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Improving the Acoustic Environment in Hospitals in Egypt: A Case Study of Manshiet El-Bakry Hospital

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***Abstract*—Noise pollution is a serious but neglected issue in healthcare facilities, particularly in crowded cities like Cairo. Although the adverse health effects of hospital noise are internationally recognized, local studies in Egypt are scarce. In the light of this, the authors address the acoustic conditions in Manshiet El-Bakry Hospital and how internal and external sound sources affect IEQ and the performance of the medical personnel, as well as the recovery of the patient. By implementing mixed methods (quantitative sound level measurements, qualitative stakeholder surveys), the study assesses the loudness of noise dependent on room function/usage, orientation and floor level. The results indicate that these values have significantly exceeded the WHO and the Egyptian Building Code recommendations, particularly in rooms directed toward high traffic loads. Noise impact perceptions differed according to hospital role and length of exposure suggesting both acute sensitivity and adaptation over the long term. The research offers sound context expectations to guide architectural, managerial and operational measures to reduce noise and improve acoustic performance in Egyptian healthcare facilities.**

***Keywords*—Noise impact; Acoustic Performance; Healthcare Building; Sound level; Hospital Environment; Strategies**

1. INTRODUCTION

Environmental noise is one of the most invisible and hidden forms of pollution due to increasing population density and urban and industrial activities (Hammer et al., 2014). Although noise pollution is invisible, odorless, and devoid of any visible or chemical byproducts, it can have profound effects on human health and quality of life that cannot be ignored (González, 2014). One of the most obvious and well-understood health effects in humans is hearing loss (Hammer et al., 2014).

Environmental noise pollution is of major public health concern in Egypt, and particularly in cities like the capital Cairo, which is among the nosiest cities worldwide (Abas & Tamura, 2003). Other studies have estimated Cairo's average noise level 90 dB, which is comparable to the exposure one would have working full time in a factory, wherein, it remains no fewer than 70 dB, even during nighttime (Abas & Tamura, 2003). This chronic exposure leads to marked health consequences, such as hearing loss, annoyance, cardiovascular effects (Basner et al., 2014).

The World Health Organization (WHO) has emphasized that hospital noise is considered a harmful factor that compromises patients' comfort and safety and impairs health worker communication (Darbyshire & Young, 2013). WHO guidelines specify that noise levels in patient rooms should not exceed 30 dB (LAeq) and 40 dB (LAmax) at nighttime, and in intensive care units no more than 35 dB (Darbyshire & Young, 2013). Low noise environment in operating rooms is an important factor in order to be able to concentrate and perform a safe operation (Hsu et al., n.d.)

According to the Egyptian building code, which determines how the settings of healthcare units are designed, acceptable indoor noise levels have been determined according to the type of room (Alazazi & Alfrd, 2020). In the individual patient's room it should be 30–40 dB; in the operating room, 35–45 dB; other spaces such as treatment rooms, corridors, lounges, and waiting areas, the limit should be 40–50 dB; while the noise limit in the toilet should be kept below 45–55 dB, to achieve safe and healthy conditions by reducing the adverse effects of noise to patients and staff (Alazazi & Alfrd, 2020).

According to scientific evidence, environmental noise pollution is among the most significant environmental hazards to human health (Stansfeld & Clark, 2015). But the consequences of noise don't end with hearing impairment; there is increasing evidence that noise does also harm mental health and behavior, such as impairing concentration, academic performance, provoking anxiety, and depression (Stansfeld & Clark, 2015). The non-auditory effects of noise extend to include physical and psychological consequences, for example, on the respiratory and cardiovascular systems, through complex interrelationships including the response to biological stress, sleep disturbance, or activation of the autonomic nervous system due to unwanted noise (Munzel et al., 2014). Maintained psychological stress and prolonged stimulation of the sympathetic nervous and endocrine systems are documented by effects of traffic, generators, or industrial equipment noise, which have been associated with higher rates of hypertension and cardiovascular diseases (Babisch, 2011). Additionally, noise pollution is a reason for sleep disruption leading to immune system dysfunction and more risk of chronic disease (Basner et al., 2014). These results emphasize the necessity of noise reduction policies and the application of acoustical prioritized measures that are locally viable and economically feasible (Basner et al., 2014).

- Research Problem

Despite the proven losses caused by noise to the hospital environment and quality of health care, there is a clear shortage of local research work in the Egyptian setting that deals with this problem as part of the environmental pollution in health care facilities (Alazazi & Alfrd, 2020). This knowledge gap is indeed a significant challenge to address, because we need to

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demystify the noise reality in Egyptian hospitals and to examine its effects on the patients and the employees and to recommend practical architectural and design solutions (Al-Fard et al., 2016).

- Research Question

What is the impact of noise from external and internal sources on the indoor environmental quality in hospitals, and what are the recommended contextual strategies for reducing noise and improving acoustic performance in healthcare facilities?

- Research Objectives

1. Investigate the effects of the indoor and outdoor noise sources on the IEQ in hospitals.
2. Investigate how much the monitoring results in the current acoustic environment in Egyptian hospitals including Manshiet El-Bakry Hospital adheres to the Egyptian Code, Ministry of Health and Housing and WHO regional Office for the Eastern Mediterranean.
3. Studying the psychological effects of noise on patients and individuals doing their duties in hospital.
4. To generate feasible recommendations regarding noise pollution collectively appropriate with the local context of the hospitals.

2. RESEARCH METHOD

This paper adopts a mixed descriptive and quantitative research methodology to study the impact of noise on the acoustic environment in hospitals and enable an understanding of the acoustic challenges facing hospitals due to disturbing acoustic effects through the study of previous research and through the application and study of the case of Manshiet El-Bakry General Hospital, which is located near the Suez Bridge, the study aims to determine the relationship between noise related to the bridge, tanks, generators, etc. in the hospital and the discomfort experienced by users and employees in the hospital. The descriptive research methodology was used to conduct the study, which included four main sections: the first section was devoted to collecting general information about the participants; the second section addressed the impact of noise on the concentration and performance of medical staff; the third section focused on the impact of noise on patient comfort and recovery; and the fourth section was devoted to receiving participants' suggestions and recommendations on ways to reduce noise and improve the acoustic environment within the hospital. Results are reached by taking the opinions of doctors and nurses to determine the extent to which noise affects their concentration and performance, as well as the impact of noise on patients' recovery in the hospital. This is achieved by following a quantitative research methodology by measuring noise intensity based on the room's function, direction, and floor location using the Extech Sound Level Meter. This data is statistically analyzed to assess measurable aspects of acoustic discomfort as shown in (Figure 1).

2.1. Case Studies

Case studies can be extremely helpful in health care research because they demonstrate how actual hospitals address issues, such as noise (Darbyshire & Duncan Young, 2022). By looking at actual examples, a fuller picture emerges of what worked,

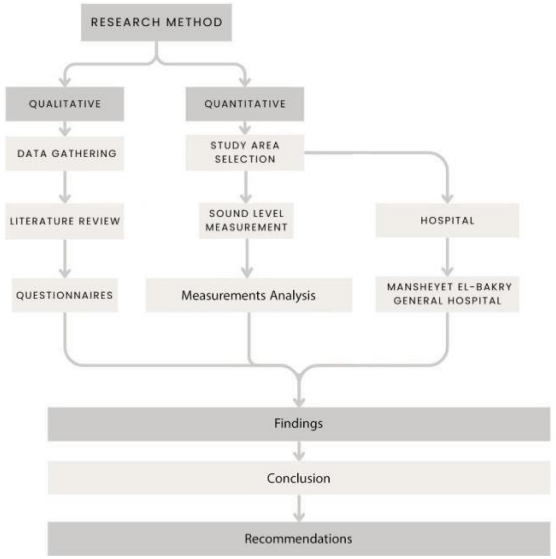

Figure 1, Research Method

what didn't, and what might work in Egyptian hospitals — especially if it's not too expensive (Mohammed et al., 2020a). Case studies also enable us to notice details that large surveys or lab experiments could overlook (Darbyshire & Duncan Young, 2022).

2.1.1 National Case Studies

In Egypt, some researches have indicated that hospital noises are a contributing problem that does not affect only Staff but also patients (Mohammed et al., 2020). Noise levels at some Cairo hospitals frequently exceeded the World Health Organization's recommended limit, adding stress and making it harder for staff to communicate with one another, the group said (Mohammed et al., 2020). Small and inexpensive adjustments, such as erecting signs or changing the way work is organized, can help to cut noise (Mohammed et al., 2020a). Such types of strategies can be successful when they are adapted to the local context and financing constraints (Mohammed et al., 2020).

- Reducing Noise in Intensive Care Units: A Practical Architectural and Engineering Framework

This research seeks to reduce the noise levels that patients in ICUs experience (Alazazi & Alfrd, 2020). This started by just measuring the noise (by use of sound level meters) to see if it was excessive, then it scoured for the primary sources of noise (Alazazi & Alfrd, 2020). And then they will cut them, with architectural and engineering responses (Alazazi & Alfrd, 2020). The study relied on actual measurement; a field visit was carried out to inspect noise in ICUs in two Cairo hospitals; Ain Shams Specialized Hospital and Ain Shams maternity hospital contrary to other studies (Alazazi & Alfrd, 2020). Noise readings were taken at different hours of the day (Alazazi & Alfrd, 2020). Subsequently, the data were evaluated and compared to internationally recommended levels of noise in healthcare facilities (Alazazi & Alfrd, 2020). They also simulated the effect of several design measures on the reduction of noise levels in ICUs using the sound plan acoustic simulation program (Alazazi & Alfrd, 2020).

Results demonstrated that the noise levels within ICUs were higher than the recommended international levels, and the

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highest noise measure of 82.4 dB was recorded near Khalifa El Maamoun street and the lowest noise measure of 57.6 dB was recorded at the rear side of the hospital (Alazazi & Alfrd, 2020). Simulation results produced by the sound plan software demonstrated that the implementation of design criteria, e.g. construction materials with good sound insulation properties, an optimized floor plan, and the placement of ICUs in proximity to low-noise sources, were effective in reducing noise levels (Alazazi & Alfrd, 2020). Background noise levels to identify the ideal location in the hospital for the ICU (on the basis of noise maps), that the location of the ICU should be in quieter areas, that single-bed patient rooms should be designed, that the number of nursing stations should be increased, and that the location of doors should be optimized to minimize sound transmission (Alazazi & Alfrd, 2020).

- Improving Patient Room Environments by Controlling External Noise: Field Measurements and Simulation at Ain Shams Hospital

The examination investigates architectural and planning solutions for minimizing noise reaching patient rooms from the external environment (Al-Fard et al., 2016). Noise was measured through a Sound Level Meter 2250 on building elevations and interior patients' rooms (Al-Fard et al., 2016). Moreover, the sound plan simulation software was employed to evaluate the efficiency of measures in terms of building orientation, landscaping (trees), perimeter walls, and alteration of building shape (Al-Fard et al., 2016).

Patient room noise exceeded the threshold level, and sound levels in patient rooms were as high as 83.3 dB on the first floor (Al-Fard et al., 2016). The simulations showed that measures such as modification of building shape and planting trees were effective in reducing noise, whereas the adjustment of building orientation had only little impact (Al-Fard et al., 2016). The authors say the findings indicate that noise needs to be addressed in the design of a hospital (Al-Fard et al., 2016). It advises focusing initially on planning and landscaping to minimize noise (Al-Fard et al., 2016). Where such methods don't make much difference, soundproofing can be a solution (Al-Fard et al., 2016).

- Evaluating the Impact of Traffic on Noise Levels in Hospitals in Cairo and Giza with Health Impacts

This study investigates noise levels in different hospitals in Cairo and Giza in relation to the influence of immediate traffic on the indoors noise environment (Ministry of Environment, 2007). It also examines the impact of hospital noise on the patients and staff both in health and functional terms (Ministry of Environment, 2007). Forty-nine hospitals were chosen from various districts in Cairo and Giza (Ministry of Environment, 2007). These hospitals were categorized into those situated on major roads more or less than 49 meters in width and the extent of surrounding traffic density (Ministry of Environment, 2007). Interior noise levels (LAeq) were recorded in the hospitals (Ministry of Environment, 2007). Staff and patients were also survey by questionnaire to find out how they feel about the noise and how it affects their health.

Most hospitals built on roads that were at least 49 meters wide — especially those on busy streets — had noise levels exceeding the limit imposed by law, 67 dB to 85 dB (Ministry of Environment, 2007). Even hospitals on smaller, quieter streets had noise levels that were above what is permitted (Ministry of Environment, 2007). In response to the survey, 55% of respondents stated that they experienced a lot of negative effects from noise, while 24% said a moderate amount (Ministry of Environment, 2007). Visitor noise and external noise transmitted from outside were the leading contributing factors, followed by hospital equipment and staff noise (Ministry of Environment, 2007). Health effects also included loss of concentration (78 percent), headaches (71 percent), nervous tension (61 percent), high blood pressure (24 percent), hearing disorders (12 percent), shortness of breath (11 percent), and digestive disorders (4 percent) (Ministry of Environment, 2007). More than 61% of those surveyed also unanimously agreed that noise had an undermining impact on their productivity (Ministry of Environment, 2007).

The study offers ideas for cutting down on noise in and around hospitals (Ministry of Environment, 2007). It recommends educating people about noise hazards and ensuring visitors and employees keep quiet (Ministry of Environment, 2007). It also suggests restricting visiting hours and visitors (Ministry of Environment, 2007). Hospitals ought to have squads to monitor noise — and traffic laws — including those against blasting horns and lumbering heavy trucks near hospitals (Ministry of Environment, 2007). It also recommends erecting sound barriers or planting more trees, and having better road surfaces to reduce the noise from the cars (Ministry of Environment, 2007). Hospitals should be sited a long way from major roads and patient rooms should not be next to noisy areas inside and outside of the building (Ministry of Environment, 2007).

- Managing High Noise Levels in Operating Rooms at Kasr Al Ainy Hospital

The objectives of the study are to measure noise levels in different hospitals in Cairo and Giza in attempt to study the impact of the surrounding traffic on these levels (Mohammed et al., 2020a). It also examines the effects of hospital noise on the health and functioning of patients and staff (Mohammed et al., 2020a). Forty-nine hospitals were chosen from various districts in Cairo and Giza (Mohammed et al., 2020a). These hospitals were further stratified based on the physical presence of major roads >49-m width, and on the level of traffic volume around them (Mohammed et al., 2020a). Noise levels (LAeq) were recorded within the hospitals (Mohammed et al., 2020a). Staff and patients were also asked to complete a questionnaire to learn how they experience the noise and how it impacts their health (Mohammed et al., 2020a).

The aim of the study is to determine the sound intensity levels that are present in the ORs at Kasr Al Ainy Hospitals during different operations and to compare them with limits suggested by the WHO (Mohammed et al., 2020a). It also assessed the feasibility and effectiveness of the smartphone app NoiseCapture in measuring noise (Mohammed et al., 2020a). Data were collected from 40 patients undergoing regional anesthesia surgeries in six ORs (Mohammed et al., 2020). Sound intensity was evaluated with a TM-102 Sound Level Meter combined with the NoiseCapture application in the smartphone (Mohammed et al., 2020a). Databases The variables of interest were the maximum, minimum, and average (Leq A-weighted) sound levels in decibels (dB) (Mohammed et al., 2020a).

Average noise levels in the operating rooms were about 73 dB, far exceeding the World Health Organization recommended limit of 40 dB for hospitals (Mohammed et al., 2020a). The obstetric room, which had the highest noise with a maximum value of 78 dB (Mohammed et al., 2020a). Results from the

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sound meter and the Noise Capture app were nearly identical, suggesting the app could be a useful, simple tool to check on noise levels in the O.R. Kasr Al Ainy Hospital operating rooms were found to be significantly louder than the international safety standards, which may put patient comfort and safety at risk (Mohammed et al., 2020a). It also suggests that monitoring noise levels during surgery, for example with a smartphone app, could help control and reduce the problem (Mohammed et al., 2020a).

- Impact of Nursing Actions on Reducing Noise and Alarm Fatigue in Intensive Care Units

This article aims to explore what nursing interventions might decrease noise and alarm fatigue in the intensive care unit (Ahmad & Younes, 2023a). Damanhur National Medical Institute wards and involve 30 convenience-sampled nurses (Ahmad & Younes, 2023a). Two instruments were employed: a questionnaire to measure alarm fatigue and a checklist to assess how well nurses implemented noise reduction measures (Ahmad & Younes, 2023a). There was an 8-week training program that included instruction on how to cut down noise and improve responses to alarms (Ahmad & Younes, 2023). Noise was measured with a smartphone app before and after training (Ahmad & Younes, 2023).

Following the training, sounds decreased from 46.35 to 37.99 decibels (Ahmad & Younes, 2023). Alarm fatigue decreased as well, from 53.65% to 49.29% (Ahmad & Younes, 2023). Nurses were more likely to follow such steps to reduce noise, and their response to alarms was better, with fewer instances of issues such as devices set up incorrectly (Ahmad & Younes, 2023). The research provides some clues, however, indicating that checking noise levels in ICUs frequently, sensing how much noise the patients can tolerate and following strategies to reduce noise are beneficial (Ahmad & Younes, 2023). It also emphasizes education for nurses about the effects of alarms and noise on patients and about alarm management as a part of nurse education and training (Ahmad & Younes, 2023).

2.1.2 International Case Studies

Research and successful experiences in other countries such as the United States and the UK have adopted various methods in attempts to reduce hospital noise levels, including the provision of technical solutions and staff-related strategies (Gupta et al., 2023). Both staff training and hospital design can help reduce noise and the work environment (Darbyshire & Duncan Young, 2022). While some of these may be expensive or not easily applied in Egypt, they provide inspiration that can be tuned to kind local context (Gupta et al., 2023).

- Effectiveness of Acoustic Treatments in General Hospital Wards in China

The purpose of the study was to investigate the impact of a variety of acoustic treatments (sound-absorbing ceilings, sound insulating doors, and double glazing) on the sound environment in hospital wards in order to learn how it may reduce the noise and reverberation and thereby support comfort and communication for patients and staff (Deng et al., 2023). The study was performed in Yibin 2nd People's Hospital in Southwest China, and two case study wards were involved, Cardiology Ward (in an old building) and Oncology Ward (in a new but untreated space). Acoustic interventions were limited to a few areas -- the nurse station, one hallway and two patient rooms (Deng et al., 2023). Treatments were high-performance acoustical ceiling tiles (NRC = 0.75), replacing old doors with doors with sound insulation, and installing double-glaze windows (Deng et al., 2023). Quantitative assessments (reverberation time, noise levels, and frequency of loud events), patient and staff survey, spectral analysis and acoustic modeling with CATT software were performed to evaluate acoustic conditions before and after intervention (Deng et al., 2023).

Advances in acoustic environment were made as a result of the mediations. Reverberation times declined 13–53%, with the Oncology Ward nursing station recording the most significant reduction (from 0.58s to 0.27s) (Deng et al., 2023). The noise level in corridors and stations decreased (5–13 dB) and that in patients' rooms decreased slightly (2–4 dB) during daytime and more (5–6 dB) during the night. The loud noise incidence had also reduced substantially (Deng et al., 2023). Feedback from participants indicated perceived benefits: more than half of the patient participants (53.5%) and almost half of the staff participants (48.5%) reported a positive difference to the sound environment (Deng et al., 2023). Patients experienced improved sleep and mood, and staff experienced enhanced communication and reduction of vocal aches and pain (Deng et al., 2023).

The authors strongly advocate the inclusion of acoustic treatment in hospital construction and renovation (Deng et al., 2023). Acoustic ceilings, doors and double-glazed glass were also found to be effective at dampening ambient noise levels, particularly in open areas such as near nursing stations (Deng et al., 2023). They also recommended resilient flooring to reduce the noise transmitted from carts and trolleys at the site, and even recommended adding natural background sounds, such as bird calls or waterfalls, to reduce stress and improve patient comfort (Deng et al., 2023). They are of low cost in relation to what is expected from them and could be integrated as part of standard healthcare facility design (Deng et al., 2023).

- Reducing Acoustic Disturbances in ICUs: Temporary Success, Long-Term Challenges

The purpose of this research was to decrease noise levels in the patient wards of three intensive care units (ICU)—anesthesiology, neurology, and neonatology—in which it is common for sound levels to exceed international standard limits (Witek et al., 2025). Too much noise is hard on patients' healing and staff performance (Witek et al., 2025). The investigators aimed to determine whether an environmental intervention (a tailored unit-specific intervention package) was associated with a significant decrease in noise and an improved sound environment in these high-stress hospital clinical settings (Witek et al., 2025).

The study was carried out as a pre–post implementation study for a 12-week period (Witek et al., 2025). An individual noise control package, to control and reduce noise, was implemented at each ICU (Witek et al., 2025). Specifically, this package included noise regulations, additional measures to prevent noise, and the use of "noise traffic light" systems to offer real-time feedback for noise levels (Witek et al., 2025). The main outcome was the change in mean ambient sound pressure level (LAeq) over 12 weeks with two further measures of peak and maximum reported for different time periods of day including 24 week post-treatment follow-up (Witek et al., 2025).

After the intervention the mean LAeq was 56.43 (SD: 3.5), being significantly lower ($t=2.4$; $p=0.034$) than before the

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intervention, 57.21 (SD: 3.2), with a difference of 0.77dB(A). The largest decrease was measured in one of the three ICUs, amounting to 2.21 dB (A ($p < 0.0001$) (Witek et al., 2025). The observed effect was somewhat diminished after adjusting for nursing workload (Witek et al., 2025). When tested separately according to time of day, the decrease in daytime noise was 0.57 dB(A), which was not significant, and that in nighttime noise was 1.11 dB(A), which was significant ($p = 0.02$) (Witek et al., 2025). Nevertheless, during the subsequent 24 weeks of follow-up, noise levels also rose again by 0.81 dB(A) ($p = 0.01$), reflecting no long-term impact (Witek et al., 2025).
According to the study, multi-faceted, inexpensive measures can achieve a short-term improvement in the noisy levels in the ICU, particularly during the night (Witek et al., 2025). However, the magnitude of noise reduction is limited in clinical relevance (Witek et al., 2025). To ensure that change is effective and sustainable, the authors advise to commit available resourcing and follow a participatory process with healthcare staff and to do this with a structured implementation process (Witek et al., 2025). "Such monitoring is key to sustainable noise reduction in the ICU, and to the effect of its reduction on patients and staff" (Witek et al., 2025).

- Choosing the Best Ways to Make Hospitals Quieter: A Study with Expert Help and Smart Tools

The objective of this study is to rank and determine which noise-mitigation strategies are most effective in hospitals (Abbasi et al., 2024a). High levels of noise in healthcare settings can disrupt both patient comfort and staff performance (Abbasi et al., 2024a). While there are a number of ways to mitigate noise, there is no consensus on which are the best (Abbasi et al., 2024a). Hence, in this study, the Multi-Criteria Decision-Making (MCDM) with the aid of Fuzzy Logic is used to analyze and prioritize noise mitigation measures (Abbasi et al., 2024a). Three primary stages comprised this study, the researchers first conducted a review of literature to identify and categorize the four main types of hospital noise sources (Abbasi et al., 2024a). Including that from external (e.g. traffic), internal devices used (e.g. air conditioners), human activity and medical equipment, through using databases like Scopus and PubMed (Abbasi et al., 2024a). In the second phase, 20 experts specialized in noise control, occupational safety, healthcare, etc., were also interviewed to identify 22 noise control and 9 evaluation methods, respectively (Abbasi et al., 2024a). These practices were categorized as engineering controls, administrative controls, and PPE (personal protective equipment) (Abbasi et al., 2024a). The 3rd phase was to apply Fuzzy AHP to the criteria to assign weights and Fuzzy TOPSIS method to prioritize the 22 strategies based on the closeness of the alternatives to the ideal solution (Abbasi et al., 2024a).The three most salient criteria of evaluation were feasibility (weight = 0.175), effectiveness (0.143) and impact in staff activities (0.140) (Abbasi et al., 2024a). Among the 22 strategies, the highest ranked noise reduction strategy was replacing noisy equipment (CCI = 0.854), and other follow-ups included the use of acoustic hoods, double leaded windows, lining of walls and doors for sound proofing, replacement of audible alarms with visual alarm or smart alert (Abbasi et al., 2024a). On the other end of the spectrum, PPE-based interventions such as earplugs and noise-cancelling headphones were rated poorly for their patient discomfort and disruption to communication (Abbasi et al., 2024a). The study suggests more resources should be allocated to engineering solutions since these were rated as the most effective and feasible with least impact on hospital function (Abbasi et al., 2024a). These could involve retrofitting or replacing noisier equipment, enhancing architectural insulation (such as double-glazing), or employing acoustic barriers (Abbasi et al., 2024a). Administrative controls, noise reduction policies and cleaning schedules were of moderate efficacy and PPE measures were the least favored (Abbasi et al., 2024a). In general, operators should focus investment on long-term engineering solutions rather than short-term or cumbersome measures like earplugs (Abbasi et al., 2024a).

3. RESULTS

By conducting a questionnaire and surveying the opinions of doctors and nurses to determine the extent to which noise affects their concentration and performance, as shown in (Figure 2), in addition to its impact on patients' recovery in the hospital, as shown in (Figure 3). Measurements were also conducted to measure noise intensity based on the room's function and orientation, floor level using an Extech Sound Level device, as shown in (Figure 4).
Based on the data collected, the results indicate a variance in perceptions of noise intensity and its impact on patients within the hospital as shown in (Figure 2). Only one participant reported that the noise level was "very low," and six considered it "not at all impactful," reflecting a small percentage who viewed noise as not a problem. While 15 participants indicated that the noise level was "moderate," 18 rated its impact as "slight," suggesting a moderate perception of the noise without considering it a significant factor. Fourteen participants rated the noise as "loud," and 11 of them considered its impact to be "moderate," reflecting an increased awareness of its potential impact. In contrast, five participants described the noise as "very loud," but none reported a "severe" impact, which may reflect a form of adaptation or a weakening association between noise intensity and the severity of its impact on patients as shown in (Figure 2).

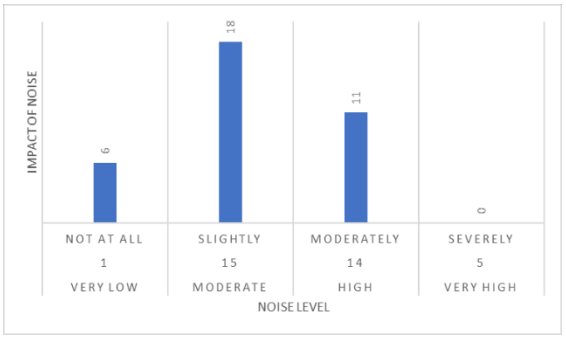

Figure 2, The relationship between noise level and its impact on performance and concentration

The survey results showed a diversity of participants' opinions about the impact of noise on patients' recovery, depending on the length of their hospital stay as shown in (Figure 3). Among participants who stayed less than one day (6 individuals), 5 strongly agreed that noise affected the recovery process. Among those who stayed from 1 to 7 days (4 participants), 6 agreed. In contrast, There were 13 participants who had been

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in the hospital for 1 to 5 years, 10 of whom expressed a neutral attitude toward the impact of noise. As for the participants who had been in the hospital for more than 5 years (12 individuals), all (12) disagreed, indicating that the perception of the impact of noise decreases with the length of time in the hospital or adaptation to the environment as shown in (Figure 3).

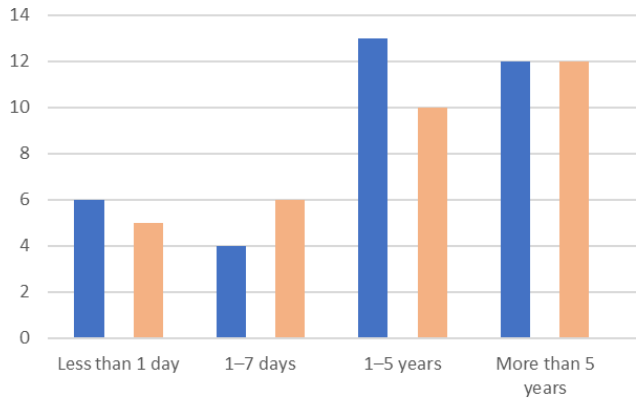

Figure 3, The relationship between people who spent longer in the hospital and the effect of noise on patients' recovery.

Noise level measurements inside Manshiet El-Bakry Hospital showed significant variations depending on the floor, room function, and whether or not the room overlooks a nearby bridge as shown in (Figure 3). On the sixth floor, noise levels of 61 decibels were recorded in the doctors' room, which lacked a bridge view. While it rose to 63 decibels in a similar room with a direct view. Similarly, in patient rooms on the same floor, 65 decibels were recorded with a view and 59 decibels without. On the fifth floor, the noise in the doctors' room reached 59 decibels without a view. On the fourth floor, the nurses' room recorded 66 decibels without a view, while the noise in the surgical dressing room reached 67 decibels with a view. On the third floor, noise was relatively higher, with 69 decibels recorded in the nursing room and 63 decibels in the patient room, both overlooking the bridge. On the second floor, the noise level in the corridor without a view reached 67 decibels, while in the outpatient clinics on the ground (first) floor, Noise levels reached 68 decibels, also without a view. This data reflects a relationship between noise levels and the proximity of rooms to noise sources, such as bridges, as well as the influence of room function and floor on noise levels as shown in (Table 1).

Table 1, Illustrates the relationship between space function, orientation, floor level, and noise intensity level.

Floor Level	Room Function	Noise Level	Bridge view
6	Doctors' Room	61	No
6	Doctors' Room	63	Yes
6	Patients' Room	65	Yes
6	Patients' Room	59	No
5	Doctors' Room	59	No
4	Nurses' Room	66	No
4	Surgical Changing Room	67	Yes
3	Nurses' Room	69	Yes
3	Patients' Room	63	Yes
2	Corridor	67	No
1	Outpatients Clinics	68	No

4. CONCLUSION

This study showed the great impact of environmental and internal noise towards the acoustic quality of the tactile environment in healthcare buildings, and mostly between other healthcare buildings of Manshiet El-Bakry Hospital. With a combination of quantitative sound measurements and questionnaires addressed to the stakeholders, it was illustrated higher sound types, particularly in rooms exposed to traffic infrastructure, to negatively influence both the staff's work and patients recovery. This was evidenced by the variance in the perceived strength of noise according to participants' observing position and length of abode, and the phenomenon of noise habituation for long residents. In addition our findings are consistent with findings from both local and international sources, indicating that existing noise levels in multiple hospitals throughout Egypt surpass the WHO and EBC recommended levels. The study stresses the critical necessity for contextually-appropriate, cost effective architectural, administrative and technical interventions to minimize hospital noise pollution. Finally, improving acoustic conditions is not only a question of comfort: It is a constitutive aspect of patient-centered, high-quality care.

5. RECOMMENDATIONS

1. Staff Training and Awareness

Making healthcare workers aware that noise in hospitals has a detrimental effect on patients' health and recovery can help to establish a more attentive and peaceful hospital setting (Deng et al., 2023). Constant reminders and ongoing communication can help to build that culture of positive behaviors- speaking quietly, closing doors softly, and that unnecessary distractions upset the work environment (Ahmad & Younes, 2023b).

2. Operational and Administrative Practices

Practical aspects are also very important in controlling noise. Hospitals should establish a policy for the use of alarms and noisy medical equipment and ensure that all are used when necessary and in an appropriate manner (Abbasi et al., 2024). The scheduling of cleaning, maintenance and other noisy activities during time when patients are less sensitive, can minimize interference with patient care areas. Foster non-verbal communication between employees in "zones" to help keep noise levels down. Limiting the number of patients per room or the occupancy percentage in sensitive zones can additionally decrease the noise level and patient's comfort (Ahmad & Younes, 2023). Also, avoiding too many staff members in closer quarters – like overnight shifts – can cut down on chattiness and general sound of people shuffling around and talking (Ahmad & Younes, 2023).

3. Noise Monitoring and Evaluation

Simple tools of monitoring and assessing noise facilitate ongoing improvements (Mohammed et al., 2020). Hospitals track noise, especially in ICUs and patient rooms, using simple sound level meters or mobile apps (Mohammed et al., 2020b). These routine surveys have assisted in pinpointing problem areas and in providing information that is useful for further noise control activities (Ahmad & Younes, 2023).

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4. Spatial and Functional Planning

Various noise problems can also be effectively addressed by way of improved spatial and functional design (Al-Fard et al., 2016). Reprogramming room layouts or the positioning of noisy spaces, such as nurse stations or waiting areas, further from patient rooms can also help reduce the transmission of noise (Al-Fard et al., 2016). Movable partitions or barriers can also help create quieter zones within open-plan departments without the need for extensive renovation (Al-Fard et al., 2016). In addition, patients are given their own single-bed rooms, to reduce noise exposure and increase privacy (Al-Fard et al., 2016).

5. Architectural Design and Construction Techniques

Architectural Underfloor solutions for Sound Long-term benefits for noise (Deng et al., 2023). Laying sound absorbing ceiling tiles, double glazing windows and acoustic doors can obviously decrease the sound penetration in intensive care wards (Deng et al., 2023). There should be a focus on construction (including when renovating buildings) which incorporates sound attenuating materials and design elements that prevent reverberation and sound transfer, particularly in areas sensitive to noise such as ICU or neonatal wards (Al-Fard et al., 2016).

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