaps. Research exploration used two way approaches using observational study with a checklist and questionnaire to collect data from 150 respondents in winter and summer seasons. Data in summer highlighted aspects of poor cross ventilation, lack of openings, higher humidity and lack of fresh air intake into indoor spaces. Winter season with higher humidity value was a major issue along with allied stated issues. Analysis showed only indoor temperature in winter was reported to be in satisfaction while remaining aspects failed to satisfy end users. Hence environmental design interventions were proposed.

KEYWORDS: Environmental Design, Healthcare Design, Gynecology & Obstetrics, Thermal Comfort

Introduction

Healthcare facilities are one of the most critical and human centered services center any society. They welcome the human beings in the most critical needs of care through treatment and medication (Osterrieder et al., 2021). Hospitals complement and amplify the effectiveness of many other parts of the health system, providing continuous availability of services for acute and complex conditions. They concentrate scarce resources within well-planned referral networks to respond efficiently to population health needs (Srinivas& Ravi Ravindran, 2017). They are an essential element of Universal Health Coverage (UHC) and will be critical to meeting the Sustainable Development Goals (SDG). Hospitals are also an essential part of health system development (M. Hussain, Rehman, Ikramuddin, Asad, & Farooq, 2018). Currently, external pressures, health systems shortcomings and hospital sector deficiencies are driving a new vision for hospitals in many parts of the world. In this vision, they have a key role to play to support other healthcare providers and for community outreach and home-based services and are essential in a well-functioning referral network (A.Hussain et al., 2019).

Amongst these typologies of healthcare facilities, one of the facility which require special attention is gynecology & obstetrics hospital. Most of the time commonly combined as obstetrics and gynecology, it's a branch of medicine that specializes in the care of women during pregnancy and childbirth and in the diagnosis and treatment of diseases of the female reproductive organs (Gough, Faulknall-Mills, King, &Luo, 2019). It also specializes in other women's health issues, such as menopause, hormone problems, contraception (birth control), and infertility and allied. Such a focused hospital requires special attention to the targeted patients, attendants, children and service providers. It's a complex system integrating spatial configurations that may help run the system for facilitation and medical consultation of the patients at its best (Peng et al., 2021).

Pakistan is one of the most fast developing country of South Asia with one of the largest population in the world. It has a defined socio-cultural and socio-economic context where women has been a source of respect, honour and dignity (Arshad, Waris, Ismail, &Naseer, 2016). A specialized area of a hospital dedicated to women in the form of Gyne department becomes one of the most critical facility in the overall complex. Hence it has been observed that apart from large complex hospitals and healthcare facilities and to manage the high influx of population, isolated, separate hospital facilities dedicated to gynecology have been developed as maternity centers across the country (Dovjak, Shukuya, &Krainer, 2018).

Rawalpindi is one of the major city of Pakistan in the province of the Punjab, the most populated province of Pakistan. The city has been a center to many healthcare facilities for public at large but in order to facilitate the public at large many allied private healthcare facilities have been developed (Anam, 2018). Since these facilities have limited resources, land and targeted audiences, hence their quality has been observed to suffer (Fabbri, Gaspari, &Vandi, 2019). One of the recent observation was done in the COVID19 pandemic and post pandemic time in one of the selected gynecology focused facility i.e. ShifaGyne Hospital in Rawalpindi which also provided surgical and emergency facilities. Built in a very small area and designed to optimize the space, functionality was observed to be at risk. Hence there was a gap to identify the current environmental conditions and thermal comfort factors amongst the users to resolve the observational gaps.

Literature Review

Numerous studies involving students or professionals in offices have demonstrated that one of the interior environment factors that substantially influences the health, productivity, and efficiency of employees is the thermal environment. Thus, it can be inferred that in sick rooms, it is essential that the thermal environment conditions guarantee the comfort of their users; yet, all technological, medical, and sanitary-hygienic needs must be satisfied simultaneously. The three methodologies used in the literature to establish how humans perceive the temperature environment are categorized as physical, psychological, and physiological. The first is founded on models of physical phenomenon that happen at the interface between people and their surroundings; the second makes use of people's real, subjective perceptions of the thermal environment, as shown, for instance, in what is known as survey research; and the third is based on physiological parameter measurements, such as body temperature. Some of the Essential variables related to thermal comfort. The major elements are shown below in figure 01 (Uścinowicz&Bogdan, 2022)..

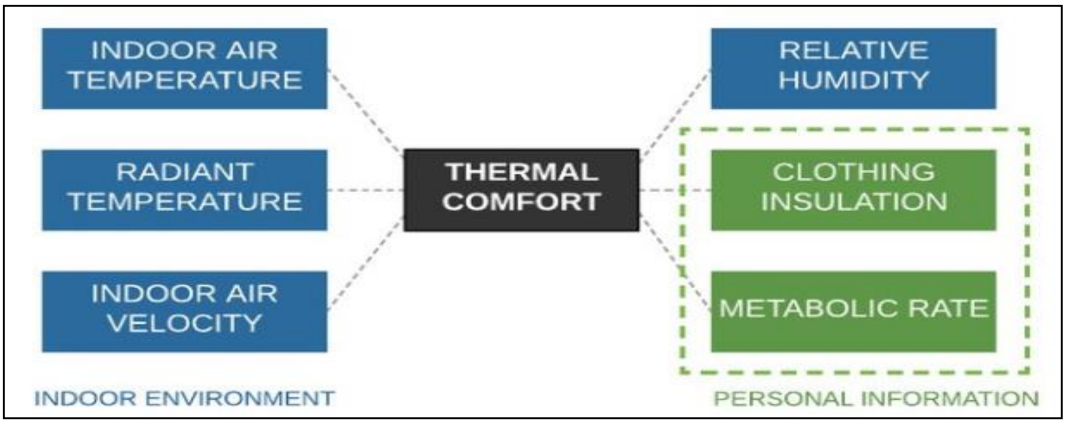

Figure 01 Factors associated with thermal comfort (Bogdan, 2022)

The term "thermal comfort" refers to how well someone feels about the temperature in their surroundings. It is regarded as one of the most important requirements for raising occupant happiness and comfort levels in the interior space. Hospital buildings are primarily made to house patients, who typically have a variety of medical ailments that require certain interior environmental standards. Staff members require a secure and comfortable working environment in hospital premises. Hospital buildings are among the most energy-intensive types of commercial and residential building types due to these needs (Health & Guidelines, 2017).

Gynecology hospital departments have different needs when it comes to interior thermal and spatial comfort. The interior environment needs vary depending on the functional zone. The intricacy of the hospital architecture stems from these features. Owing to the unique qualities of the many populations that hospital buildings serve, a safe and cozy interior atmosphere is crucial for regulating patients' emotions and promoting staff productivity. Furthermore, a hospital's indoor environment can save 9–20% of the expenditures related to airborne infections (Muni, Pahari, &Uprety, 2019).

Consequently, the requirement to keep hospitals' interior spaces welcoming is increasing. There have been some recent developments in hospital construction that are connected to thermal comfort. Since the COVID-19 breakout, hospital infrastructure has become increasingly crucial and must be expanded to satisfy the medical demands of the populace (Bhatti &Ghufran, 2020). Hospital patients who are at risk may contribute to the advancement of medicine and the creation of novel therapies for life-threatening conditions. They will have the difficulty of establishing a more suitable hospital atmosphere while yet needing more focused treatment (Bhatti, Ghufran, & Shah, 2023). Furthermore, a plethora of new technologies pertaining to patient welfare are developing as research advances (Yuan et al., 2022).

There are restrictions on airflow within and between the hospital's departments. In order to reduce and eliminate pollution, there are also particular needs for ventilation and filtration. Too many variations exist between the criteria for temperature and humidity in each region. More sophistication in design is required to enable precise management of environmental conditions, as patient recovery is impacted by thermal comfort in hospitals. Therefore, the regulation of temperature, humidity, and air flow is essential for ensuring thermal comfort in hospitals (Nahar, Tripathi, &Rana, 2019).

Women are one of the most critical part of our society which have to play a significant role in the sustainability of the humanity itself (Mora &Meteyer, 2018). Conceiving mothers have to go through a number of stages during conceiving a baby and during this time, they have to visit the multiple departments including emergency in the hospital facility multiple times (Shujat Bhatti, Anjum, &Abid, 2022). Thermal comfort has a strong impact on the overall feel of the women during pregnancy stage (Rus, Cruciat, Nemeti, Mare, &Muresan, 2022). Visiting these spaces, waiting for your turn in diagnostics, circulation and meeting your consultant for review and checkup may take many hours and have to be in a comfortable environment to enable better coping and stress management (Khalid, Zaki, Rijal, &Yakub, 2018). Multiple studies have correlated this time with better coping of the mother through their pregnancy period (Fallis, Hamelin, Symonds, & Wang, 2006).

It has been observed that women not having thermal comfort environment in the gynecology departments tend to visit them less and hence risk their health as well as that of their unborn child (Soebarto, Zhang, &Schiavon, 2019). Another study mentioned that thermal comfort acts as a major decision factor for better socio-economic background women to decide towards selection of healthcare facility for consultation (Yuan et al., 2022). It was also evident that ample spatial design and functional integration increases user satisfaction in OPD facilities for women visiting with consultation or post operative review stage (Wang, Wu, Jia, Gao, &Gu, 2022).

Based on the review of literature, it was concluded that a through detailed observational study along with documentation of the selected facility as well as data collection from respondents based on the aspects of thermal comfort will be carried out. The focused research methodology is shared below.

Material and Methods

In order to continue forward, the overall research process has been broken down in multiple phases and steps as shown below in figure 02.

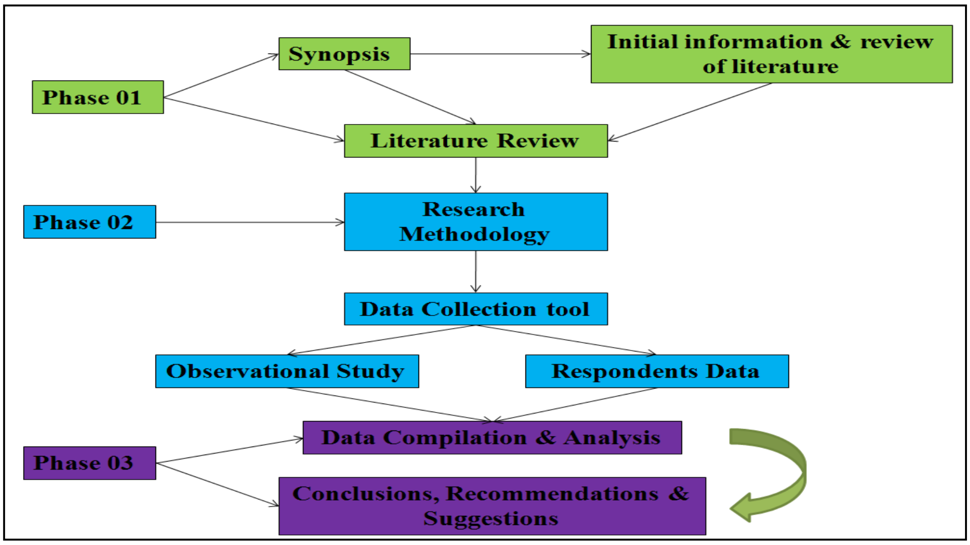

Figure 02 Phase-wise research program and major steps

Based on the explored review of literature and defined research methodology, research project further processed towards data collection and its analysis stage. Here the foremost aspect was to define and develop a data collection tool which could be used for both observational study and later for data collection from the end users and the facility respondents in the form of visitors, patients and allied. Later once the data has been collected and observational study completed, comparison for correlation and major gaps identification was done. Hence with the help of identified major aspects and variables, observational study checklist and data collection tool was evolved using adaptive approach from integration of multiple research articles in the review of literature. Much emphasis was done to ensure it must correlate with the local context and many questions not related with the local context have been eliminated after discussion with the research supervisor and later piloting the tool as well. Major aspects were as follows:

1. Floor Level.
2. Orientation of space.
3. Space type / utilization
4. Size
5. Temperature
6. Humidity
7. Cross ventilation & openings
8. Overall feeling of the space

Allied aspects of clothing and food intake / metabolism or activity level was not considered with respect to focus on the environmental and physical aspects of the study.

Results and Discussion

After seeking prior permission, research activities were carried out as per shown table 01.

Table 01
Research activities timeline (Site visits, Observational study & data collection)

S.No	Phase	Season	Months	Visits / Purpose
01	01	Summer	May, 2021	Documentation of the existing facility, photography & researcher data through environmental multimeter& respondents data
02	01	Summer	June, 2021	Observational study & Respondents data collection.
03	01	Summer	July, 2021	Observational study & Respondents data collection.
04	02	Winter	November, 2021	Observational study & Respondents data collection.
05	02	Winter	December, 2021	Observational study & Respondents data collection.
06	02	Winter	January, 2022	Observational study & Respondents data collection.

As shown above in the table 01, overall observational study and data collection from the respondents was carried out simultaneously to ensure same timeline and same physical environment was explored in the context of the thermal comfort by the researcher for the end users. Based on the observational study phase 01 during the moth of May, 2021 the existing facility documentation through architectural plans was completed. The architectural and location plans are shown below as follows:

Figure 03 Location plan of Shifa Gyne Hospital, Rawalpindi (Source: Google Earth, 2021)

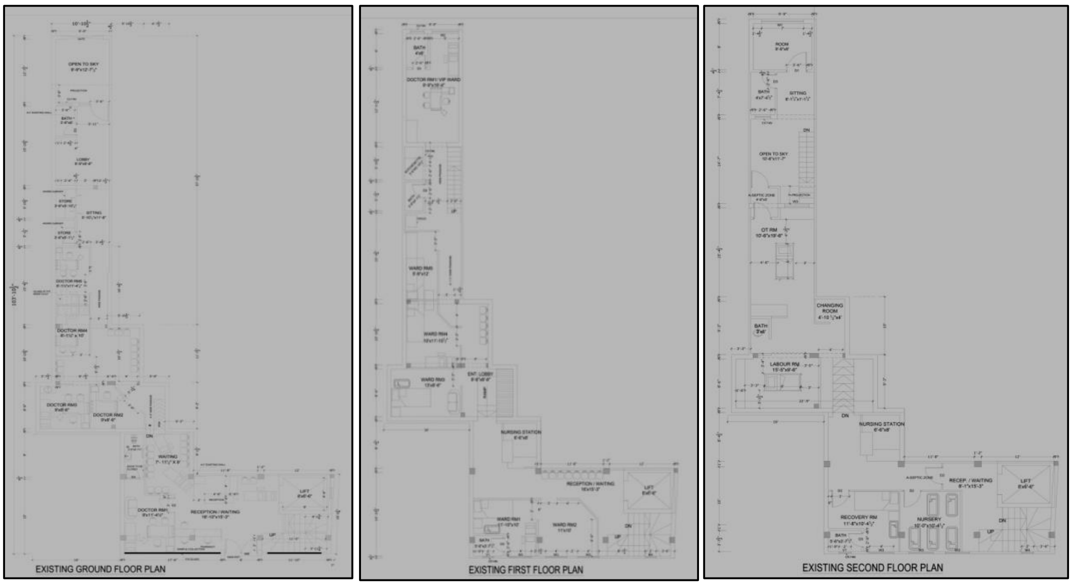

Figure 04 - 06 Existing Ground, First & Second Floor Plans

As shown above in the figure 03–06, the selected ShifaGyne Hospital is in a very congested and highly populated area of the Rawalpindi city. Ground floor mainly consists of the main reception followed by lift and OPD waiting along with Pharmacy. There were five multiple Doctor's OPD (Out Patient Department) clinic for patients with diversified gynecology and obstetrician needs. There were also added staircase for vertical access to the first floor along with 2-3 toilets for the patients and staff as well. First floor of the facility mainly comprises of reception and multiple nursing station along with lift and staircase area followed by multiple single and two patient bed wards for different patients requirements and economic options. Second floor mainly comprises of reception, lift and staircase followed by baby nursery and patient recovery room with nursing station followed by Labor room and allied Operation Theater with multiple storage, changing and rest rooms.

Overall the plan of the facility was interconnected into very thin and long corridors with passages and has deep lengths but its depth was very less and hardly were able to fulfill the bare minimum requirements set forth for any gyne basic healthcare facility. The indoor spaces were mainly limited to reception and allied spaces where attendants and common public could reach. This was mainly done towards the social privacy factor of the local people and patients who mainly were wiling to provide information and become respondents but were not willing to take part in the photography. The multiple pictures of the site explored indoor and outdoor and shown below:

Figure 07 View of the main entrance and parking

Figure 08 Main reception, Doctor room 01 & OPD waiting space

Figure 09 Lift and staircase lobby with waiting space for attendants

Figure 10 Patients in waiting lobby and pharmacy counter

Figure 11 Main view of the building from the opposite side of the access road

As shown above in the figure 07 – 11, the overall context of the facility selected and its major reception along with vertical access are shown. The spaces were optimized with respect to functional usage with maximum usage of every corner and inch available which saturated the overall space. During multiple visits, it was seem to be over crowded due to higher influx and faced many issues related to managing thermal comfort. Based on the observational study using the checklist, following major spaces were explored in both summer and winter seasons during the patient usage as shown below in table 02.

Table 02
Major spaces selected on each floor for observational study

S.No	Floor	Space Name	Orientation / opening
01	Ground floor	Reception	North - No
02	Ground floor	Pharmacy	South - Yes
03	Ground floor	Waiting lobby 01	North - No
04	Ground floor	Waiting lobby 02	North - No
05	Ground floor	Doctor room 01	South - Yes
06	Ground floor	Doctor room 02	North - No
07	Ground floor	Doctor room 03	North - No
08	Ground floor	Doctor room 04	North - No
09	Ground floor	Rear lobby	North - Yes
10	First floor	Reception & Waiting	North - No
11	First floor	Ward 01	South – Yes
12	First floor	Ward 02	South - Yes
13	First floor	Ward 04	North - No
14	First floor	VIP Doctor room	North – Yes
15	Second floor	Nursery	South – Yes
16	Second floor	Recovery room	South – Yes
17	Second floor	Waiting	North – No
18	Second floor	Nursing station	North - No
19	Second floor	Rear sitting space	North - No
20	Second floor	Rear room for medical staff	North – Yes

As shown above in the table 02, all major spaces have been kept under exploration with respect to observational study and later respondents data from each space was taken for cross relating the collected data. Hence the observational data collection for summer and winter are shown below:

Table 03
Summer Observational data

Sr	Floor	Space Name	Orientation & Openings	HVAC	Temperature Centigrade	Humidity	Cross Ventilation
1	Ground floor	Reception	North - No	Yes	26	57%	Moderate

2	Ground floor	Pharmacy	South - Yes	Yes	26	57%	Moderate
3	Ground floor	Waiting lobby 01	North - No	Yes	26	57%	Moderate
4	Ground floor	Waiting lobby 02	North - No	Yes	27	61%	Poor
5	Ground floor	Doctor room 01	South - Yes	Yes	24	57%	Poor
6	Ground floor	Doctor room 02	North - No	Yes	24	57%	Poor
7	Ground floor	Doctor room 03	North - No	Yes	24	60%	Poor
8	Ground floor	Doctor room 04	North - No	Yes	22	63%	Poor
9	Ground floor	Rear lobby	North - Yes	No	28	59%	Moderate
10	First floor	Reception & Waiting	North - No	Yes	26	62%	Moderate
11	First floor	Ward 01	South – Yes	Yes	27	60%	Moderate
12	First floor	Ward 02	South - Yes	Yes	27	60%	Moderate
13	First floor	Ward 04	North - No	Yes	27	61%	Poor
14	First floor	VIP Doctor room	North – Yes	Yes	22	51%	Good
15	Second floor	Nursery	South – Yes	Yes	28	63%	Poor
16	Second floor	Recovery room	South – Yes	Yes	28	62%	Poor
17	Second floor	Waiting	North – No	No	29	61%	Moderate
18	Second floor	Nursing station	North - No	Yes	26	61%	Moderate
19	Second floor	Rear sitting space	North - No	Yes	27	59%	Moderate
20	Second floor	Rear room for medical staff	North – Yes	Yes	27	61%	Moderate

As shown above in the table 03, summer observational sheet is shared. It was evident that the only openings available on all the floors was either at the main front side of the building or the rear and since the overall building lacked any openings on the sides it created major issues related to natural and cross ventilation. Though most of the spaces were managed through HVAC (Heating, Ventilation & Air Conditioning) system incorporation yet humidity level was very high as compared to applicable limit of comfort standards where humidity should be in range of 30% - 40% for general indoor spaces. This had negatively impacted the overall space thermal comfort where though the indoor temperature was controlled yet the poor ventilation and higher humidity let alone created major issues with poor thermal comfort in the explored spaces.

As shared above, the overall HVAC system was able to manage the temperature during the observational study timeline in the indoor spaces. During the timeline, most of the time external temperature ranged between 35^{o}C to 40^{o}C. Hence the temperature was managed better as compared to humidity where the higher humidity level created discomfort during the observational study done by the researcher. This also has a direct relationship with poor cross ventilation. Observational study was carried out along with respondents data collection from the end users of the spaces explored. Winter observational study data is shared below in Table 04.

Table 4
Winter Observational data

Sr	Floor	Space Name	Orientation & Openings	HVAC	Temperature Centigrade	Humidity	Cross Ventilation
1	Ground floor	Reception	North - No	Yes	22	61%	Moderate
2	Ground floor	Pharmacy	South - Yes	Yes	22	61%	Moderate

3	Ground floor	Waiting lobby 01	North - No	Yes	23	61%	Poor
4	Ground floor	Waiting lobby 02	North - No	Yes	24	64%	Poor
5	Ground floor	Doctor room 01	South - Yes	Yes	24	61%	Poor
6	Ground floor	Doctor room 02	North - No	Yes	25	67%	Poor
7	Ground floor	Doctor room 03	North - No	Yes	25	67%	Poor
8	Ground floor	Doctor room 04	North - No	Yes	26	68%	Poor
9	Ground floor	Rear lobby	North - Yes	No	26	55%	Moderate
10	First floor	Reception & Waiting	North - No	Yes	25	61%	Poor
11	First floor	Ward 01	South – Yes	Yes	27	67%	Poor
12	First floor	Ward 02	South - Yes	Yes	27	67%	Poor
13	First floor	Ward 04	North - No	Yes	28	68%	Poor
14	First floor	VIP Doctor room	North – Yes	Yes	28	55%	Moderate
15	Second floor	Nursery	South – Yes	Yes	30	67%	Poor
16	Second floor	Recovery room	South – Yes	Yes	31	68%	Poor
17	Second floor	Waiting	North – No	No	28	61%	Poor
18	Second floor	Nursing station	North - No	Yes	27	61%	Poor
19	Second floor	Rear sitting space	North - No	Yes	28	55%	Poor
20	Second floor	Rear room for medical staff	North – Yes	Yes	28	57%	Moderate

As shown above in table 04, winter observational data is shown. With reference to the data collection of winter season, same OPD timings were opted during the observational study. As evident from the data shown, temperature was managed better in winters as compared to summers however the humidity level was very high. This created a lot of suffocation and lack of thermal comfort in the indoor spaces explored during the winter season. The comparative graph of temperature and humidity is shown below in figure 13 for Winter data.

As shared above, two major factors of temperature and humidity have been shown for winter observational study. Temperature was managed better through HVAC system. Humidity was even higher which resulted again in the feeling of discomfort. Suffocation was more higher inside the spaces as compared to summer season. Only those spaces were having lower humidity values where natural ventilation or cross ventilation was better managed through introduction of wall openings. Since the outdoor temperature was not very low in the context of the Rawalpindi city, managing it was a manageable task. However higher humidity was still a challenge. Again poor cross ventilation facilitation and incorporation in design lead to poor performance of the building with respect to thermal comfort.

Along with observational study, respondents data collection was also done to ensure that both data sets were collected and compared at the same time with reference to the same physical context and settings. Overall the respondents major categories were identified and divided as shown below in the table 05.

Table 05
Basic Demographics – Summer respondents data

S.No	Variable	Choice	Count	%
1	Gender	Male	65	43%
2		Female	85	57%

3	HR Category	Doctor	8	5%
4		Nurse	14	9%
5		Patient	79	53%
6		Staff	16	11%
7		Attendant	33	22%
8	Time spent	Less than 2 hours	32	21%
9		2 to 4 hours	28	19%
10		4 to 6 hours	24	16%
11		6 to 8 hours	56	37%
12		more than 8 hours	10	7%

As shown above in table 05, the overall 150 respondents were included in summer season. Major count included 85 females with 65 males as shown below in figure 12. Males mainly included attendants, staff and one doctor. Rest were all mainly females. Major respondents share was that of patients occupying spaces with 53% representation followed by 22% attendants and then staff, nurses and doctors followed as shown below in figure 15. Time duration of stay was mainly 6-8 hours by 37% of respondents which included nurses, doctors, staff and many patients & attendants as well. It was followed by 21 % of those visitors and patients who opted for OPD visit and were treated within 2 hours and left back, they comprised of second major chunk i.e. 21%.

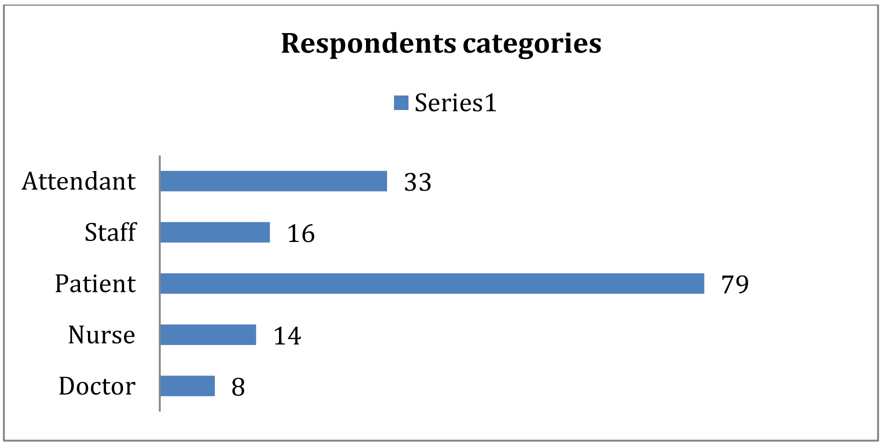

Figure 12 Respondents categories

The overall respondents data with response to summer season is shown below in table 06.

Table 06
Respondents data for summer season

Sr	Questions	Highly Unsatisfied	Unsatisfied	Neutral	Satisfied	Highly Satisfied
1	How much are you satisfied with the current indoor temperature?	**42**	25	26	31	26
2	How much are you satisfied with the cross ventilation?	**87**	**32**	15	6	10
3	How much are you satisfied with air movement within the space?	**77**	**28**	26	15	4
4	How much are you satisfied with the humidity within the space?	**81**	**29**	23	15	2
5	How much are you satisfied with the overall thermal comfort of the space?	**64**	**36**	24	15	11

As shown above in the table 06, summer respondents data clearly highlights major aspects of dissatisfaction amongst the respondents with respect to thermal comfort variables.

As shared above, in all major aspects explored respondents of all major categories were found to highly unsatisfied with the thermal comfort. It was further explored with respect to each category to identify what they will prefer with respect to the overall ambient temperature. 80% above stated they wished the spaces to be more cooler and have fresh air. Hence questionnaire further explored the major causes of lack of satisfaction amongst the respondents and respondents feedback is shown below in figure 17. Overall ranking of the major thermal comfort aspects were listed and the respondents ranked them on the priority of issue they faced.

As shared above, 45% of the respondents believed that due to high humidity in the indoor spaces, thermal comfort has been compromised. It was later followed by 15% believing that its has been caused by poor cross ventilation. These two factors are highly correlated since cross ventilation could be the best sustainable way to reduce the humidity and add fresh air to the indoor spaces. The overall respondents demographic data with response to winter season is shown below in table 07.

Table 07
Winter respondents demographics

S.No	Variable	Choice	Count	%
1	**Gender**	Male	58	39%
2		Female	92	61%
3	**HR Category**	Doctor	8	5%
4		Nurse	14	9%
5		Patient	85	57%
6		Staff	15	10%
7		Attendant	28	19%
8	**Time spent**	Less than 2 hours	38	25%
9		2 to 4 hours	28	19%
10		4 to 6 hours	24	16%
11		6 to 8 hours	50	33%
12		more than 8 hours	10	7%

As shown above, the winter total respondents count was kept the same as summer except that the overall female count increased to 61% and male was reduced to 39%. Overall medical team members remained the same while the patients count increased and attendants decreased as compared to summer. OPD clinic patients count for less than 2 hours stay also increased. Overall respondents data for winter season is shown below in table 08.

Table 08
Winter respondents data

Sr	Questions	Highly Unsatisfied	Unsatisfied	Neutral	Satisfied	Highly Satisfied
1	How much are you satisfied with the current indoor temperature?	16	23	33	**67**	11
2	How much are you satisfied with the cross ventilation?	**65**	28	24	18	15
3	How much are you satisfied with air movement within the space?	**61**	39	22	18	10
4	How much are you satisfied with the humidity within the space?	**86**	31	11	12	10

5	How much are you satisfied with the overall thermal comfort of the space?	**74**	38	15	15	8

As shown above in the table 08, winter data had similar response to the summer data except for the indoor temperature where satisfaction was reported by 67 out of 150 respondents. As shared above, only indoor temperature was found to be satisfactory in the winter data while all other aspects were mainly reported in the highly unsatisfactory range. It was explored with the respondents about their level of satisfaction through discussion and it was concluded that during to winter season, higher influx and patient & attendants presence give the ambient indoor temperature a better value and gives cozy effect. However due to lack of ventilation and higher humidity, the overall ambient experience of the space becomes poor. Once again lack of cross ventilation, higher humidity and the lack of fresh air in the indoor spaces created suffocation amongst the end users and was the major reason for the lack of thermal comfort. Overall ranking of the major thermal comfort aspects were listed and the respondents ranked them on the priority of issue they faced.

As shared above, 46% of the respondents believed that due to high humidity in the indoor spaces, thermal comfort has been compromised. It was later followed by 21% believing that it has been caused by poor cross ventilation. These two factors are highly correlated since cross ventilation could be the best sustainable way to reduce the humidity and add fresh air to the indoor spaces.

Discussion

Observational study in summer highlighted the aspects of poor thermal comfort observed being caused by poor cross ventilation, lack of ventilation openings, higher humidity and lack of fresh air intake into the indoor spaces used by patients, attendants, doctors, staff and nurses. Same was also observed in the winter season. Higher humidity value was more of an issue in the winter season. Due to winter season, most of the openings which were already very few in number were kept closed and hence the indoor spaces lacked fresh air intake.

Respondents' data was collected through questionnaire in both seasons. Summer data correlated with observational study. Major issues were ranked in each season and have correlated with the observational study in the causes identification of poor thermal comfort performance. It was concluded through comparative analysis that only indoor temperature in winter was reported to be in the user satisfaction while all other parameters including humidity, cross ventilation, air movement and overall thermal comfort feeling were all falling into lack of satisfaction category. As per applicable standards for OPD related to gynecology patients, preferred range of temperature was 21-24 degree Celsius but overall in both seasons it was not within limit for the OPD spaces explored. The instruments used were calibrated prior to taking readings and data. Winter season higher humidity level clearly shows issues with poor cross ventilation and since the air conditioning system was not dual i.e. hybrid or alternate. Due to higher influx in winters of patients and longer stay time, the overall humidity increased and created a lot of discomfort amongst the end users.

Based on the data analysis and comparison of observational study with respondents data and later on discussion with patients, environmental design interventions were needed to be incorporated into the existing design to enhance the workability and the functional usage of the indoor spaces with reference to the thermal comfort deemed necessary for end users including service providers i.e. doctors, nurses, paramedic and support staff along with service seekers i.e. patients, attendants and visitors. Environmental design interventions must address the cross ventilation, fresh air intake, humidity and poor overall ambient thermal comfort of the spaces explored.

Conclusions

Major findings included that lack of thermal comfort was mainly caused by poor cross ventilation as there were no major openings available for cross ventilation. This was a major design gap findings as the plot on which the hospital was build started to narrow down as it moves back and has other neighboring functions and buildings on its sides, hence openings could only be added at the front and the rear side. This created a major issue and hence openings could not be added to facilitate the light or cross ventilation. Here the 150 respondents data which included patients, attendants, visitors, doctors, nurses, staff and allied did also agreed with it.

Lack of cross ventilation was a major issue observed in the summer but in winter due to cold weather, most of the few available openings were also kept closed and hence lead to higher level of humidity. This even worsened the existing summer conditions and hence lead to further discomfort for the end users. Lack of fresh air intake created hurdles and hence in few locations forced ventilation was also used.

It was also a finding in the operational observation phase that in order to manage these prevalent issues, rather than opting for design improvement or intervention, hospital management plans the actions in such way that higher influx could be avoided. They develop a planned schedule for the OPD patients influx and each patient gets around 10 minutes of stay/wait and 10/15 minutes of consultation time only unless patient requires admission or IPD services. This indeed impacts not only the service quality provided to the patients but also hampers the quality of consultation and engagement. Hence there was a need to explore the existing issues and must be addressed through environmental design interventions.

COVID19 pandemic had a strong impact on the overall usage of the explored facility. Being a facility used extensively across the whole year, during the initial stages of COVID19 multiple waves, OPD facilitation was limited to few hours with preference for those who need immediate care or having a delivery soon. Apart from that, allied facilitation was also kept on a very low usage unless and until deemed necessary. The overall workflow did got disrupted but for those in the advanced stage were allowed for physical visit while defined time based consultation was opted with having 1-2 patients at a time to avoid any form of cross contamination or spread of virus from one patient or carrier to another due to any form of a slight mistake. Pandemic SOP's were strictly followed and medical team along with attendants & patients were bound to follow them for their and medical team safety. Any one with symptoms of the disease was advised 1-2 weeks off from the facility. In the post COVID19 time frame and during recent times, timing of the facility and consultation was brought back to normal routine but SOP based compliance is still followed and ensured to avoid any spread of disease. All medical team got vaccinated and was also advised to all the visitors, attendants and patients to get vaccinated prior to visiting the facility.

Recommendations

Following were the major recommendations proposed with respect to the explored research done:

1. Increase number of openings on the available front and rear sides on all floors.
2. Enhance cross ventilation and fresh air intake through forced mechanism where natural openings fail to provide them.
3. Provide a duct for cross ventilation and natural light for the rear side of the hospital.
4. Reduce the issue of higher humidity through engaging the false ceiling space and providing / integrating ducts for cross ventilation and enhancing the fresh air intake.

5. Propose locations for dehumidifiers as well as locations for HVAC related equipment.
6. Also incorporate the infection control through HVAC or bifurcation mechanism.

Proposed Design Interventions

As per the recommendations highlighted above, following major design interventions have been proposed below:

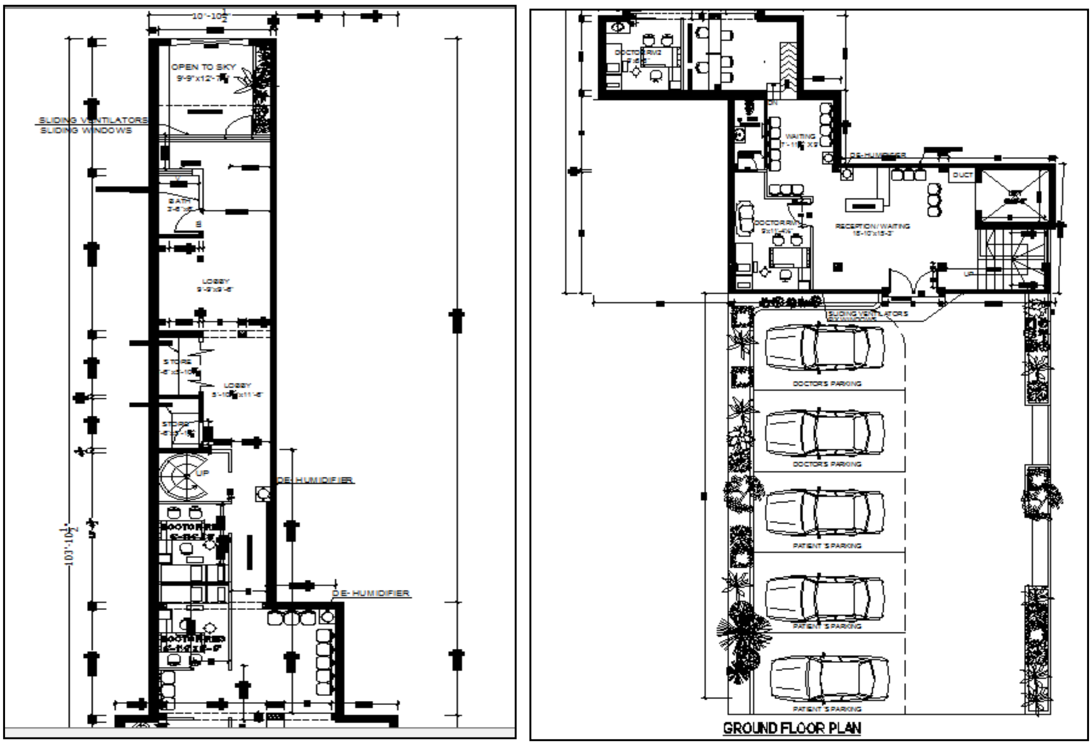

Figure 13 Proposed Ground Floor Updated

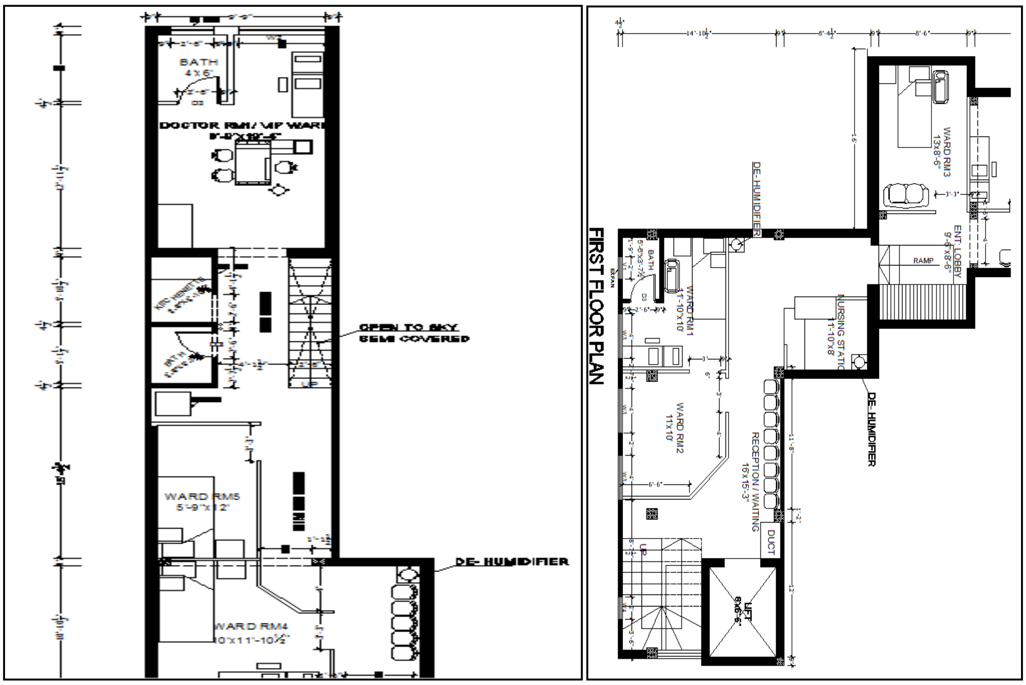

Figure 14 Proposed Interventions in First Floor plan

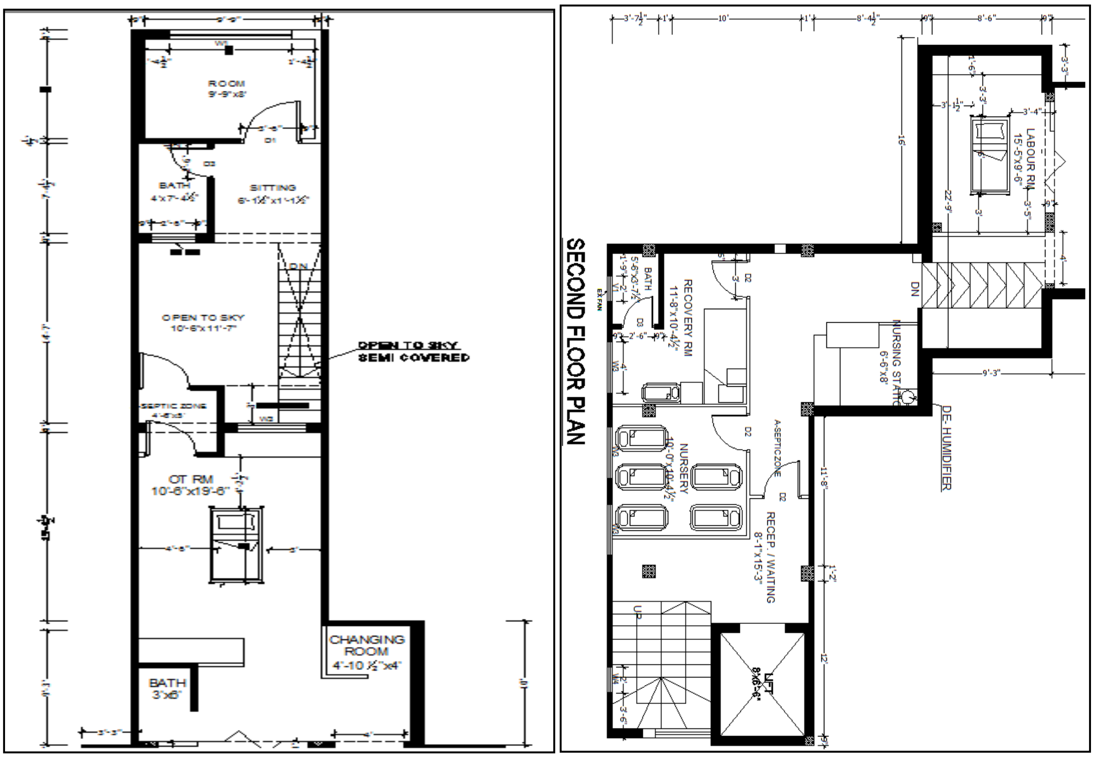

Figure 15 Proposed Interventions in Second Floor plan

Proposed recommendations have been addressed through addition of the following:

1. Sliding windows and ventilators on all openings.
2. Dehumidifiers have been proposed on floor plans.
3. Open to Sky ducts.
4. HVAC has been revised based optimization of false ceiling.
5. HEPA filters have been proposed as well.

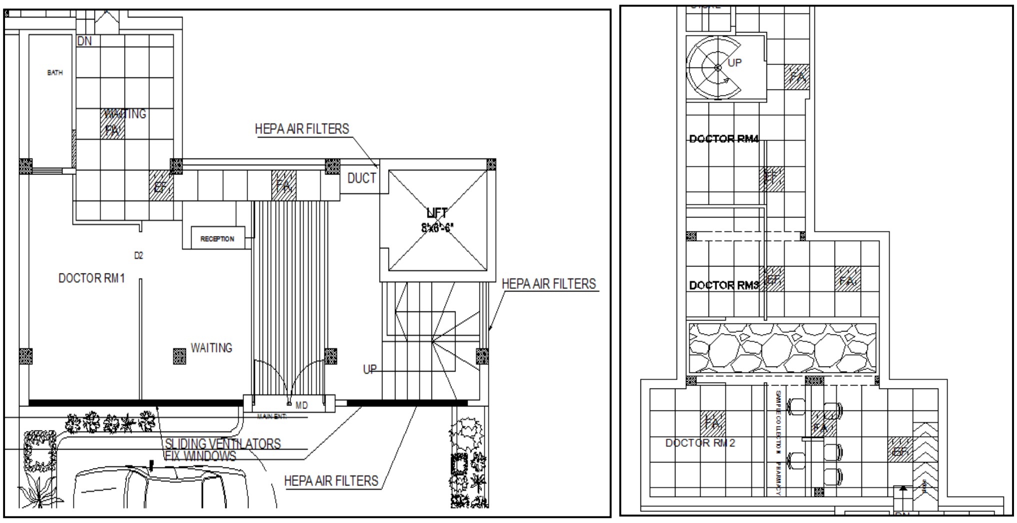

Figure 16 False ceiling plan for ground floor

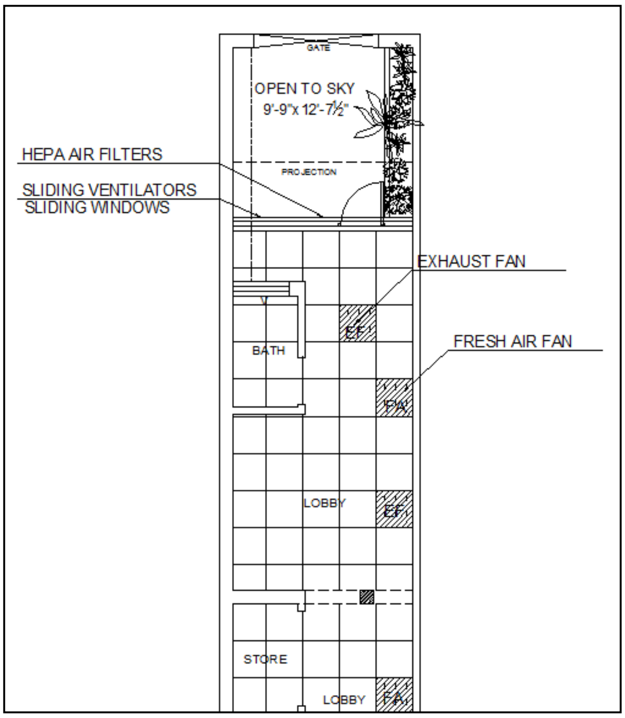

Figure 17 False ceiling plan for ground floor rear side

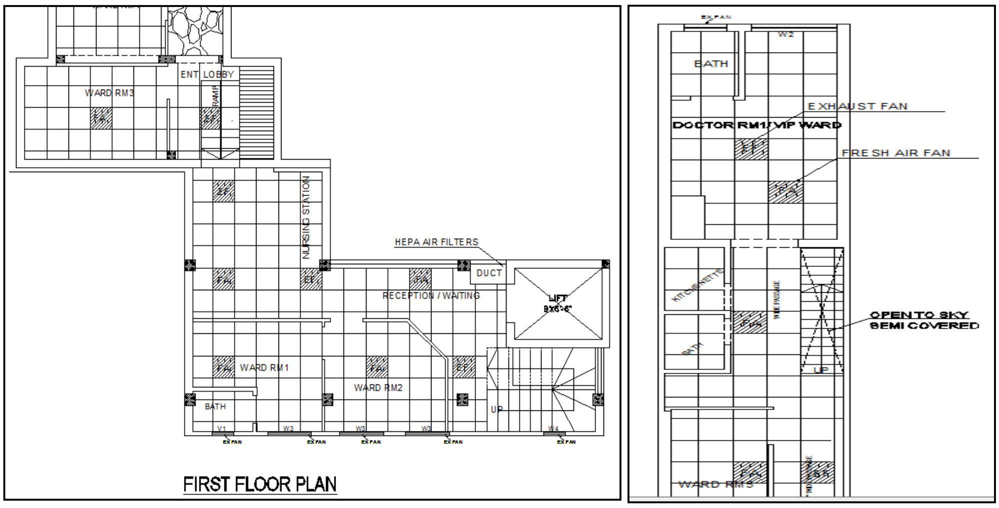

Figure 18 False ceiling plan for first floor plan

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