A Model for Understanding the Role of Sound Perception in Hospital Spaces

Timothy Onosahwo Iyendo

Submitted to the
Institute of Graduate Studies and Research
in partial fulfilment of the requirements for the degree of

Doctor of Philosophy
in
Architecture

Eastern Mediterranean University
September 2016
Gazimağusa, North Cyprus

Approval of the Institute of Graduate Studies and Research

Prof. Dr. Mustafa Tümer
Director

I certify that this thesis satisfies the requirements as a thesis for the degree of Doctor of Philosophy in Architecture.

Prof. Dr. Naciye Doratli
Chair, Department of Architecture

We certify that we have read this thesis and that in our opinion it is fully adequate in scope and quality as a thesis for the degree of Doctor of Philosophy in Architecture.

Assoc. Prof. Dr. Rafooneh M. Sani
Supervisor

Examining Committee

1. Prof. Dr. Füsun Demirel
2. Prof. Dr. Çiğdem Polatoğlu
3. Assoc. Prof. Dr. Maya N. Öztürk
4. Assoc. Prof. Dr. Rafooneh M. Sani
5. Asst. Prof. Dr. Nazife Özay

ABSTRACT

A hospital can be a stressful place, and for patients and health care providers being in a hospital can be an exceedingly distressing experience. Evidence from existing literature has propounded that exploring the positive aspect of sound in a hospital context can evoke positive feelings in both patients and staff. However, the pursuits of visual dimensions of space, and the dominance of intensive acoustic analysis have undermined the notion that sound can positively influence experience in hospital space design. This aspect is often overlooked, as research in architectural practice relies more on aesthetic listening rather than developing a critical listening technique. This suggests that there is a scope for research into the aspects of hospital space experience with a focus on the role of sound as they relate to what may be positive, negative effects and the feelings that different sounds can evoke.

This study aims at developing a theoretical framework, a paradigm for noise research and architectural design practice for hospital environments. The intention of this investigation is to move beyond the conception that noise is simply unwelcome and to explore the extent to which investigators have researched into the meaning of sound in the environment of health care indoor spaces.

This study is interdisciplinary, taking up the subject that includes theories of sound perception and ecology, empirical studies, evidence-based design theories, environmental psychology, hospital management and multisensory design in architecture, including other environmental factors and hospital experiences. A qualitative content analysis was employed to analyse a vast body of literature retrieved from the Web of Science, PubMed, Scopus, ProQuest Central, MEDLINE, and Google scholar. Additionally, a qualitative research inquiry based on observation, discussion with experts on related field via emails and documentation of studies was used to address the study objectives. These form grounds to derive and develop a conceptual model to serve as a guideline for improving healthcare experience and design practice for hospital spaces.

The result of this study pointed out that not all sounds give a negative impression within healthcare soundscapes. The perception of sound was shown to bring about positive change in patient-reported outcomes such as eliciting positive emotion and decreasing the levels of stressful health conditions. The study findings also showed that hospital space designed to incorporate sound, good space qualities, wall openings and access to nature, including appropriate materials and finishes has the potential to impact upon patients and staff health outcomes, thereby reducing stress and improving coping strategies, effectiveness in delivering care, safety, and overall sound quality satisfaction. Therefore, with the support of evidence-based research, conceptualizing the nature of sound in the hospital context as a soundscape, rather than merely noise can permit a subtler and socially useful understanding of the role of sound and music in the hospital setting. This may create a means for improving the hospital experience for patients and patients care teams. This area should be further explored to create a greater understanding of this new paradigm in the field of hospital noise.

Keywords: Architectural design, environmental design, hospital experience, music psychology, noise, positive distraction, sound design, sound perception, soundscape, stress reduction.

ÖZ

Hastahaneler son derece stresli bir yer olabilir, hastalar ve personel için stresli bir deneyim oluşturabilir. Literatürde ortaya atılan kanıta göre, bir hastahane ortamındaki sesin pozitif yönünü keşvetmek, hastalar ve personel için olumlu duygular uyandırabilir ancak, alanların görsel boyut takipçiliği ve yoğun akustik hakimiyetin analizi, hastahane alanlarındaki sesin, mekanı olumlu etkileyebileceği fikrini zayıflattı. Mimari uygulamalardaki araştırmalar daha fazla estetik dinlemeyi değerlendirirken, kritik dinleme tekniği göz ardı edildi. Hastahane alanlarında yapılan araştırma kapsamında olumlu ve olumsuz sesin ne olduğuna odaklanıldı ve farklı seslerin nasıl duygular uyandıracağı araştırıldı.

Bu çalışmayla birlikte, teorik bilgiye dayanarak ses için yeni bir paradigma oluşturmak ve hastahaneler için yeni bir tasarım denemesi yapmak amaçlanmaktadır. Bu amaçla, gürültünün sadece istenmeyen bir olgu olmadığı kavramı geliştirilip, sağlık alanlarındaki iç mekanlarda sesin anlamının araştırılması hedeflenmektedir.

Bu çalışma disiplinlerarası bir çalışma olup ses hakındaki ekolojik, deneysel, kanıt temelli tasarım teorileri, çevresel psikoloji, hastahane yönetimi ve mimarideki çok algılı tasarımla diğer çevresel faktörler ve tecrübeler içermektedir. Bu çalışma kapsamında yapılacak olan nitel araştırma gözlem'e, bu alandakı uzmanlarla email yoluyla tartışmaya ve dökümantasyon çalışmasına dayanmaktadır. Bununla birlikte, nitel araştırmanın içeriği, Web of Science, PubMed, Scopus, ProQuest Central, MEDLINE ve Google scholar aracılığıyla çoğu literatür taraması yapılmıştır. Ses hakkında türetilen tasarım ve konsept çalışmaları bu literatür araştırmasıyla modellenmiş olup konseptsel çerçeve, pozitif ses atmosferinin tasarımı geliştirilerek, hastahaneler için tasarım denemesi yapılmıştır.

Sunuç olarak bu çalışma sağlık merkezlerindeki tüm seslerin negatif etki yaratmadığnı göstermiştir. Sesin algılanması, pozitif bir duygu yarattığını ve sağlık merkezlerindeki stresli atmosferin düzeyini azalttığını göstemektedir. Bu çalışma aynı zamanda hastahane alanlarının sesi birleştirmek, iyi alan kalitesi, duvar açıklıkları, doğayla bir erişim bağlantısı kurmak için, tasarlandığını göstermektedir. Uygun malzeme ve kaplama hastaların ve personelin algısını etkileme potansiyeline sahip olup, stresi azaltma ve başa çıkma stratejileri geliştirmede yardımcıdır. Bakım, güvenlik ve genel ses kalitesi memnuniyeti, hastalar ve çalışanlar üzerindeki etkiyi etkilemektedir. Bununla birlikte, kanıt odaklı araştırma, hastahane bağlamındaki ses atmosferinde, doğadaki sesi kavramsallaştırma yerine, hastahane ortamındaki sesin ve müziğin rolü üzerinde incelikli ve topluma yararlı bir anlayışa izin verebileceğini göstermiştir. Bu da, hastalar ve çalışanlar için daha iyi bir atmosferin yaratılabileceğni göstermiştir. Bu alan ayrıca hastahanedeki seslerle ilgili alandaki bu yeni paradigmayı dahada geliştirmek için araştırılmalıdır.

Anahtar Kelimeler: Mimari Tasarım, Çevresel Tasarım, Sağlık Kazanımları, Hastahane Deneyimi, Müzik Psikolojisi, Gürültü, Pozitif Dikkat Dağıtıcı, Ses Tasarımı, Ses Algısı, Ses Alanı, Gerilim Azaltma.

DEDICATION

I would like to dedicate this dissertation to my loving family (wife, daughter, and parents), and the Almighty Jehovah God who kept me alive during this difficult, but the most enjoyable enterprise of doctoral journey.

ACKNOWLEDGMENT

It could never have been possible to complete this dissertation without the help of so many people. First and foremost, my sincere thanks go to my academic supervisor, Assoc. Prof. Dr. Rafooneh M. Sani for her knowledge, guidance, constructive criticism, support and timely feedback over the past few years make her the best supervisor, I have met so far… It is really a pleasure to work with her. I am very grateful to Assoc. Prof. Dr. Maya Öztürk, Assist. Prof. Dr. Nazife Özay, Prof. Dr. Hifsiye Pulhan, and Assoc. Prof. Dr. Sadiye Müjdem Vural for their kind assistance in the completion of this research work.

I am indebted to Prof. Dr. Şebnem Hoşkara for her guidance and most importantly for giving me the opportunity to serve as a research assistant in the faculty of architecture, which I believe must have substantially supported me throughout my Ph.D. studies. Her kindness would never be forgotten. Similarly, I desire to sincerely express my gratitude and thanks to Prof. Dr. Naciye Doratli for her generosity. She gave me hope when I thought all hope was extended.

Also, worthy of acknowledgment are all members of staff of the department of Architecture, who directly or indirectly contributed to the success of this research work; Assist. Prof. Dr. Polat Hançer, Assoc. Prof. Dr. Netice Yildiz, Prof. Dr. Özgür Dinçyürek, and Prof. Dr. Yonca Hürol. In addition, my appreciation goes to my colleagues Dr. Olusegun A. Olugbade, Patrick C. Uwajeh, and Ikenna S. Ezennia for their direct and indirect assistance and supplications during my research. I also appreciate the time and intensive efforts made by Prof. Dr. Çiğdem Polatoğlu and Prof.

Dr. Füsun Demirel in reviewing and providing highly insightful comments that greatly elevated the quality of this dissertation. I thank all of you so much for helping me to the completion of this Ph.D. study.

My acknowledgements go to my beloved wife Shairmila Colombage De Soyza and daughter Ejiroghene Gabriella Iyendo, I feel immense gratitude towards them for encouraging and supporting me in all means possible throughout this difficult and interesting journal called Ph.D. My utmost gratitude goes to my parents Mr. and Mrs. Johnson A. Iyendo whose moral and financial support afforded me the opportunity for undertaking and completing this programme successfully. I am also entirely indebted to my brothers and sisters, whose care and love have been a compelling force that enabled me to aspire once more to excellence.

I finally give all glory to the Almighty Jehovah God for sustaining my life and giving me the knowledge in Jesus name…………. Amen.

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LIST OF ABBREVIATIONS

ADHD	Attention Deficit Hyperactivity Disorder
ADL	Activities of Daily Living
dB	Decibel
dB(A)	A-Weighted Decibel
EBD	Evidence-Based Design
EBHD	Evidence-Based Healthcare Design
EBM	Evidence-Based Medicine
EBP	Evidence-Based Practice
HERD	Health Environments Research & Design
Hz	Hertz
ICU	Intensive Care Units
L10 or L10	Noise Level Exceeded for 10 Per Cent
L90, T or L90	Level of Sound Exceeded for 90% of The Monitoring Period
L_{DN}	Day-Night Average Sound Level
LEM	Low-Cost Environmental Modifications
L_{eq}	Equivalent A-Weighted Sound Level
LFN	Low Frequency Noise
L_{max}	Maximum A-Weighted Sound Level
L_{peak}	Peak Pressure Level
MRI	Magnetic Resonance Imaging
NICU	Neonatal Intensive Care Unit
PICU	Pediatric Intensive Care Units
RT	Reverberation Time

SAP	Sound Absorbing Panel
SI	Speech Intelligibility
SPL	Sound Pressure Level
WHO	World Health Organization
μPa	Micropascal

Chapter 1

INTRODUCTION

In the last few decades, research on healthcare design and planning has foregrounded substantial relationships between physical environmental factors and wellness. This supports the Evidence-based Design Practice (EBDP) which conceptualised credible evidence to influence healthcare design in order to improve patients and healthcare providers' well-being, patients' healing, safety and reduces their stress outcomes. In this way, the physical environment where patients are cared for plays a significant role in their outcomes and should reduce pain, anxiety, and stress for patients' comfort and safety. The environmental design of hospital facilities has been shown to directly affect the well-being of staff, patients, and their families psychologically and physiologically. Studies supporting the Evidence-based Design Practice has shown that poorly designed environment exacerbate patient anxiety and stress and diminish their health care experiences.

As it may be expected, healthcare environments designed to support a patient's wellbeing result in improved health outcomes. Evidence-based research and soundscape design research have demonstrated that one major aspect of the environmental design interventions or supportive design factor to enhance wellness and wellbeing in the hospital settings include sound, although sound has been intensively documented in terms of acoustic measurements along with the potential adverse effects it has on users in the healthcare ecosystem. There is concrete evidence to suggest that exploring the positive aspect of sound in a hospital context can evoke positive feelings on hospital occupants. However, this is not always the case, as subjectively, sound hold both positive and negative aspects. Regardless of sound level measurements or sound reduction, this research documents the role of sound perception in the hospital environment and its effects with a particular focus on the user’s experience as it concerns health and well-being. Additionally, it is worthwhile to mention that in spite of the numerous research on sound in hospital physical environments, only a limited effort has been made to explore and understand the role that sound has, as it relates to perception and user experience within the hospital and regards sound in the hospital environment as a soundscape. This present study goes much deeper than just diminishing sound levels and explored the extent to which investigators have hypothesised the positive aspects of sound sources and sound of music in the health care ecological system.

Consequently, the intention of this study is to move beyond the notion that noise is merely unwanted and to explore the extent to which investigators have researched or theorised the meaning of sound in ecological systems of hospitals, and to discover a new paradigm in the area of hospital noise that contribute to achieving positive outcomes for hospice residents. Thus, exploring the positive meaning of sound in hospital context is pertinent as this will provide a way of improving patients emotional feeling and recovery within these environments. As sound perception is subjective, experience of the hospital positive and negative soundscape aspect should be explored. However, in order to achieve this postulated theory, there is a need to theoretically define and elucidate the meaning and core effects of sound perception as it relates to users’ experience in the hospital built environment.

Although there is a great body of literature on the use of sound medicine to help reach healing goals in hospital settings, there is comparatively limited evidence-based research supporting the impact of negative and positive sounds, and the feelings that the perception of sound evokes on health in hospital spaces. To address this, the study primarily focuses on the role of sound and its influence on health outcomes in hospital settings. Therefore, this study aims at developing a theoretical framework, a novel paradigm for noise research and design practice for hospital environments.

1.1 Background of the Investigation

Much effort has been made to understand how perception of soundscape or sounds can be applied to improve urban experiences (Axelsson et al., 2010; Cain et al., 2013; Davies et al., 2013), but only a little progress has been made towards understanding the positive role of sound perception to improve user's emotional experience within the hospital soundscapes (Mackrill et al., 2014). This aspect of the hospital design commonly known as the auditory landscape is often disregarded and mostly based on sound level or acoustic analysis, although sound level is one important aspect of a soundscape, but not necessarily the major factor affecting soundscape perception (Schulte-Fortkamp, 2007). Additionally, sound in hospital space has traditionally been regarded from a negative impression of being intrusive and unwanted and based mainly on sound levels. For example, when dealing with sound in the environment, Engineering evaluations commonly consider simple A-weighted sound level of spaces and decide which sound sources should be mitigated with reference to guidelines. Consequently, much of the studies conducted within the hospital context have applied this approach and documented sound level reduction, especially in intensive care units (ICU). Subjectively, however, there are many positive aspects of sound within the hospital auditory soundscapes that convey meaningful information that is positive for patients and staff, which can be used to effectively facilitate recovery from illness (Ratcliffe et al., 2013; Rubert et al., 2007).

However, Joseph and Ulrich (2007) supported that sound, in its diverse form, can bear a profound impression on patients, staff, and visitors in hospitals, although, this can range from soothing to therapeutic, it can also be stressful and disrupting. Moreover, studies have also shown that undesirable sound within the environment of care can evidently be unfavourable to health and impede recovering process (Stansfeld & Matheson, 2003; Choiniere, 2010; Hagerman et al., 2005). In addition, an early research by Nightingale (1860) advocated that hospital design should do the sick patients no harm. In support of this theory, investigation has linked poorly planned healthcare design to psychological and physiological distress (Ulrich, 1992), however, these negative effects can be tackled through good or supportive design. In this way, hospital spaces have the potential to mitigate stress and anxiety, as well as promote emotional comfort and safety for patients (Douglas & Douglas, 2004). Similarly, patients' hospital experiences are largely driven by their medical outcomes, which indicates that their interactions with staff and the perceptions of their physical environment should be a top priority, as this would support a positive patient experience. Additionally, it has been pointed out that an intentionally designed environment takes into account the entire ambient elements, letting both auditory and visual to incorporate seamlessly into the patient experience (Mazer & Smith, 1999). Previous studies on the hospital healing environment suggest that the environment of care should help patients refocus from undesirable stimuli to something desirable and familiar (McCaffrey, 2008). One feature of such an environment might be soothing sound of music, an intervention that transforms an environment and can help distract patient's attention away from unpleasant to pleasant experience, thus helping them to deal with emotional stress (Good et al., 2001; Fredriksson et al., 2009). Indeed, research studies have revealed that patients receive a positive satisfaction and more serious recovery in an environment that integrates desirable sounds (Gross et al., 1998; Rubin et al., 1998).

There is an indication that some type of sounds has shown to produce a positive experience from the occupants, especially patients within the hospital context. For example, studies have revealed that hospital environment that incorporates musical sounds has been shown to be a positive distraction that may effectively mask other irritating sound (Shepley, 2006), thereby reducing negative emotional feelings and facilitating recovery from illness. This supports the hypothesis that certain natural sounds in a given space may enhance positive feelings (Guastavino, 2006). Similarly, one study that looked into the influence of intraoperative natural sound on anaesthesia patients established that the application of contain sounds, such as soothing bird sounds, rippling stream, and a soft wind in a general anaesthesia context, significantly blunt physiological changes after anaesthesia, as well as heightened perceived acceptability of anaesthesia to the patient (Tsuchiya et al., 2003).

In this vein, theoreticians and psychologists have supported the notion that some certain kind of sound when integrated within the hospital environment improves or produces positive outcomes for patients and staff, thus enhancing the hospital space experience. Further buttressing on this notion, Ulrich's (1991) theory of environmental design postulated that incorporating positive distraction such as soothing sounds of music, fountains, bird song, and water bodies in hospital design would alleviate stress-related outcomes, thereby enhancing occupant's experiences within this space. Additionally, a study undertaken by Diette et al. (2003) in a Baltimore teaching hospital observed that the combination of positive distraction therapy and nature sounds significantly reduced stressful pain in patients undergoing flexible bronchoscopy when matched with patients who did not receive any sound therapy. However, the same study concluded that in order to improve the understanding of how nature sounds affect individuals healing, further research should consider this area. Similarly, the theory of psychosocially supportive design conceptualised by Dilani's (2005) affirmed that when a hospital physical environment incorporates water topographies, as well as an orchestra playing pleasant music promotes a positive experience that stimulates the senses, soothes the nerves and makes the whole hospital experience comprehensible, manageable and meaningful. As well, Salandin et al. (2011) discovered that implementing white noise in the intensive care unit showed lowered (i.e. reduced difference between peak noise and background noise) impact of noise and improved sleep among patients. Additionally, the same research concluded that using music, ocean sounds, and random sounds have the ability to improve the sound quality of hospital ward design.

Furthermore, it is worthwhile mentioning that visual articulation of hospital spaces has been highly recognised and studied by previous studies (Andrade et al., 2012; Barlas et al., 2001; Parsons & Hartig, 2000). In spite of this fact, Mourshed and Zhao's (2012) study revealed that patient care teams placed sound as the number three most essential design factors ahead of visual aesthetic features such as views, landscaping, and colour. However, this might not be unexpected, as sound perception is a very substantial sense for inhabitants in the environment of health care (Dilani, 2005). In addition, Shafiro et al's. (2011) findings demonstrated that sounds of auto horns, baby crying, and tweeting sounds of birds can alert listeners to imminent dangers as well as lead to an individual's sense of awareness and well-being. This approach matches with

Dawson's (2005) long-held notion that there is an opportunity for investigation to look into the positive influence of sound, as this may provide a sense of control and thereby create a more positive impression of the hospital space experience (Mackrill et al., 2013a). For example, a study conducted on white noise perception found improved mental clarity and enhanced relaxation in children with attention deficit hyperactivity disorder (ADHD) (Söderlund et al., 2007).

Therefore, viewing sound in the hospital environment as a positive addition to the healthcare soundscape, rather than noise may enable a subtler and socially substantive interpretation of the role of sounds in such spaces. Similarly, a more recent review by Brown et al. (2015) suggests that conceptualising sound in this way would improve the health care, ecological quality, which may promote psychological benefits and would build a richer positive approach to deal with sound within the hospital context. In addition, studies have evidently demonstrated that it is worthwhile to take into account a user-based approach to the perspectives and perceptions of other dimensions within the environments, such as spatial-physical comfort and social functions (Fornara et al., 2006; Andrade et al., 2012). However, sounds may add to increasing or diminishing an architectural experience, which establishes the impression that sound might be pleasant or unpleasant in a given architectural space (Dilani, 2005). As yet to be fully explored in this present study, sounds may not possibly always cause annoyance, particularly when it is controllable and make sense in the environment, can potentially add to the psychosocial meaning, lifestyle, and experiences found within the hospital space. Therefore, there is a need to explore this area with the curiosity of understating the positive role of sound perception in hospital spaces and how this understanding can be used to improve users' health and wellbeing.

1.2 Problem Statement of the Study

Hospitals are usually stressful environments for both patients, their families, and caregivers, and have been shown to affect individual's psychological and physiological well-being. Additionally, aural characteristics found within hospital spaces has often been termed to stir negative emotions and impede health recovering. Thus, as a result, the auditory quality of hospital spaces or physical environments is quite important. As research in architecture is more oriented to the visual articulation of space, suggests that there is a need for research into the auditory quality of hospital spaces.

Furthermore, regardless of the prominence of theories surrounding aural perception of sounds within architectural practice, surprisingly limited theoretical has been provided by previous research for understanding sound perception in hospital design spaces for improving user experience. Indeed, the absolute consideration of the acoustic environment within architectural design practice has traditionally been set aside entirely for those specialised listening spaces such as cathedrals, opera houses, recording studios, theatres and concert halls. In addition, the pursuits of visual dimensions of space, and the dominance of sound level reduction or acoustic analysis in contemporary society have undermined any notion that sound can positively influence experiences in contemporary design, most especially in hospital space design. Also, the design verification methods of social functionality are generally based on an evaluation of visible aspects or aesthetic evaluation (Brown & Gifford, 2001), however, visual information is not the only one determinant of quality and social functionality of the built environment. In fact, taking into account mostly visual aspects, leaving other factors to dominate during design evaluation may lead to decreasing the accuracy of predictions about social and behavioural aspect of spatial functionality.

Consistent with past and recent studies, a great bit of late calls from architects and theoreticians (Sheridan & Van Lengen, 2003; Fowler, 2015; Pallasmaa, 2005) have strongly suggested that architectural practice should seek to move beyond the vanity of form and the seductive immediacy of pure visual articulations of space (Till, 1999). As a consequence, other theorists have contended that architectural disciplines have discontinued dwelling in a finite domain, which implies that its scope has dissipated as the meaning of what architecture continues to evolve and expand (Fowler, 2013b; Ostwald,1999). The eagerness for architectural theorists to focus more on the visual aspect of space has contributed to the disregard of recent theories or concepts of sound (scape) and aural architecture (i.e., the aspect of real and practical spaces that creates an emotional, behavioural, and intuitive response in space occupants) postulated by scholars such as (Schafer, 1977; Ulrich, 1991; Truax, 2001; Dilani, 2000, and Blesser & Salter, 2007). Fowler (2015) pinpointed that this oversight may have been insignificant of notice, if not for the recent investigations into population density inversions between rural and urban areas and the progress made in the potential health and well-being risks from elevated sound levels across Europe. In line with this notion, research works have reported excessive sound to be a global problem across Europe and the United States, which is contributing to a large amount of stress for hospital users (Rhud & Meagher, 2001).

Another important issue to be noted is that sounds in hospital space are commonly evaluated in terms of sound level and obtained results matched with the world health organisation (WHO) guidelines of 30-40dB (A) (Berglund et al., 1999). However, it has been demonstrated that sound levels have progressively risen since the 1960s (Bush-Vishniac et al., 2005) and often exceed these guidelines. Conversely, it has been reported that no study has measured noise levels in hospital space, particularly in the intensive care units (ICUs) and neonatal insensitive care wards that comply with the World Health Organisation (WHO) recommended sound level guidelines (Persson Waye, 2013). This gives the impression that mitigation or reduction of sound in hospitals might not be the right way to look at the social aspects or role of sound. For example, clinical practice in hospitals gives more priority to treatment of illness while often overlooking a patient’s psychological, social and spiritual needs, which indicates that psychosocially supportive design is essential to reduce anxiety and promote positive psychological emotions (Dilani, 2004). It has been demonstrated that there is no strong association between reduced noise levels and physiological improvement (Drahota et al., 2012). This supports the notion that the absence of sound in a context does not necessarily generate a positive context (Truax, 2001). Therefore, understanding the role of sound perception in the healthcare environment offers a way to improve the hospital space experience, thus promoting physical, psychological, emotional, spiritual and social wellbeing of users.

1.3 The Research Aim, Objectives, and Questions

The motivation of this investigation comes from the need to develop an understanding of sound perception in hospital environment and shows how this understating can be used to enhance the hospital design space experience that promotes health and well-being. Thus, the main aim of this study is to develop a theoretical framework for understanding the role and significance of sound perception for improved hospital space experience, rather than the absence of it. Additionally, this study also aimed at improving the healthcare space experience by exploring and incorporating the theory of psychosocially supportive design, the theory of supportive design for healthcare and that of soundscape design connotations. This includes defining and extracting attributes that could be employed to enhance the hospital design space outcomes, as this would strengthen the occupants' health and well-being. Thus, understanding sound perception and its use within hospital space suggests the way forward in the area of ambient acoustics that integrates psychological, physical, and societal views.

Hospital buildings in their physical aspects should produce a healing environment for patients, visitors and staff psychologically, mentally and physically. Additionally, the physical environment where patients are admitted has an influence on their health outcomes, including safety and satisfaction. This also affects patients' care team efficiency and comfort. Furthermore, the design of a good hospital design environment or space may start by recognising the basic functional needs, however, would not stop there, but must also satisfy the emotional demands of those who utilize such facilities at times of uncertainty and dependency as well as promoting unthreatening, comfortable, and stress-free as possible.

From the aforementioned theories, it is the intention of this research work to focus on the attributes of sounds as one of the cost-effective psychosocially and psychologically supportive healthcare design aspects that have the ability to evoke positive feelings on hospital space experiences/well-being. Thus, this thesis explores the health care indoor space with a focus on the perception of sound, individuals experience and how they interact with their physical sound environments, and how this understanding can be used to improve health and wellbeing for hospital occupants. It also explores the role of musical sound as an environmental design for promoting hospital healing space for occupants. Another target of this qualitative study, however, is to argue that noise is merely not always objectionable and to explore the scope to which studies have investigated the meaning and the role of sound perception in healthcare, indoor spaces and to identify a novel paradigm for viewing sound which currently is termed noise in the study of health environments research and design practices. This study hypothesises that psychosocially and psychologically supportive health care design that incorporates positive sound would stimulate the mind and create experiences that include pleasure, creativity, satisfaction and enjoyment within the hospital environment. Then, the quest of this investigation is to fully understand the impression that sound has in the hospital ecological systems.

These objectives, identify the gap in which this present study explores. It is the outward from these objectives that the subsequent research questions under investigation is raised:

> *Hospitals might be seen as utility environments; in such environments or spaces, how can sound be better incorporated so as to evoke a positive influence on the occupants' experience?*

This focal question under investigation was inspired by a desire to understand how sound perception can influence or promote meaningful space experiences for hospital occupants. To achieve this, the following underpinning sub questions were considered:

- What are the fundamental theories relating the perception of sound and space in an architectural design?
- How can sounds that are termed positive or negative be identified and differentiated within a hospital environment or space? Does sound quality affect the perceived auditory space, and how can such spaces evoke an emotional response for improved health outcomes?

- What are therapeutic/healing environments and how can such a space support the social meaning and lifestyle, including wellbeing of the hospital occupants? How can psychosocially and psychologically supportive hospital design space be achieved to promote user experience?

1.4 Methodology of the Research

A qualitative research inquiry based on observation, discussion with experts in the related field via emails, documentation of studies (including theories of sound perception, empirical studies on sound/noise, evidence-based design theories, and design in architecture as a multisensory medium) was used to address the study objectives. To achieve this, an interdisciplinary research approach was employed in this study. This was drawn from different subject fields, including psychology, architecture, engineering, ecology, sociology, hospital management, neuroscience and collective concern with the hospital settings. In addition, the vast knowledge sources /materials retrieved to establish the understanding of this study were analysed using a qualitative content analysis approach. This approach was considered fitting to answer the research questions because it provides information and understanding of the phenomenon under investigation, and is flexible for analysing text data/literature (Cavanagh, 1997). The conventional (inductive) and directive (deductive) content analysis approach was used in this study. The conventional (inductive) method begins with the observation of raw data without a theory-based categorization matrix. In the inductive approach, the researcher has to read all data repetitively or word by word to achieve immersion and get a sense of the whole from the text or data (Hsieh & Shannon, 2005). In this type of method, codes are derived from data by scanning through text to highlight the exact words or phrase from the text that seem to capture main ideas or concepts that describe the phenomenon under investigation (Miles &

Huberman, 1994). Whilst the directive research method has been conceptualised as a deductive use of theory based on their distinctions on the role of theory. Using this research method, the investigators start by classifying key concepts as initial coding categories, and the definitions for each category are determined using the theory. Specifically, codes emerge from pre-existing theory or concept or relevant research findings and are identified during and after data analysis (Hsieh & Shannon, 2005).

More precisely, in this study text data were driven from electronic sources, observation of data from articles, books, and manuals or guidelines. Taking content analysis approach into consideration, a content investigation of a vast literature was undertaken between September 2013 and August 2016. This involved searching several electronic databases, as the intention of the researcher is to explore the scope to which research have studied the meaning and the role of sound in hospital physical environments and to identify a new paradigm for investigation and practice in healthcare architecture.

1.4.1 Data Collection Sources

The literature search of this present study was purposely wide-ranging and interdisciplinary. This included aspects of architecture, acoustic ecology, medicine, psychology, nursing, and a collective concern with the health care environment. Using the content analysis method was found appropriate for investigating the nature and trend of published articles in journals. This method was applied to arbitrarily selected articles, indexed in electronic databases written and published in the English language. There was no restriction to article publication dates applied in this investigation. Precedence was given to full-length feature articles in index journals. Article (transcript) selection was generally founded on the title and the abstract. In the case of uncertainty, the researcher read the entire text of a report. In addition, book reviews, non-empirical articles, news items, monographs, duplicates, encyclopaedia articles, non-English publication, and editorials were in most cases excluded from the materials used for data collection. The main inclusion criterion was that the references contained significant content concerning physical environmental factors (sound, soundscapes, and sounds of music) that enhances wellness in a clinical context.

Data sources used in this present study incorporates pertinent United Kingdom/other relevant policy documents and the results of a literature conducted in major databases and Eastern Mediterranean University library services. An extensive literature search was carried out using ISI Web of Knowledge and Electronic Database Resources, including Web of Science, PubMed, Scopus, ProQuest Central, and MEDLINE for relevant articles that covers psychological, physiological, and epidemiological studies related to the impact that sound perception and soundscape has on health outcomes in the hospital environments. It was not possible to rely only on simple electronic searches of databases; therefore, the reference lists of relevant sources (e.g., books/book chapters and proceedings) were hand searched to identify other studies of related interest. Previously published studies were also searched through Google Scholar databases. As the intention of the study was to include all that concerns sound perception, soundscape, hospital, health, wellbeing and patients and staff experiences, references of extracted articles were further scanned for extra pertinent material and historical articles/books significant in defining the field of study under investigation and a final electronic search was carried out in the July 2016.

Additionally, a wide range of search terms was used for related publication in combination with sound OR noise OR music OR architecture. The major search terms and themes identified in this study include but not limited to: *Ambient sounds; Access to nature; Anger; Annoyance; Anxiety; Architectural spaces; Architectural theory;*

Architecture; Auditory pathways; Auditory perception of space; Aural architecture; Behaviour of people; Brain; Cancer; Cardiovascular; Clinical environments; Clinical settings; Cognitive; Coping; Design factors; Emotion; Emotional response to sound; Evidence-Based design; Healing environments; Health; Healthcare Design; Healthcare; Hearing; High blood pressure; Immune system; Landscape; Locus of control; Mental health; Music and nature sound; Music Psychology; Natural view; Nature sound; Noise and sound; Noise reduction; Noise; Occupants; Operative room (OR); Pain; Parkinson; Patients experience; Patients; Perception of sound; Physical attributes; Physical environment; Physiological; Positive distraction; Psychological; Relaxation; Sleep; Social support; Sound sources; Sound; Soundscape; Space; Spatial space; Staff; Stress reduction; Stress; Stressor; Stroke; Theory of salutogenic approach and Psychosocially Supportive Design; Theory of soundscape design; Theory of supportive design; Therapeutic sound; Trauma; Urban soundscapes; Visual perception of space; Wellbeing; Wellness; hospital, and relevant additional terms derived from the materials retrieved.

1.4.2 Data Analysis Procedure

Using the content research method, the researcher carefully reviewed transcript (e.g., books, articles, documents etc.) that was identified during the data collection by highlighting all text that appeared to describe the phenomena, assigning codes to specific characteristics within the text. The researcher further read through each transcript word by word and allow the categories or codes to emerge from the data. All the transcripts accessed in this study were coded using inductive and deductive content research method, which excerpt key themes and categories from the data or pre-existing theories or research. The inductive content research method was preferably used because it consists of reading the transcripts, identifying possible themes, comparing and contrasting themes, and building theoretical models from existing theoretical frameworks. Furthermore, the themes or codes were basically derived from transcripts read, including existing theories and the intensive literature survey. In a nutshell, the full coding schedule was developed from the review of the literature. Other relevant themes used in this study were deduced from a prior theoretical understanding of the phenomenon under study, and by considering titles, abstract and themes used in previous literatures, as well as already agreed upon professional definitions found in literature reviews, common sense constructs from the researcher, personal experience, and contact with colleagues in related field of study.

It has been proposed that when human coders are used in content analysis two coders should be applied, which implies that reliability of human coding in content analysis is often evaluated using a statistical measure of intercoder reliability or the amount of agreement or correspondence among two or more coders (Neuendorf, 2002). In this present study, the codification of text was carried out manually (i.e., by hand) without the utilisation of any data analysis tool or software. In order to make a valid inference from the text, the researcher was knee about the classification procedure for reliability and consistency. In this case, different people code the text in the same way to obtain a similar outcome. Therefore, once the initial codification has been obtained and developed, to reduce bias, it is refined and rechecked by re-coding the texts or transcripts. In order to confirm the rigor of the coding framework, a colleague (PU) often verified the codification by randomly analysing selected transcripts and all the transcripts recorded. Moreover, final codes were created to present the major themes and trend within the data. The codification is in the form of axial coding, in which related themes and categories derived from the data were explored and constructed forming a conceptual model for understanding and improving sound perception in hospital indoor spaces for occupants' experience, thus, permitting a theoretical description of the results to emerge. Additionally, the model was formulated through a logical understanding of the correlation between themes and analysis of the narrative, which as deduced from the theoretical investigation, thereby ensuring that the context was correctly interpreted.

1.5 Significance of the Study

Evidence-based design (EBD) practice has been well documented as the hospital healing environment that is widely applied in the creation of new healing environments and the expansion and renovation of existing health care facilities. This work is significant because it establishes a novel contribution to a developing body of knowledge by providing an in-depth look at the perspectives of one of the many significant measures for producing a healing environment for hospital occupant experience, which includes the patients and their family members as well as healthcare service providers. One of the factors among others is the positive role of sound in the context of healthcare environments, which has been negatively termed as both intrusive and unwanted.

The findings of this present research would be of importance because of the specialised knowledge its provide in relation to sound experience for improving hospital patients' physical comfort and decreasing emotional discomfort. As the hospital is an institution that provides patients with holistic care, the use of music, nature sounds and the combination of music and nature sounds may add to the patients' pleasure during the terminal stage of their illness. The results of this study also will provide knowledge and evidence to extend the middle range theory for promoting health and well-being in a hospital population. This work also provides an account of occupants' perspectives about the experience of the hospital physical environment. While this study is merely a sliver of work in a very specific setting, it should be used as a springboard from which more research should arise. The perspectives of the patients, family members and healthcare providers in this study both reinforce and challenge some of the elements of evidence-based design (EBD) practice in health care environments. The challenges that were discovered should be addressed by further research both similar in design to this study and more empirical in nature. This present investigation contributes to a growing body of knowledge by providing an awareness to architects and their collaborators with a new design intervention and relevant options required to effectively interpret the significance and the use of sound within healthcare spaces. Furthermore, the inference of this present study will be useful to Architectural and urban planning students as well as their associate who may be interested in conducting a similar study or related subject. The findings of this research might also be useful to other beneficiaries such as governmental ministries, including research institutions or organizations who may find its contents very rich for further planning and development. The research study also tries to identify attributes critical to the process of designing healing environments and to develop healing attributes which include sound to support healthcare designers in their problem-solving.

1.6 Scope and Limitations of the Study

There are many aspects that can affect patients and patients care teams in hospitals, such as lighting, temperature, and air quality, however, this is not within the scope of this investigation. This study only focuses on sound perception and users experience in hospital indoor spaces. This cover the sound environment in a patient room and nurses station, therefore the results might not be valid for all types of spaces that exist within the hospital. The study focuses on spaces and room types such as patients' rooms, patients care providers' stations, operation rooms, corridors and waiting room. Several limitations may have impacted the findings reported in this study. The issue of insufficient proposed conceptual framework to guide hospital soundscape research. Investment in basic scientific research that supports the health and economic prosperity of North Cyprus is lacking and this might have undermined the outcome of this study. Rigid governmental policies that restrict hospital research, such as not gaining access or obtaining basic information about hospital facilities within North Cyprus. The unavailability of enough hospital environments in Gazimağusa, North Cyprus, time constraint, and insufficient income might have posed a major limitation in this research.

The proposed model is by no means conclusive, this suggests that future research is needed to explore the conceptual notions expressed in this thesis in a rigorous manner to fully determine the role that sound perception plays in hospital spaces for users' experience. Many of the factors that affect soundscape perception do not relate to the sound itself, which includes variations in demographics, activity, time and space. As a result of the diversity of users of the hospital space, the approach may be positioned more for creating patient benefit than for patient care teams.

1.7 Theoretical Underpinnings of Study

In order to inform the understanding of the phenomenon under investigation, three contemporary theories frame the inquiry of this study. As set out in Figure 1.1, these theories include Theory of Soundscape Design (Schafer, 1977), Theory of Psychologically Supportive Design (Ulrich, 1991) and Theory of Psychosocially Supportive Design (Dilani, 2000, 2001). These theories are mainly founded on the way built environment can influence general health and well-being to bring about stress reduction through supportive design in the health care setting. Additionally, they incorporate the physical, cultural, social and psychological/behavioural aspects of the built environment. The consolidation of these pre-existing theories and keywords driven from these theories allowed a methodology to be produced to explore the hospital physical environments in terms of sound and soundscape, putting the user experience at the fore. Specifically, the combination of these theories identifies beneficial tools for use in the healthcare systems, and direct attention to variables measuring social and physical emotional factors. This investigation attempts to concentrate on the intersection attributes of these theories that promote supportive design for positive patient experience as it correlates with sonic environments and health concern.

Theory of Supportive Soundscape Design (Schafer, 1977)

Specifically, Schafer theory of soundscape design centers around the manner in which the qualities of a soundscape and its communicative power be considered within the urban or architectural design. This is an extension for architectural design to become an act of spatial composition that synthesises anticipated visual and auditory effects (Blesser & Salter, 2007). By definition, a soundscape is a sound or a mixture of sounds that forms or arises from an environment. Schafer (1977) conceptualised it as the world soundscape, the vast musical composition which is unfolding around individuals ceaselessly. The notion behind the theory of soundscape design is to create environmental comfort by influencing the mood, the emotion, the appraisal, and the restoration of individuals visiting the place or space (Kang & Schulte-Fortkamp, 2015).

Theory of Psychologically Supportive Design (Ulrich, 1991)

Theory of supportive design conceptualises the ways in which the healthcare physical-social environment affects patients' health and well-being, including the alleviating of stress related problems to enhance experiences within the hospital environment (Ulrich, 1991). A research further suggests that healthcare physical and social environments promote well-being if they are designed to nurture a sense of control over physical-social environments, incorporate access to social support, and access to positive distractions (Andrade & Devlin, 2015). This theory is well documented and is often used to describe and interpret patients' needs or to suggest strategies or approaches for achieving supportive design within the hospital premises (Martin et al., 1990).

The conceptualisation of positive distraction was first incorporated in the Recommended Standards for Neonatal Intensive Care Units (NICUs) Design in 2006. Since then, other official guidelines have addressed this topic to varying degrees in general hospital settings, which in turn have impacted hospital spaces such as the Pediatric Intensive Care Units (PICUs) and NICUs (Shepley, 2014). Specifically, the main intention of positive distraction integration into hospital designs is to alleviate stress by helping patients or family members shift their focus from experiences that challenge their ability to make choices and their sense of control to experiences that have a positive effect on them. In fact, positive distractions include art, access to nature, music and other supportive sounds, entertainment/activities of daily living (ADL) support, and social interaction (Ulrich, 1991).

Theory Psychosocially Supportive Design (Dilani, 2000, 2001)

The Theory of Psychosocially Supportive Design demonstrates a shift in biomedical attitude from a pathogenic concept of disease to a more salutogenic perspective that permits for a more substantial integration of building design and care philosophy, including enhanced quality of medical care and strengthened health processes (Dilani, 2001, p. 31). The basic function of psychosocially supportive design is to set forth a mental process by attracting human attention, which may reduce anxiety and promote positive psychological emotions. Health processes could be fortified and encouraged by implementing a design that is salutogenic, that is, designs that concentrates on the elements that improve wellness, rather than those that promotes poor health (Dilani, 2005). According to Dilani (2001), the previous notion of pathogenic perspective focused more on patients as an object and concentrated on individual 'sick parts' of the human body. This as a consequence has bent the health care facilities to concentrate more on reducing risks to exposure of diseases (that is factors that cure disease and factors that lead to disease), rather than giving precedence to the psychological, social, or spiritual needs of patients in the design of healthcare facilities. Additionally, this approach is believed to calm the patients and make them feel relaxed in spite of traumatic hospital experiences (Dilani, 2001). In contrast to pathogenic perspective, the salutogenic perspective or health theory of Salutogenesis developed by Antonovsky (1996) suggests looking for wellness factors rather than risk factors. This implies that the Salutogenesis is an approach focusing on factors that support human health and well-being and has become more evident in the creation of new healthcare buildings. Additionally, it also focuses on the patients' physical, psychological, and social health needs. The salutogenic theory is the guide to health promotion through healthy lifestyle by focusing on stress reduction as well as coping with factors that cause stress (Dilani, 2000). On the other hand, drawn from a Salutogenic Approach Dilani (2008) strongly have the notion that there is an important link between an individual's sense of coherence and the characteristics of the physical environment.

From Salutogenic theory, Antonovsky (1996) developed the concept of sense of coherence which incorporates three vital components including comprehensibility, manageability, and meaningfulness. In a wider scope, sense of coherence is related to the ability to value and handle stress factors which may affect overall health with a stressor. For example, an individual with a strong sense of coherence will, firstly, wish to, be motivated to cope (meaningfulness), secondly, believe that the challenge is understood (comprehensibility), and thirdly, believe that resources to cope are available (manageability) (Antonovsky, 1996, p. 15). Furthermore, Dilani (2000) translated the Salutogenic Theory into Environmental Design Factors in in which he termed Psychosocially-Supportive Design. The Psychosocially-Supportive Design model aims to augment users' wellness and wellbeing by attracting their attention, remove/reduce their anxieties, challenge their minds to construct stimulation, creativity, satisfaction, enjoyment and admiration (Dilani, 2001). Additionally, Dilani (2000) further led a strong emphasis on the increase in the consideration of wellness factors within the design to enhance wellbeing and health processes and thereby creates environments that are not only functionally efficient but also highly psychosocially supportive. The wellness factors that must be utilized in the design of healthcare facilities are aspects or components of the physical environment which may affect emotions, experiences, and behaviours in a positive manner (Dilani, 2005). These wellness factors consist of access to nature, art, sound of music and natural sound, lighting, architecture and building proportion, use of culture, familiarity, creating landmarks and references in buildings, aesthetics, spatial composition and articulation, and provision of inviting spaces for social support etc. (Dilani, 2008, 2006).

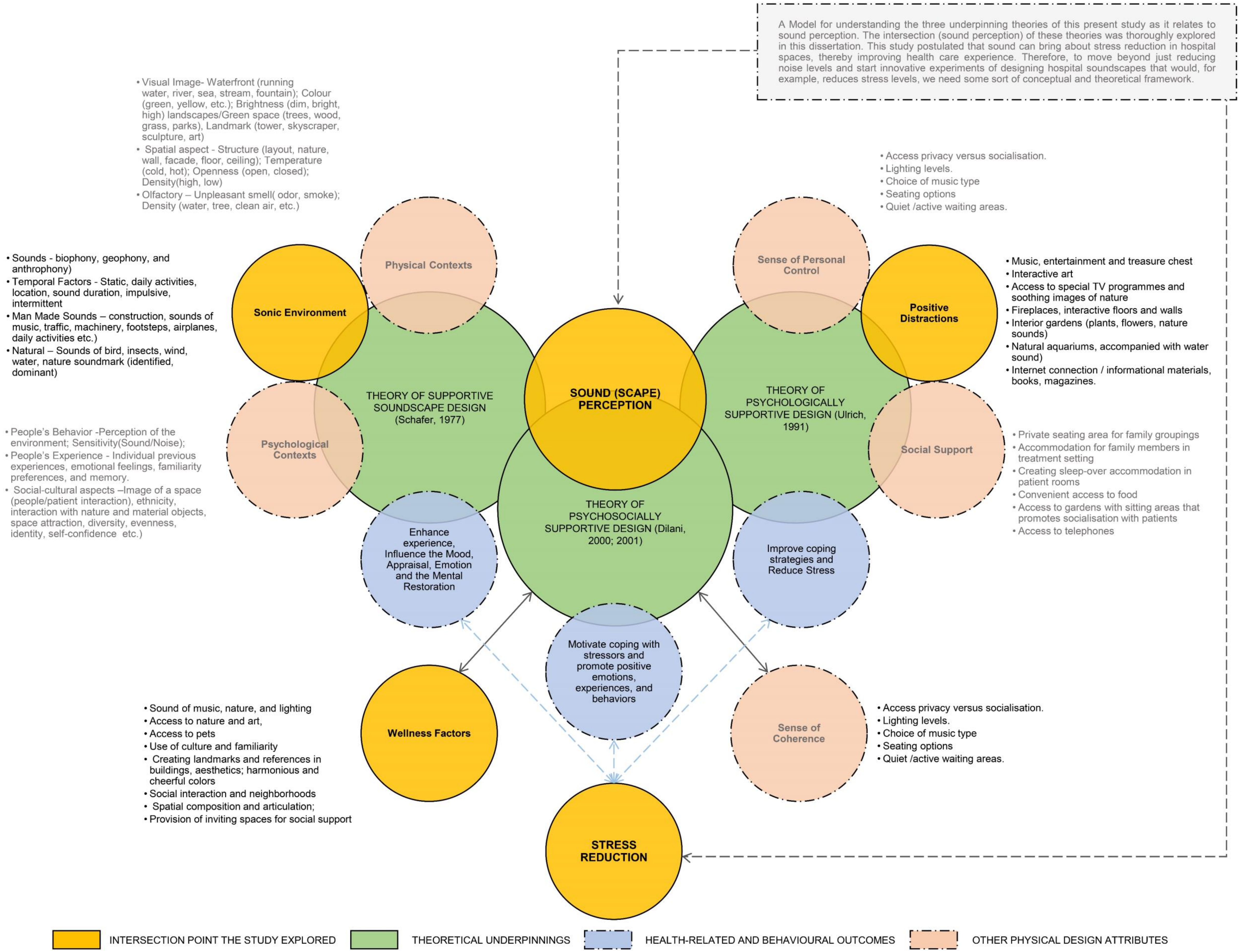


Figure 1.1. A model for understanding the underpinning theories as they relate to sound perception (Compiled by the author)

1.8 Definition of Common Terms Used

Aural Architecture: This is that aspect of real and virtual spaces that produces an emotional, behavioural, and visceral response in inhabitants. Such pace produces feelings of intimacy, anxiety, isolation, connectedness, warmth, as well as a mystical sense of spirituality. Similar to visual architecture, except that space is experienced by listening rather than seeing. Musical spaces are the most obvious applications of aural architecture where space and musical instruments are intimately fused (Blesser & Salter, 2007).

Environmental psychology: The effects of the physical, social, psychological, and behavioral environment on human performance.

Evidence-Based Design (EBD): According to Nussbaumer (2009) EBD is a research encompassing the collection of data through both fact finding and location of new evidence and applying that evidence to a design solution.

Evidence-Based Medicine (EBM): The application of observations assessing the strength of evidence regarding risks and benefits of treatments (including lack of treatment) and diagnostic tests.

Healing Environment: The built environment has therapeutic attributes and enhances the behavior of humans in a positive manner.

Health: A balanced state of complete physical, psychological and social well-being; not only the absence of illness.

Psychosocially Supportive Design (PSD): Theory designed to support the built environment through meaningfulness, comprehensibility, and manageability (Dilani, 2000; 2001)

Salutogenic Perspective: Salutogenic perspective focuses on factors supporting human health and well-being, rather than on factors that cause disease.

Supportive Design Theory (SDT): A theory designed to explore the ways a designer can utilize the built environment to reduce stress; by providing users a sense of control, access to social support and access to positive distractions in physical surroundings (Ulrich, 1991).

Theory of Soundscape Design (TSD): A soundscape is a sound or a combination of sounds that forms or arises from an environment. The world soundscape, the vast musical composition which is unfolding around individuals ceaselessly (Schafer, 1977). TSD is to create environmental comfort by influencing the mood, the emotion, the appraisal, and the restoration of persons visiting the place or space (Kang & Schulte-Fortkamp, 2015).

Wellness Factor: An aspect or component of the physical environment affecting emotions, experiences, and behavior of the quality of life in humans.

1.9 The Structure of the Thesis

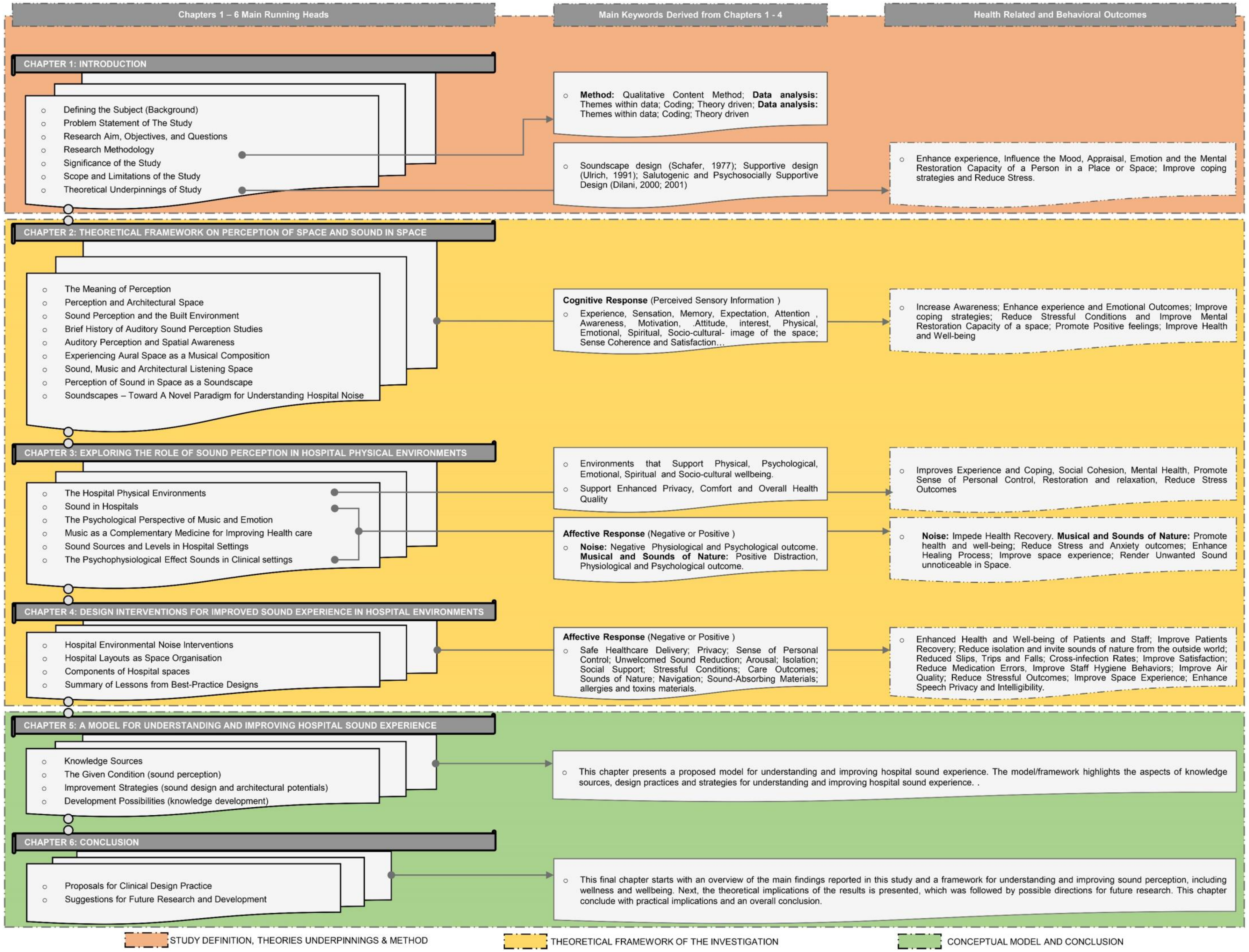


Figure 1.2. Overview of the thesis chapters in relation to the accumulated empirical knowledge (Compiled by the author).

1.10 Chapter Summary

This chapter embraces an introduction that forms the contexture knowledge of the study. This introduces the research area, including that of sound/soundscapes, music psychology, and hospital noise, with a description of the statement of the research problem, aim, objectives and question of the dissertation. This chapter also covers the significance/rationale behind the study, the scope, and limitation of the study, methodology, the theoretical underpinnings which this present study is based on, the structure of the thesis and definition of technical terms used in the thesis was discussed. This chapter provides a means for a theoretical discourse that describes the systematic approach to the research which addresses each of the objectives raised.

Chapter 2

THEORETICAL FRAMEWORK ON PERCEPTION OF SPACE AND SOUND IN SPACE

2.1 The Meaning of Perception

Indeed, the implicit nature of our daily environments often impedes individual perception. Since the rise of experimental psychology in the 19th Century, psychologist has made much progress to understand perception by combining a variety of techniques and theories or models (Gaulin & Donald, 2003, p. 81–101; Gibson, 2002, p. 77–89; Gregory, 1987). Perception has been defined by the online Oxford English Dictionary as the interpretation of sensory stimuli, which results in, importantly, the mental product, or result of perceiving something (Oxford English Dictionary, 2005). The term perception was originally coined from a Latin word “perceptio” or “percipio” meaning the organisation, identification, and interpretation of sensory information in order to represent and understand the environment (Schacter et al., 2011).

In other words, perception defines the multiple ways in which individuals receive information from their environment, permitting them to know their surroundings, that is the direct responses that our senses show to the structures or forms (Lang, 1987). However, the perceiver's attitudes, motives, interests, experiences, expectations are significant factors to consider, as these could affect an individual’s perception (Gregory, 1987). Likewise, Grutter (2006) supported that any judgment of individual perception includes two main fundamentals: Object (the perceived or the objective) and subject (perceiver or the subjective). As well, it is important to mention that all perception comprises of signals in the nervous system, which then result from physical or chemical stimulation of the sense organs or system (e.g., ear, eye, nose, and brain) (Goldstein, 2014). Moreover, for instance, odour molecules mediate the human sense of smell, vision involves light striking the retina of the eye, whilst hearing comprises of pressure waves. Perception is not the passive receipt of these signals but is shaped by learning, memory, expectation, and attention (Bernstein & Douglas, 2010). In addition, on the one hand, evolutionary psychologists embrace that the primary function of perception is to guide action, whilst on the other hand, scientists who have investigated perception and sensation have long realised the human senses as adaptive mechanisms (Goldstein, 2014). For example, depth perception (i.e., the visual ability to perceive the world in three dimensions (3D) and the distance of an object) processes over half a dozen visual cues, each of which is based on a regularity of the physical surroundings. Moreover, this support the fact that depth perception seems not to only help in understating the distances of other objects, but somewhat helps individual navigates within a space (Howard, 2012).

Architects and urban designers, on the other hand, have sought to understand perception through enclosed and open spaces, which argues that perception is a deeply involved concept in the understating of 3D spaces. For example, as illustrated in Figure 2.1, ‘Rubin vase’ can be perceived in various ways, depending on what the mind chooses to interpret as the background, one perceives either a turned white vase in front of a dark background or the profiles of two faces against a white background (Roth & Clark, 2013, p. 71).

Figure 2.1. Illustration of Rubin vase can be perceived in more than one way (Leggett, 2008).

This confirms that the knowledge we have about 3D Euclidean space is filtered through our perception of it, which is also similar to both natural and synthetic worlds (Bertol & Foell, 1997, p. 19). The perception we have for a landscape, for example, a mountain, are completely different, however, depending on if we fly over it, drive around it or climb it. A similar observation can be made about the fabricated world and architectural space in particular. An array of different perception arises when we drive and walk around a building or when we are in an architectural space (Porter, 2014, p. 25).

2.2 Perception and Architectural Space

Architectural spaces are the defining organisational model that puts all things in relation to each other, but conversely when observe on a different level, could also appear to be void. This is because individual's behaviour is based on their perception of what reality is, not on reality itself. These paradoxes highlight that in architecture, three-dimensional Euclidean space is the primary medium of perception. Therefore, this demonstrates that the definition, dimensioning, organisation, construction and formal design of space are the most substantial tasks of architecture (Perren & Mlecek, 2015). Like Aristotle, on the other hand, once defined space as a container of things, a kind of succession of all-inclusive envelopes. Space is, thus, of necessity a hollow, limited externally and filled up internally. Indeed, this suggests that there are no empty spaces since everything has its position, its location, and its place (von Meiss, 1991, p. 101). Approaching this from a psychological discourse, to possess the ability to perceive something by sight means to find its place in the given entity or context. This level of reasoning gave rise to the theory, which postulates that 'the perception of space is warped by objects' (Vickery & Chun, 2010). It is also significant to note that architectural objects are never isolated, be it actual space, natural or manipulated space or surroundings, always represents some context. Objects are becoming objects of human perception primarily from two fundamental perspectives, which include, the moment when the object, by its characteristics, imposes itself as the object of perception, and when the target is focused willingly and purposefully for some certain reasons (Alihodžić & Kurtović-Folić, 2010).

Similarly, in any architectural object, it is obvious that there are always an extensive number of properties or characteristic that evokes our perception, such as the height (number of storeys), size, proportions, colour, materials, and characteristics of the style. Indeed, there are also more complex messages emitted by the architecture to our perception (Michel, 1996, p. 8). Accordingly, at a theoretical level, architectural space is born from the relationship between objects or boundaries and from planes which do not themselves have the character of an object, but which defines limits. Moreover, these limits may be more or less explicit, constitute continuous surfaces forming an uninterrupted boundary, or, on the contrary, constitute only a few cues between which the observer establishes relationships, enabling the observer to interpret an implicit limit (von Meiss, 1991, p. 101). In addition, Michel (1996) supported that boundary edges of walls, floors, and ceiling enhance depth perception through linear perspective, which creates elongated, directional character in an architectural space.

It could be concluded that among all the fields of space perception that of visual perception of physical characteristics has received the most research (Carlucci et al., 2015; Huang, 2015; Hwang, 2014) and literature uses the term space perception in a more general sense to mean perception of any object or basic features such as colour/texture, height, orientation, shape/form, and size of a space. As mentioned earlier, vision is part of a complex network of the total human sensory system and is closely related to touch and hearing. For example, studies have shown that the process of environmental perception is based on capturing a wide variety of environmental stimuli with differing levels of validity; however, some stimuli provide a more accurate representation of the real environment than others do (Montañana et al., 2013).

A number of theorists who have been dealing with the visual perception of architecture and Urbanism of cities throughout history designate the significance of interaction between man and the environment and the importance of the image creation in the users' memory (Arnheim, 1977; Foster, 2000; Robinson, 2001). Perhaps this is because the human mind is programmed by nature to seek meaning and significance in all sensory information sent to it. It is not surprising, even purely and random aural phenomena are given a preliminary interpretation by the mind based on what evaluative information it already stored away. This implies that what an individual perceives is based on what he/she already knows (see Roth & Clark, 2013, p. 69 – 91). Likewise, our visual perception of an environment is not defined simply by the solid-void dialectic as a mere presence-absence of matter. The three-dimensional space of our experience is perceived as a projection on the two-dimensional surface of our retina, and the stereoscopic effect causes the perception of depth, which is given by our binocular vision (Pirenne, 1975). Therefore, of the three physical dimensions of space, the width, height, and depth are the most "subjective, this is so “because it is related more to the way our visual perception works than to the physical reality of the objects of our perception. In line with this, a French philosopher has defined depth as "the most existential of all dimensions" as "it is not impressed upon the object itself, it quite clearly belongs to the perspective and not to things" (Maurice, 1961, p. 256). This suggests that the manner in which a spatial form is visually perceived as a two-dimensional projection is different from its three-dimensional, measurable reality. Put it differently, in line with the philosophy of representative realism, another consideration is to reconstruct a three-dimensional scene from two-dimensional image information (Marr, 1982).

As it may be expected, perceptual space can be different from physical space. Several common phenomena occurring in our most basic visual perceptions demonstrate this potential for difference: the size of an object decreases with its distance from the observer, rectangles are perceived as trapezoid, angles change amplitude, parallel lines meet at a point (the vanishing point), and parallel horizontal planes meet in a line known as the horizon (Bertol, 1996). This supports the notion that when an individual faced with a random or unknown visual information, the mind organises the data according to certain built-in preferences, which are for proximity and closure, as well as a figure-to-ground relationship (Roth & Clark, 2013, p. 69 – 91). On one hand, the proximity is when an object close to one another is perceived to represent a pattern, and points in space are interpreted as lying in a single plane, even if one is distant and another is closer. On the other hand, repetition implies to equality of spacing or distance are perceived even where none exist, so that a row of lines or dots will be seen as being equidistant and two parallel lines, slightly different in length, will be seen as equal length, for example, the corner columns of Greek temples. Whilst, figure-to-ground relationship are shapes perceived in the context of enclosing shapes will be interpreted as a form against a background, with the mind deliberately choosing which is which, as illustrated in Figure 2.1 (see Roth & Clark, 2013, p. 69 – 91).

In harmony with Lidwell et al. (2010, p. 144), the Law of Prägnanz and the Face on Mars is one of the several principles referred to as Gestalt principles of perception. This law is one of the underlying principles of gestalt perception and deals with the direction in which people perceive visual data. In a nutshell, it asserts that when people are confronted with a set of ambiguous elements, that is, elements that can be understood in different ways, they interpret the elements in the most elementary manner. This simplest way refers to arrangements having fewer rather than more elements, having symmetrical rather than asymmetrical composition, and generally observing the other Gestalt principles of perception (O'Boyle, 2014, p.243 – 244). There is a trend to perceive and recall images as simpler as possible if cognitive resources are being utilised to translate or encode the images into simpler shapes. This suggests that fewer cognitive resources may be needed if images are simpler at the outset. Supporting this idea, research on visual perception confirms that people are better able to visually process and think of simple figures than complex images (Hatfield & William, 1985).

Generally, Gestalt psychology attempts to describe how people organise visual elements into groups or unified wholes by applying various principles, such as closure, common fate, figure-ground relationship, good continuation, proximity, similarity, and uniform connectedness (Lidwell et al., 2010, p. 144). In addition, Mennan (2009) briefly summarised these principles as follows: (1) Factor of Proximity (this is a positional concern about objects that are close to one another are perceived to be more related than objects that are spaced farther apart, that is, stating about the visual unity created by objects that come closer to each other. (2) Factor of similarity (this refers to a figurative concern about the effect on perception of the degree of sameness between various objects, that is, the human mind tends to group together similar objects). (3) Factor of uniform destiny (this implies that a slight alteration of direction would not have an effect on the grouping of objects perceived together). (4) Factor of objective set (this infers that a particular organisation is the result of the sequence in which it appears). In other words, this asserts that seeing one organisation instead of another is a result of objective conditions. (5) Factor of continuance (is another positional factor in the visual grouping of objects that have the same directionality). (6) Factor of closure (this includes a basic qualitative gestalt principle concerning the completion or closure in the mind of visually incomplete images). Additionally, this principle grounds upon all previous principles and expresses the gestalt tendency towards unification and wholeness. Furthermore, it is also associated with gestalt simplification, for it may work through the addition of missing parts, and the elimination of redundant ones, a choice that seems to depend on the degree of simplicity or complexity of the image. (7) Figure-field/ground (this refers to the tendency of the mind to identify a figure from its background or field). Additionally, in any case, when the figure-field relationship is rendered ambiguous by a perfect balance between the figure and its ground, perception tends to favour one interpretation over the other, this phenomenon is likewise known as a 'gestalt switch' (Mennan, 2009).

Moreover, from both a physiological and psychological notion, the existence of three senses capable of generating the perception of space includes vision, hearing, and touch are a fundamental human need, as well as when considered improve human spatial space quality (Alho et al., 1993). Similar to the Gestalt principle of good continuation, a sound that changes smoothly or remain constant are habitually created by the same source. This indicates that sound with the same frequency, even when interrupted by other noise, is perceived as continuous, while highly variable sound that is interrupted is perceived as separate (see Wolfe et al., 2008). As a result, not only visual but also sound can be used for carrying spatial information to the brain, and thus, creating the psychological perception of space. In addition, individuals perceive sound as coming from a location when the object is seen, although, an audition can also affect visual perception. For example, a little click sounds when heard can help people perceived object source, in this instance, auditory cues help interpret visual cues (Sekuler et al 1997). It is worthwhile to mention that these two (visual and auditory perception) issues provide some interesting alternatives to consider. However, it is not within the scope of this thesis to fully elaborate on the visual cues of space perception, as this thesis is to understand the role that sound perception has in hospital indoor spaces. Therefore, it is from here that this thesis would consider the auditory aspects of space in terms of sound perception and its influences on the built environment.

2.3 Sound Perception and the Built Environment

Perception of multifaceted sound is a process carried out in everyday life situations and this contributes to the way individuals perceive reality. Research has established that listening is one of the psychological functions through which people perceive the world (Liu & Kang, 2016), giving an indication that sound is an inbuilt component of any space. Sound plays a significant role in the act of reshaping a particular space or inducing certain psychological and physiological responses. Sound informs individuals about the size of things, what they are made of, where they are, and what they are doing, which implies that objects, distances, speeds, or densities can be compared by listening (Barrass, 1996). Therefore, it could be argued that any space is a sound space, any sound propagated in a space generates an experience, and any experience happens in a sound space. This is in harmony with Kata Gellen's notion that "sound without space is not only inaudible, it is unthinkable" (Gellen, 2010). In support of this opinion, research propounded that propagation of sound in any space depends on the source and the listener, suggesting that the sound propagation medium is all around us (Barron, 2009).

Sound is generated by vibrating object, and in its physical nature, is a vibration, fluctuation of air pressure that stimulate the auditory systems (Plack, 2013). Sound is the medium that connects individuals with space by means of volatile air vibrations, and that the human auditory systems are barely directional, makes hearing such an invaluable multisensory organ. This indicates that our perception of space, interpretation of sounds, sense of equilibrium and the information we receive about movement in our built environments and vibrations that happen around us mostly depend on our ears, which play a meaningful role in regulating or filtering the sounds, we perceive (Belgiojoso, 2014). For example, humans hear themselves speak or talk and sometimes hear sounds produced by the working of their inner organs, bodily fluids, and bones, which might or might not be audible to others. This is also applicable, when our eyes are closed, we can easily understand and distinguish the fundamental spatial characteristics of the space or environment we are in (e.g., general ward sounds, a gothic cathedral, a classroom, an urban square, a bustling marketplace, and a place in the countryside); due to the sound, they produce or generate (Belgiojoso, 2014). Consequently, this supports that sound exists as a phenomenal for understanding an architectural space, which provides a currency for Fowler's notions that architectural design might harness the sounding environment as a design construct whose auditory content delivers meaningful experiences (Fowler, 2015).

From a theoretical notion, Blesser and Salter (2007) sees sound as a device for acoustic illumination, a novel design parameter that is often overlooked yet capable of providing an aural compliment to design decisions that may have been biased from a focus on purely visual articulations of space. However, this theory can be further broadened from three fundamental perspectives: the 'sonic environment', which deals with natural and artificial sound sources, and temporal characteristics, 'physical' which incorporates spatial and visual images aspects, and 'psychological context' which refer to individual sensitivity and experience to sound, familiarity, socio-cultural aspects such as the image of the space (Jeon et al., 2011). As context plays a significant role in soundscape perception, it has been broadly defined as the setting in which sound of any type is heard and perceived, and include various factors such as visual images, landscape, motivation, and experience (Zhang & Kang, 2007).

Furthermore, Truax (2001) advocated that speech, music and the sonic environment (i.e., total sound energy in a given context) could be associated with each other on a common basis, which therefore indicates that sound is an information source. Likewise, Viollon et al. (2002) supported that a soundscape is perceived within a global context that includes auditory information in addition to that from other sensory modalities. One such example is music, although a complex sound, contributes to communication and conveys information with semantic and emotional elements (Iakovides et al., 2004). This implies that music could be any agreeable (pleasing and harmonious) sounds, incorporating instrumental or vocal tones (or both) in a structured and continuous manner to produce beauty of forms, harmony, and expression of emotion. Moreover, this suggests that music is a communication through sound, and has been characterised as a soundscape because it is a form of communication derived from sounds (Truax, 2008). From the quality of the sounding environment, soundscape has been comparable to music or music of life or as a global music (Cance et al., 2010). In terms of music, soundscape compositions are often a form of electronic music or electroacoustic music. Musical composers who use soundscapes include real-time granular synthesis pioneer such as Barry Truax, Hildegard Westerkamp, and Luc Ferrari, thus contributing to the advent and progress in musical soundscape composition (Truax, 1992, p. 374). Similarly, more sophisticated, smart sound metres are being developed that permit individual to segregate the sound stream into auditory objects and label these objects, taking into account expected sounds at a given location or space. In addition to mimicking the auditory scream segregation, Kang and Schulte-Fortkamp (2015) mentioned that such measurement approaches similarly could account for the frequency of paying attention (noticeability) to particular sounds. Likewise, from Truax's concept about electronic music or electroacoustic music, it is obvious that now through digital expression or technologies; architectural space can attain new heights of creative supremacy. As a result, Truax (2008) believes that both acoustic and electroacoustic soundscapes are frequently connected and experienced with a familiarity, which led to the notion that:

> […] just as the soundscape can be listened to as if it were music or at least organised sound, so too can electroacoustic music be listened to as if it were a soundscape, even if an imaginary one… (Truax, 2008).

Conversely, studies have shown that music comprises of brief sound separated by silence and that the difference between music and noise is silence (Deutsch, 1996; pp 53 – 56). For example, Blesser and Salter (2007) stated that just as silence gives us a better appreciation for sound, and just as darkness is a prerequisite for understanding light, therefore "spacelessness" highlights the experience of a real space. Put differently, music is ordered sound whilst noise is disordered sound, yet, it is possible for an individual to hear musical sounds, but consider it noise if it does not fit with their personal tastes (Peretti & Zweifel, 1983). This suggests that noise is the subjective interpretation of sound, and any sound that is intrusive and undesirable is referred to as noise (Kam et al., 1994). Accordingly, an architectural space helps music to evolve, and this has a profound positive impact on occupant’s expression of thought or feeling and experiences. Similarly, Schafer and Truax theory of soundscapes support that aural architecture is a designation of the properties of a space that can be experienced by attentive listening (Fowler, 2014, p. 81-82).

Indeed, detecting or perceiving a sound differ from responding to it, which indicates that listeners react both to sound sources and to spatial acoustics because each is an aural stimulus with social, cultural, and personal meaning. Though the auditory spatial awareness, that is the auditory perception to a location in space plays a significant role in the perception of sound (Shinn-Cunningham, 2008). The auditory spatial awareness has been described as how good listeners are capable of analysing the spatial properties of sound sources in multifaceted auditory scenes and to maintain sufficient awareness of these properties over time to be able to rapidly identify and respond to subtle changes in the auditory context (Brungart et al., 2014). Concisely, auditory spatial awareness embraces all parts of the auditory experience, this includes sensation (detection), affects (meaningfulness) and perception (recognition) (Blesser & Salter, 2007).

Similarly, Fowler (2015) argued that sounds are perceived in space, and an aural architect utilises sound sources in combination with the material properties, geometry, context, and programme of design to produce unique multisensory architectural experiences. This is consistent with Schafer (1977) and Truax's (2001) theories of soundscape, however, with a slight difference in their conceptualisation of soundscape as a collection of sounds that produces space experience. Additionally, soundscapes often termed as the auditory landscape has been defined as an environment of sound with an emphasis laid on the way it is been perceived and understood by an individual or a society (Truax, 1999). For instance, taking a closer glimpse of the world from its sounds, the songs of birds, the laughter of children at the playground, or the sound of music blaring from an open window, sound from surrounding water bodies or fountains, sounds from the wind or rain. Indeed, in such situation hearing consequently becomes more useful and meaningful than sight or visual articulation of space. Supporting this postulation, Teixeira (2014) reported that solely through sound, an entire space, complete with memories and emotions, comes alive. Additionally, this infers that we as individuals feel involved in the life of the soundscapes of an environment.

2.4 Brief History of Auditory Sound Perception Studies

Historically, the awareness of sound perception has frequently played a more central and generative role in the design process of ancient buildings, and listening than it serves today. Thus, it can be argued that sound, music and architectural space have a long story, tied back to ancient times, if not more than five thousand years ago, and has been well documented in the historical works of ancient cultures, such as Egypt, China, and India, as well as Greece, Rome and the designs of early theatres. Even in recent years, the power of musical sound remains the same, however, used much differently than it was in ancient times. In addition, a more recent study urged that the Greeks have long acknowledged acoustic about 2700 years ago, during the Sybarites prohibited metalwork, involving hammering within the city limits (Cordova et al., 2013).

In the 6th century B.C., a Greek philosopher, Pythagoreans identified various potential connections between numbers and the perception of sounds, with this awareness he discovered the properties of vibrating strings that produce delighting musical intervals and of hammers hitting anvils (Hankins & Silverman, 1995). Furthermore, Pythagoras, Aristotle, Hippocrates, as well as Plato and Confucius, believe that musical sounds contribute greatly to health, and serves for the purification of the soul, mind, spirit, emotions and individual behaviour (Lippman, 1994) if applied in the right manner. Similarly, before the great nineteenth-century Hermann von Helmholtz was perhaps another scientist that saw the deep insight of studying sound perception and music as a means to understand other physical and physiological phenomena (Helmholtz, 1895). Through the work of Hermann Helmholtz, the physical basis for the perception of sound began to be seriously investigated.

There is an indication that the mythology that surrounded sound in early history continues to the present day, with a combination of theories adopted from, psychologies, philosophies, sciences, beliefs, and spiritual practices (Mazer, 2010b). Healing spaces have existed since ancient Greece, and at that time people who were sick visited temples in the hope of receiving a dream in which the god would reveal a cure. Somewhat ironically, the first medical references to sound belong to ancient Egypt, and date from the 17th century BC. They described auscultation and tinnitus, although not distinctly. Hippocrates, in the 5th century BC, was the first physician to describe tinnitus clearly, as a slight buzzing sound in the ear, as well as the first to recommend that sick individuals should be kept away from excessive sound sources. However, not until the industrial revolution did the British medical community begin to recognise that noise might be a menace to health (Goldsmith, 2012, p. 317). Little further progress was made until the late 18th century; in Europe, hospital buildings were governed through the church and were run by religious women, called sisters, and myths were replaced with liturgical scripture, and comfort for the soul more than the body (Goldin, 1984). Much can now be said about musical sounds application for healing in hospitals, which began to appear in the 20th century, in the wake of World Wars I and II, when, community musicians would travel to veterans' hospitals and play music for veterans' soldiers suffering from war-related emotional and physical trauma. As a result, the patients' positive emotional responses to music led the doctors and nurses to request the hiring of musicians by the hospitals (Degmečić et al., 2005). Additionally, Florence Nightingale who also cared for veterans' soldiers suffering from war-related emotional distress advocated that noise can inflict harm on sick patients, in which she emphasised on the need of managing what patients perceive as noise in the hospital space (Nightingale, 1860). Similarly, in recent years, with much progress in experiments, predominantly on the emission of sound by the ear, and with ideas and analysis from researchers, the basic behaviour of at least the cochlea is becoming largely understood (Wolfram, 2002, p. 1080).

2.5 Auditory Perception and Spatial Awareness

According to Schacter et al. (2011), the auditory perception or audition is the ability to perceive sound by detecting vibrations, changes in pressure of the surrounding medium through time, through the ear organ. On the other hand, a similar study has identified that the perception of auditory sensation, for example, is in many ways similar to that of vision (see Figure 2.2). In the same study, it was further stated that oscillations in the air make contact with the functionally asymmetrical ear (i.e., the pinna), which then strike the eardrum and then through the mechanisms of the middle ear, and in turn transmit the sensations into the cochlea (Mallgrave, 2010). Furthermore, it is in cochlear the first phase of sound processing begins, as sounds move across the basilar membrane and resonate with some of the sensory receptors or hair cells in each cochlea. Additionally, these nerves then convey the information to the auditory nerve, after an elaborate number of intermediate stations that include the thalamus, sends the signals to the primary auditory cortex (Mallgrave, 2010).

Likewise, the cortex is responsible for breaking down the encoded elements of sound, it also segregates it from its background, analyses it for several factors, and transmit out signals to sub-regions of the auditory cortex in which neurons are particularly sensitive to specific qualities of sound, such as intensity or frequency. Therefore, in the real sense, when sound is combined with rhythm the result is music.

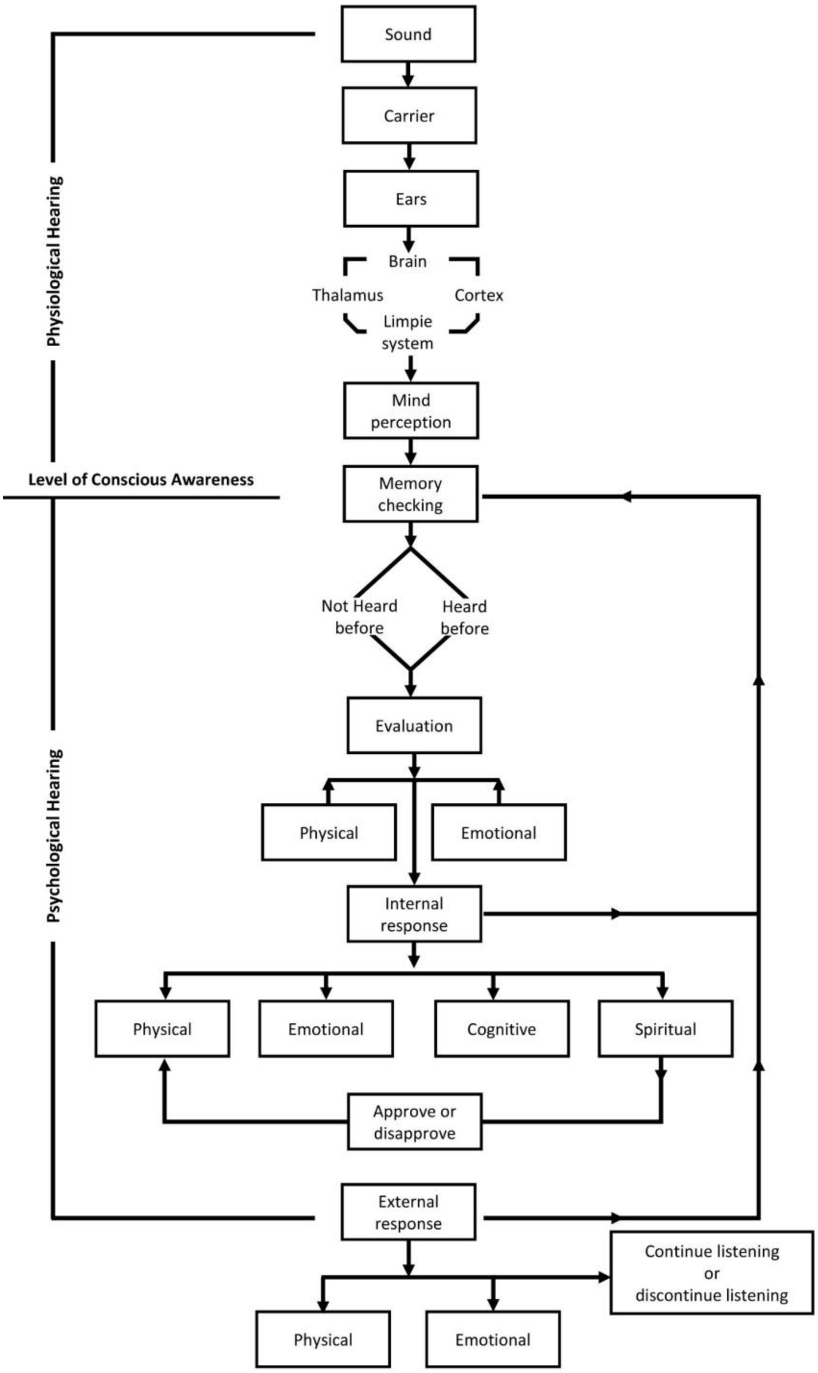


Figure 2.2. The phycology and physiology of auditory perception (Adapted from Mallgrave, 2010).

Moreover, as the human brain is extremely receptive to the nuances of both speech and music. Harry Francis Mallgrave also noticed that musical perception takes place in the auditory cortices of both hemispheres, and is aided by a connection between the auditory cortex and motor cortex that is unique to individuals (Mallgrave, 2010).

Gordon Shepherd acknowledged this fact and inferred that hearing is the sensing of sound by human beings or mammals and its medium is the ear and the brain (Shepherd, 1994). Another study indicated that in vertebrate, the organ of hearing and balancing is the ear and practically only animals with spinal column, have ears. Similarly, the same study showed that invertebrate animals, for example, jellyfish and insects do not have ears, but have other structures or organs that serve similar functions (Camhi, 1984). Interestingly, the ear of individuals is capable of hearing many of the sounds produced in nature, but indeed not all sounds can be heard by them (Blauert, 1983). As such, the human hearing fall between two distinct thresholds curves, the threshold of hearing, that is limited to audible sounds, and the threshold of feeling, which occurs when sound begin to cause pain (threshold of pain). On this ground, studies have elaborated on this and described threshold of hearing as the weakest sound an average human ear can detect, however, the value of the threshold varies slightly from person to person. On the other hand, the threshold of pain describes the strongest sound a human ear can tolerate, such as those experienced in an explosion, for example, a bomb blast or gunshot (Kinsler et al., 1999, p. 315 – 316). Additionally, for example, calm breathing is measured at 10dB, while normal conversation falls between 40 to 60dB. Thus, there is an indication that individuals cannot hear low-frequency sounds (LFS) such as a heartbeat of 1, or 2 hertz, unlike sonar sounds produced by a marine creature such as dolphins that are too high for human hearing. Measured in decibel (dB), the human ear can only sense or detect sound limit of 0 dB (see Figure 2.3). It is also worthwhile to mention that frequency above the range of the human hearing are termed ultrasound, and that below the range of human hearing are termed infrasound, but may be detected by other mammals such as whales and dolphins because they use ultrasound for their navigation (Broner, 2008). According to Olson (1967, p. 249), the physical reception of auditory sensation in any human hearing is limited to a range of frequencies normally about 20 Hz and 20,000 Hz (20 kilohertz).

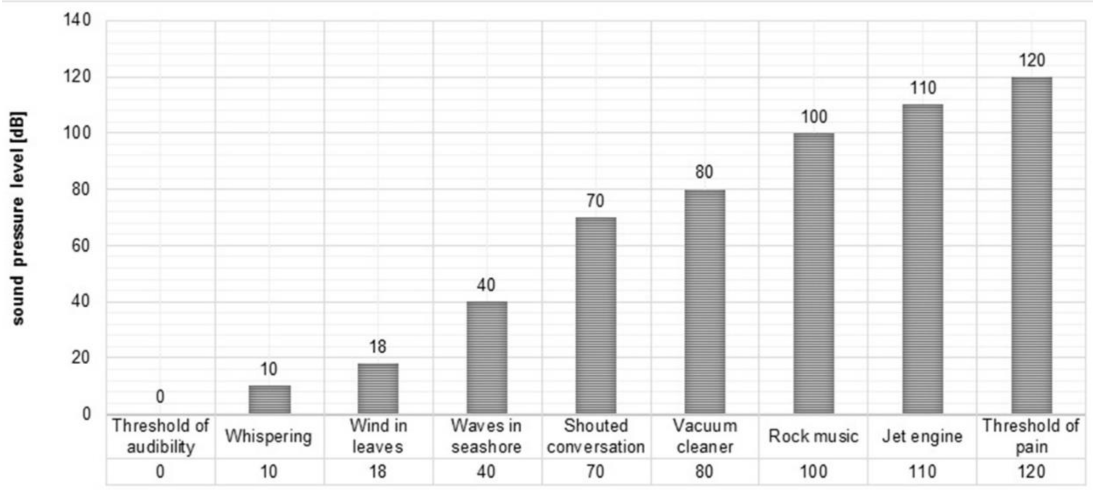


Figure 2.3. Graphical representation of various sound intensities in decibel (dB) (Compiled by the author).

In addition, it is worthwhile to mention that normal hearing individuals, with similar measured responses to test signals in the laboratory, vary in their ability to hear and respond to components of the soundscape. This cannot be argued because variability arises from cultural acoustics, which involve cognitive strategies and sensory training that determine how listeners experience sound. Thus, the ability to appreciate aural architecture, soundscapes and various kinds of auditory awareness are not intrinsic. Though evolution provided bats and dolphins with specialised biology for using echolocation to navigate space, a more latent form of auditory spatial awareness exists in hamsters, oilbirds, rats, and human beings (Etienne et al., 1982). In general, people possess a latent ability to become proficient at using hearing for detecting objects, geometries, and other exceptional attributes, however, actualising this ability varies dramatically. This indicates that to an extent, some individuals actually have the abilities to visualise objects and geometries of a space even though they are not a source of sound. For example, in sensing large objects, such as doors and walls, only some limited individuals can aurally identify small objects, such as the hexagonal shape of a stop sign (Blesser & Salter, 2009). In fact, hearing is not only involved in areas of entertainment where its demands are well known; it also has a role to play in the paving of streets, in the materials for staircases, in the ceilings and floors for a workplace, etc. For example, a school classroom, however large, well laid-out, well lit, or of splendid spatial composition, becomes a place of suffering if echoing exceeds certain limits, whether caused by the materials or by excessive height (Pallasmaa, 2005). It is obvious, that even without an exceptional training, most humans can hear, for example, the emptiness of an unoccupied house, the depth of a cave, the proximity of a low-hanging ceiling, softness of a room with thick carpets, and the cavernous avenues of an urban city. This could be noticed even when an individual is unsighted, most people can approach a wall without touching it, just by paying attention to the way the wall changes the frequency balance of the background sound. This means that our perceptual skills are learned. The human cortex can preferentially allocate cortical areas to represent selected peripheral inputs. That is to say that, when individuals engage extensively in particular types of sensory experience, their brains adapt to any perceptual changes (Buonomano & Merzenich, 1998; Münte et al., 2001).

Given the breadth and complexity of hearing, in the twentieth-century Maurice Merleau-Ponty (Merleau-Ponty, 1945) believes “that the body and mind cannot be separated from subject and object”. This signifies that the perception of the body acts upon what is perceived by the mind. In addition, Zumthor (2006) on the other hand, acknowledged that interiors are compared to large instruments that collect sound, amplify it, and transmit it elsewhere. However, the shape of the room, the surface of materials they contain, and the way those materials have been applied in the interior space plays a significant role here. This implies that sounds are associated with certain rooms, places, and memories. It is of interest to note the perception of sound in space is heard through physical presence and sensitivity. Put differently, sound stimulates emotional and sensual responses of individuals in space. However, material, scale, memory and familiarity all create a sense of sound in a building interior. An individual within a space have the responsibility to identify and connect with the sounds present. That is to articulate, that sound is a sensational atmospheric quality, which allows an individual to physically hear it, experience it, and sense it characteristics present in space (Zumthor, 2006).

Likewise, Randall McClellan believes that every sound has its conception (i.e., preparation), birth (i.e., attack), growth (i.e., the time it takes to reach its maximum loudness), old age (i.e., decrease of loudness), death (i.e., the point at which the sound ceases, and an afterlife (i.e., memory of the sound) (McClellan, 1991, p.35 – 36). Furthermore, Randall McClellan also discovered that within the world of sounds, relatively few are organised into what we normally regard as music. For instance, when an individual liberates his/herself from their conditioned perception of what is or is not music they begin to discover a far larger diversity of music just around them. This buttresses the notion that humankind accepts a tremendous power to perceive unity in any "random" series of sounds. Additionally, it is also worthwhile to mention that the limitation of human preconceptions causes them to disregard that unity. The relish humans derived from hearing both very soft and very loud sounds give them the opportunity to expand their awareness beyond the narrow band of what is often viewed comfortably. Moreover, on one hand, soft sounds require complete attention and openness and on the other hand, loud or excessive sound intrudes upon individual's complacent ears and pushes away all thoughts. There is that tendency that when this occurs, people no longer listen to the sounds, instead, they acquire the sensation of peering out at the world from within the centre of the sounds (McClellan, 1991, p. 36).

Of course, all individuals tend to give little attention to soft sounds and try to avoid loud ones. However, this is not the case, as the loud sound is not responsible for the discomfort. Furthermore, there is the tendency that the humans' resistance to the sound triggers tension and in turn, this tension results in discomfort. This suggests that the way to experience a sound at the threshold of feeling or pain is to be at a physical relax state. In addition to this, studies have shown that tension or stress causes the muscle construction that decreases blood and oxygen supply. Thus, refraining from resistance allows sound to flow freely through individuals. Conversely, when people surrenders to the sound, this allows it to fill the head and in turn, this merge with the energy of the body. This supports the notion that the full perception of true hearing is without judgement. Likewise, in relinquishing control, individual's minds are still, that is, free of expectation, free of a verbal monologue, free of fantasies, and free of fear. Moreover, in this case, hearing ego seems to be circumvented, that is, the future and the past give way to continuous successions of the present. Hence, this indicates that at this point, people are drawn into the centre of the sound and to the sound beneath the sound (McClellan, 1991, p. 36).

2.6 Experiencing Aural Space as a Musical Composition

Every space has an aural architecture. Individuals experience spaces not only by seeing but also by critical listening. We as individuals can navigate a room in the dark, and hear the emptiness of the space without furniture. This indicates that our experience of music in a concert hall depends on whether we sit in the front row, middle or under the balcony. This highlights that audition is always active, without earlids or a voluntary point of spatial focus, listeners are involuntarily connected to those events that are audible regardless of their location or position. When listeners are engaged in auditory spatial awareness, they can detect and interpret the audible attributes of spatial sound quality in a confined space. For example, audible cues can produce emotional responses, such as an elevated sense of intimacy, and on the other hand, cues can change behaviour (Blesser & Salter, 2009). However, aural architecture is not a direct way to solve complex issues in acoustical sustainability at the urban scale but could offer a substantial framework for how architectural practice might reconsider its disciplinary boundaries. However, this could be feasible by enquiring into the integral associates between materiality, volume, and sound sources. This was supported by Blesser and Salter from the need to increase auditory spatial awareness among the technologically mediated general population across the Western world (Blesser & Salter, 2007, p.5). This indicates that aural architecture could be described as the:

> "Properties of a space that can be experienced by listening. An aural architect, acting as both artist and social engineer, is, therefore, someone who selects specific aural attributes of a space based on what is desirable in a particular cultural framework. With skill and knowledge, an aural architect can create a space that induces such feelings as exhilaration, contemplative tranquility, heightened arousal, or a harmonious and mystical connection to the cosmos. An aural architect can create a space that encourages or discourages social cohesion among its inhabitants" (Blesser & Salter, 2007, p.5).

Interestingly, Luigi Russolo, a noise artist, in his book *The Art of Noises*, advocated that the industrial revolution had given modern men a greater capacity to appreciate more complex sounds. He found traditional melodic music confining, and envisioned noise music as its future replacement. Russolo, re-formed the noises of the city with his noise machines, thereby re-contextualising the sounds of the city as musical units (Morgan, 1994). Supporting this concept, John Cage, potentially used a musical instrument to direct the listeners listening toward the sounds of the immediate environment. Indeed, both composers, in the real sense, inspired their audience to consider the sounds of their immediate soundscape as elements in a composition (Lacey, 2014). This intention was vividly achieved in the works of sonic theorists, Marshall McLuhan and R. Murray Schafer. On the other hand, McLuhan looks into the visual dominance in perceptions of space which brought awareness of the depth of information contained in auditory space, as well as the potential experiences to be had through listening to space (McLuhan, 2013). Similarly, Murray Schafer the main advocate of the term soundscape made enormous progress in the understanding of the word soundscape. This propelled him to advocate that the sounds of the world are a macro-composition unfolding around humans ceaselessly and that the everyday soundscape is a composition (Schafer, 2013, p. 29). There is also an indication that most composers and philosophers considered auditory or aural space as active, information-rich and full of compositional potential. Along with this conceptual reasoning, one can be convinced that architectural space can be seen as compositional space. This is in line with the notion that architectural space can also be a designed auditory experience and thus may include the addition of sound sources, that when acting in concert with passive aural embellishments, provide particularly striking multisensory experiences (Blesser & Salter, 2007, p.2).

2.7 Sound, Music and Architectural Listening Spaces

Indeed, studies in music theory, the aesthetics of music, and the psychology of music have all inclined to treat music as if it were a phenomenon profoundly distinct from other auditory component within the environment. However, music is often inextricably blended with the wider auditory world, as it sounds within it, integrates environmental sounds into its own material, and takes on a fluid relationship with the physical and social spaces that it occupies. This indicates that music is traditionally considered from practical and normative to provocative and paradoxical (Born, 2013, p. 90). Furthermore, certainly, individuals can accept that music is a temporal art space, which means that the perception of space is also an essential part of the music experience. In other words, music, simply describes sound organised in time and space, and space and time have been objectively described, however, individuals may feel how time in its inexorable passage is carrying them away, and they can neither halt nor prolong it. Conversely, humans cannot recover a single moment of existence, this entails that the flow of time is beyond human control. For example, time could mean when (e.g., daytime, night, weekday, weekend, summer or winter) people are listening and for how long, whilst, space itself could mean the location, use and physical characteristic of the space (Jennings & Cain, 2013). Indeed, it could be argued that music has always comprised a spatial component that is strongly associated with the space of performing, locating of sources sound, and positioning of the body of the listener. Additionally, Alan Licht and Jim O'Rourke advocate that not until the end of the sixteenth century and beyond that example began to appear, in which the experience of space was the aspect affecting the creative process and perception. Likewise, space thus conditions the manner of composing, perception, and entire poetic and creative result (see Licht & O'Rourke, 2007, p. 42).

With the progress made in electronic music, space acquires a constitutive part in organising and presentation of music discourse and work. One such example is the works of Pierre Schaeffer, concrete music (musique concrète), in which distribution of the potentiometer of space (potentiomètre d'espace) was conceived, the device controlling the orbit of the sound between the speakers. Another important example is the idea of spatial music, which was elaborated by a German composer Karlheinz Stockhausen (Srećković, 2014). Undeniably, Karlheinz Stockhausen was fully aware that the synthesis of sound and space music would be the most important aspect of the music of these times and of the future to come. In addition, he proposed a new concept of the concert space which should be of spherical shape, equipped with over fifty loudspeakers placed in concentric circles, with a platform in centre for the audience, or a greater number of mobile platforms, at different heights, which would enable to feel ’coming’ of the sound from different directions (Harley, 1994, p. 117). Karlheinz Stockhausen succeeded in realising this idea in the German pavilion within the 1970 EXPO in Osaka Japan (see Figure 2.4 a & b) when his compositions were emitted by means of a multichannel system for rotation of sound in space, enabling circular and spiral sound movements.

(a) (b)

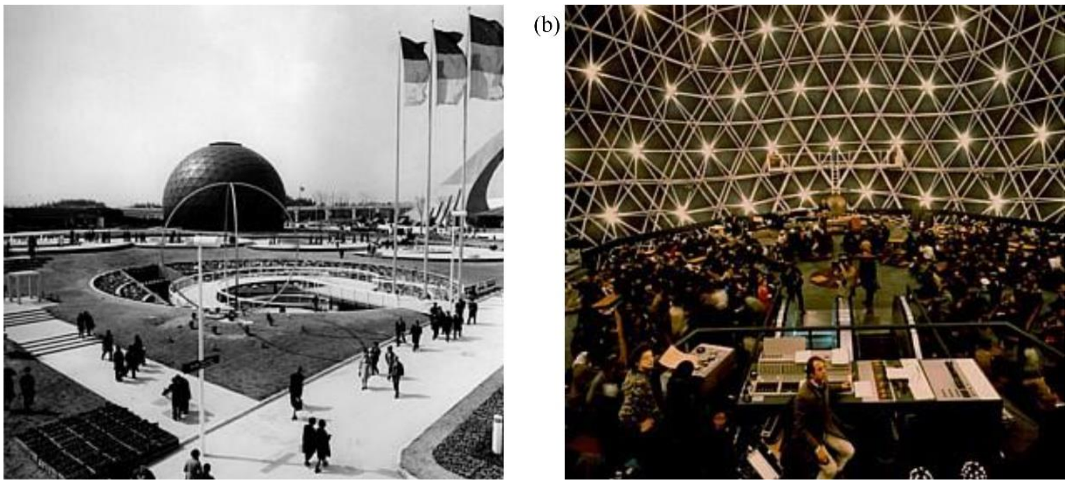


Figure 2.4. The spherical Auditorium, German pavilion Expo 70, Osaka, Japan: (a) exterior of the German auditorium, (b) Stockhausen performing in the auditorium (Source: Expo 2005 Photo Essays).

In a nutshell, Karlheinz Stockhausen’s pieces portrayed spatial music that strongly demonstrates the works of Gesang der Jünglinge (1955–1956), Gruppen (1955–1957), and Carre (1959–1960) (see Srećković, 2014). In addition, these spaces were capable of producing intense multisensory experiences, including projections and lighting effects that were offset through the capabilities of the spatial projection of sound sources within the pavilions using electronic means, and via multiple loudspeakers (Flower, 2015).

Since the late 1960s, an Austrian artist, and architect, Bernhard Leitner has been working in the realm of architecture, sculpture, and music, conceiving of sounds as constructive material, as architectural elements that allow a space to emerge (Lopez, 2011). Bernhard Leitner focuses his work on sound as a plastic, sculptural, and architectural medium, that is, as the means of space shaping. Until recent times, Bernhard Leitner is considered a trailblazer of the art form generally referred to as "sound installation." Bernhard Leitner introduced sound to the installation space, allowing the installation space to emerge through the sound. In precise sketches and workbooks, he first approaches the sculptural, architectural qualities of sound in theory. One of the first examples of Bernhard Leitner masterpiece was 'The work Sound Tube in 1971 (see Figure 2.5), which based its installation on the complex structure made of speakers through which the listener passes physically (LaBelle, 2006, p.178).

Indeed, Leitners' works deal with the audio physical experience of spaces and objects, which are determined in form and content by movements of sound. This notion gives the advance sign of the key topics of his poetic, that is, the relationship between the sound and the body during the act of perception. This incorporates the role of the entire body in the process of perception, the relationship between sound and space, and the possibility of space shaping by sound. In line with this, Leaner's often uses the term 'sound architecture' throughout his works since 1971. Among the most outstanding examples of sound, installations are those witnessed in the works of Bernhard Leitner (LaBelle, 2006, p.178).

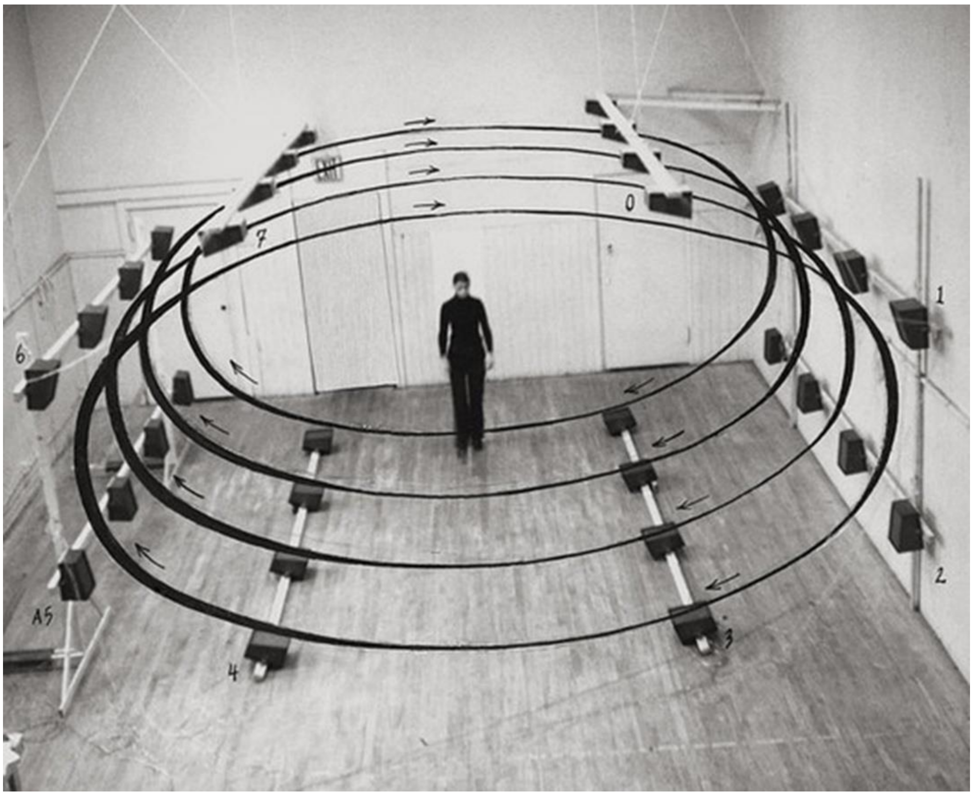


Figure 2.5. Atelier Leitner - Sound Tube 1971 (Lopez, 2011).

Furthermore, another example of a good listening space and exceptional building that stand out were created by Le Corbusier. Le Corbusier was a music composer and an architect who reviewed the relationships between architecture, music, and mathematics, and postulated that music is time and space like architecture that depends on measure (Curtis, 1986). A notable historical example of the ways in which the perception of aural architecture influences the bodily perception of space is absolutely the colossal Philips Pavilion designed by Le Corbusier, Iannis Xenakis, and Edgard Varese for the 1958 Brussels world fair. Instead of just putting a series of systems of loudspeakers into an architectural shell, Le Corbusier, and Iannis Xenakis developed a hyperbolic paraboloid geometry for the building that directly influenced the behaviour of sound and vice versa (Franinović & Serafi, 2013, p. 57 – 60). Conversely, as set out in (Figure 2.6) Le Corbusier, Iannis Xenakis, and Edgard Varese’s’ project at that time was unique among early modern works, and was conceived from the onset as both an aural and visual experience. Organized intentionally around a series of sonic concepts and strategies, the building's final form proved to be as visually fascinating as was its acoustic capacity to sculpt sound (Franinović & Serafi, 2013, p. 57 – 60). In particular, Xenakis sought to create a space where architectural surfaces would help define the manner in which sound moved through space and, consequently, the techniques by which the human body would physically interact with and navigate through such a space. Shapes are doubly primordial due to the sound quality of sound they reflect, and by the way, space itself conditioned the human body. Similarly, this implies that we live in such spaces, we listen with our ears, that is, we hear space with our ear, and we see it with our eyes, therefore both senses, as well as the body's movement within a given space, are involved (Franinović & Serafi, 2013, p. 57 – 60).

Figure 2.6. The Philips Pavilion in Brussels, 1958 by Le Corbusier, Iannis Xenakis, and Edgard Varese (Thuroczy, 2014).

2.8 Perception of Sound in Space as a Soundscape

Soundscape, commonly termed as acoustic ecology is broadly described as the entire acoustic environment of individuals lives, and this includes how sound in a given environment affects both humans and non-humans, alike. On the other hand, Krause (2008) described soundscape as all the sound from a particular environment that human perceived through auditory experience. Similarly, Mazer (2010a) perceives soundscapes as an auditory cluster or environment. The word ‘soundscapes’ was formally coined into the scientific vocabulary by Murray Schafer in the late 1970s (Krause, 2002). Additionally, the soundscape is what a post-World War II electronic art, music composer, Oliveros (2005, p. 18) described as all of the waveforms faithfully transmitted to our audio cortex by the ear and its mechanisms. In other words, soundscape can also be described as an audio recording or performance of sounds that create the sensation of experiencing a particular acoustic environment, or compositions created using the found or organised sounds of an acoustic environment, either exclusively or in conjunction with musical performances (Truax,1992, p. 374). Additionally, Murray Schafer introduces the concept of soundscape in 1977 in his book – ‘Tuning of the world’, and thus defined soundscape as all the sound from a particular environment that are perceived by the human ear. Schafer further broadens this concept by advocating that humans are linked to the natural world through its perceived voice, which inspires them to consider what first stimulated their communities to form sound into cohesive patterns such as music, speech, and even dance. Moreover, he defined soundscape as the sonic environment (Schafer, 1977). Additionally, Krause (2008) advocated that Schafer’s work discloses the improvement of new words to depict an acoustic natural event as hitherto unexplained in our limited sonic vocabularies.

In spite an increasing attention in the natural soundscapes, which began in the early 1980s, researchers were unable to express in single term a particular component of natural soundscape that comprised merely the non-human sounds of biological origin in a particular environment (Wrightson, 2000). Soundscapes phenomenon has been explained from three basic scientific words, biophony, geophony and anthrophony, and are terms employed to characterize sounds that occur in the landscape (Pijanowski et al., 2011). Biophony refers to the sounds produced by living organisms, such as birds, amphibians, insects, mammals, fish, and other terrestrial and aquatic systems. This is sounds used by animals as a means of communication. Geophony are sounds produced by physical processes such as the wind, water flow, thunder, rainfall, earth movement (earthquakes) and other exothermal cases. Whilst anthrophony (or technophony) are sounds generated when humans use mechanical devices, such as fans and air conditioners, and mobile machines used for transportation and construction such as aircraft, cars, trucks, boats, building cranes, bulldozers etc. (Fuller et al., 2015). In addition, from a broader viewpoint, anthrophony can be characterised into physiological (e.g., talking, singing, laughing, crying, screaming, grunting, body sounds), controlled sound (e.g., music, theatre, etc.), and incidental (e.g., walking, clothes rustling, etc.), electromechanical, oil exploration and shipping (Krause, 2002; Pijanowski et al., 2011).

Soundscape in the real sense is precisely similar to “landscape,” but used for sounds to describe an area, normally in an urban city or the aural features of an area (Schafer, 1977), and can also be used to avoid the term “noise”. On the other hand, landscape describes the visual features of the land, such as the beautiful vegetation, land, water bodies, animals, structures, etc. whilst soundscape can be referred to as the interrelationship between sound, nature, and society (Wrightson, 2000). Achieving a natural soundscape on a daily basis is quite difficult for humans due to the size increase in the world population, the widespread locations of urban and suburban areas, and the use of several noise-producing technologies. Moreover, the effect of human-generated sounds on both humans and animals is becoming a growing issue and need to deliberate on them is significant to achieve a quieter acoustic environment or soundscape (Timmerman, 2010).

2.8.1 Landscape and Soundscape

A soundscape has been well-defined as an acoustic environment understood or perceived by individuals within a specific context (Hong & Jeon 2015). On the other hand, Schafer (1977) believe that soundscape, a term derived from the landscape is the designation of any human-audible sounding environment. Thus, it can be said that the relationship between perceptions of a sonic environment and contexts is important to understand the soundscape of a space or place. Moreover, this ideology of soundscape created a prospect for an interdisciplinary investigation into the relationship between a given space and the sensation of listening. This is what Truax (2001) designates as the importance of sound as a mediator between human and environment, in addition to the notion that active listening involves a listener embedded within the soundscape (Fowler, 2013a).

Specifically, landscapes and soundscapes surround us in our daily lives, even if we do not always know their existence. Adding to this, Hong & Jeon (2015) advocated that even if a visual environment is appropriate in a given place or space, if the soundscape is not appropriate, the overall environment might be perceived as disharmonious. In addition, according to Von Meiss (1991), if an individual closes his/her eyes to remove the dominance of the visual world in order to listen more intently, that is real proof of the sheer pleasure of the auditory experience. Several researchers have explored the relationship between visual and sound components and observed that among various visual factors, the aesthetic quality of the visual environment is considered to be the most significant factor affecting soundscape perception, which indicates that a more pleasing visual environment enhances the soundscape qualities (Carles et al., 1999). This indicates that these two components are of significance to humans as this identify their being in the world through hearing, feeling, sensing and experiencing their surroundings. From this perspective, Ripley (2007, p. 2) conceived that sound and sight are two elements that mutually strengthen one another in individuals' perception of space and the qualities of a space affect how individuals perceive a sound and sound affect how individuals perceive a space. In addition, it has been suggested by Ingold (2007) that sound should be considered neither as mental nor as material, but as a medium of perception, as a phenomenon of experience in which people are immersed.

Therefore, viewing sounds as an indispensable component of the affective and aesthetic properties of a space influence profoundly how individuals experience spaces sensually. This notion is also supported by (Schafer, 2004, p. 29–38) for the hi-fi environment which makes it possible for discrete sounds to be heard clearly as there is no background noise to obstruct even the smallest disturbance. In the same study, it was similarly observed that all sounds are unique in nature and occur at one time in one place and cannot be replicated, which suggests that it is physically impossible for nature to reproduce any phoneme twice in exactly the same manner. Additionally, for example, when Schafer (2013) was referring to keynote sounds, he was stressing on sounds (e.g., nature geography and climate which includes sounds of weather, water, forests, plains, birds, insects, animal vocalizations) that may not always be heard consciously, but contributes to the character of the people living in a surrounding. These sounds include musical composition, mechanical sounds, sound design, warning devices, bells, activity, sound generated from a place, conversation, whistles, horns, sirens, road traffic etc. (Truax, 2001).

2.8.2 Landscape and Sound Pollution

There are certain environments that are exceedingly stressful and such settings are ordinarily found in hospital spaces, due to the medical procedures that are frequently associated with discomfort. Therefore, the ability to draw upon the therapeutic qualities inherent in nature can extend one's capacity to cope with uncertainty, and this, in turn, can potentially improve health outcomes (Verderber, 2010). The landscape and its relationship with health have been observed for decades and in various periods and diverse cultures and societies. There have been arrays of investigation on the therapeutic effects of landscape on hospital occupants, and this is believed to have effects on human beings in several ways, including aesthetic appreciation, health, and well-being (Velarde et al., 2007). The healing effects of nature to ameliorate patients' recovery was first deliberated upon, written, and published by Florence Nightingale in Notes on Nursing in 1860. Nightingale propounded that visual connections to nature, such as natural scenes through the window and bedside flowers, contribute to the recovery of patients (Nightingale, 1860).

Similarly, a study has been demonstrated that patients who viewed trees had shorter post-operative stays, took fewer pain relief drugs, and had a favourable response about their outcomes in medical notes compared to those exposed to view a brick wall (Ulrich, 1984). Additionally, research has shown that viewing natural vegetation, water bodies, and other natural elements can improve stress and patients' well-being in healthcare environments (Velarde et al., 2007; Dijkstra et al., 2008). Ulrich (1999) supported that gardens will likely calm stress efficaciously if the garden integrates verdant foliage, flowers, water, congruent natural sounds such as the one found in birds, breezes, or water, and visible wildlife. Furthermore, it has also been demonstrated that natural scenes when incorporated with trees, green vegetation, and cultivated fields to improve well-being, reduced anxiety, and increased positive outcomes in post-surgical complications (Ulrich, 1991; Ulrich, 1984).

Activities that take place in the hospital therapeutic garden can range from sitting outside to dozing, napping, or being engaged in meditation, prayer, exercise, walking to a preferred spot, eating, reading, working outside, viewing children playing in the garden, self-involvement in raised bed gardening, and light sports activities (Cooper-Marcus, 1999). Previous research has designated that hospital garden-users reported significant positive mood change resulting from garden use, and that time spent in observing nature establishes a restorative experience (Whitehouse et al., 2001). Research evaluations indicate that incorporating gardens in the hospital settings can improve the quality of life for patients, and afford an opportunity for them to exercise without becoming agitated, and lighten the burden of care for nurses (Hartig & Cooper-Marcus, 2006). Several studies have pointed out the environmental and social benefits associated with green spaces in terms of enhancing mental and physical wellbeing, supporting social interaction and integration, mitigating climate potential in the form of cooling effect, and noise mitigation (see Kabisch et al., 2015).

On the other hand, the links between landscape and environmental noise pollution and its adverse effects on human well-being have been well documented. These adverse effects can reduce productivity, decreased performance in learning, leads to absenteeism in the workplace, increased drug use and accident rates in the hospital environment (Berglund et al., 1999). However, several studies have suggested that landscapes can mitigate a large amount of the environmental impacts of urban growth, which in turn improves urban hydrology and air quality, reduces noise pollution and the energy requirements of the city (Konijnendijk et al., 2005). Similarly, an investigation has demonstrated that soft lawns mitigate noise by decreasing the reflection of sound waves, an effect that improved quietness experienced after a snowfall, on the other hand, the study results also showed that tall vegetation helps to reduce noise by absorbing lateral short-wavelength sound (Barth & Schmid, 2001). Additionally, as individuals exhibit strong preferences to natural sounds such as birdsong, there is likely for bird song to increase and mask other surrounding noise if green space has a significant shrub layer (Irvine et al., 2009). In a study related to the effects of interior plants on acoustics in spaces, results demonstrated that plants can reflect, diffract, or absorb sounds at varied frequencies. The same survey presents that, plants worked best at reducing high-frequency sounds in rooms with hard surfaces and was argued to be as effective as adding carpet (Lohr, 2010). Likewise, a previous study conducted to examine the effect of landscape design on sound fields reduction in courtyards suggested that vegetation/landscape could conduce to the mitigation of noise pollution in atrium/courtyards (Kim et al, 2014).

2.8.3 Hospital Sounds as a Soundscape

Thus, far the study has discussed the individual sound components of the soundscape and their associated effects with a wider elucidation. From earlier discussed limited work could be found focusing on sound in hospitals in terms of sound and music as well as a soundscape, by understanding the perception and response in a holistic manner distinct from sound level pressure only. For an improved understanding of the hospital soundscapes, by means of an ethnographic methodology with interviews, Rice (2003) explored the sounds of patient life at a public hospital in London, focusing on patients' experiences of ward soundscapes. Moreover, the same survey, remarked that hearing becomes noticeable while in hospice as the visual context is blunt and even restrictive, as other senses are not employed and stimulated, thus meaning these are made redundant. This harmonises with both Ulrich (1992) and Wilson's (1972) who believe of sensory deprivation within hospital spaces, that takes a holistic approach to understanding the environment, stating that the hospital environment is one which the sensory experience is ordered and therefore restricted to patients. A study conducted by Posner et al. (1976) on visual dominance, demonstrated that if visual information is inadequate, then it implies that sound plays a more dominant role in people's perception of an environment. This was also noticed by Rice (2003) who remarked that hospital patients' perception of sound was higher as the visual stimulus generated by the environment was reduced. In the same study concluded that "lack of opportunity for insight leads to the prospect of in sound".

Indeed, investigations have demonstrated that habituation syndrome occurs in individuals' response to noise, such as, at the initial stage they find it annoying, but then it is too much onerous to do anything about it and therefore, in time they become acclimatised to it (Truax, 1984). Certainly, the subjective response sound manifests itself in a defeat reaction where individuals may become depressed, which is especially present in environments where people cannot break loose from the exposure (Rylander, 2004). For instance, the hospital spaces are one such setting where both staff and patients are subjected to the same constant sound sources. In line with this theory, Rice (2003) remarked that there is a need for possible significance of positive sound within the hospital environment. This means that the soundscape of a hospital should always be changing to periods of silence and other sounds to produce a temporal element and stimulus for patients (Mackrill, 2013). In harmony with this, Mazer and Smith (1998) indicated that the hospital environment should not be of any single type of sound all the time, change and flexibility are all important in the sound environment. From Truax (1984) point of view, soundscape environment functions as a system where all the interaction and mutuality of the sound environment is balanced making it a pleasant environment to be within. Such environments have been termed as 'hi-fi', where there is a correlated balance between sound sources and each single sound can be heard clearly. This contributes to the perception of a comfortable positive environment, on the other hand, in an environment that is unbalanced the perception is often termed as noise, which results in data loss, stimulating a spirit of being cut off or separated. In the same workpiece, it was advocated that the 'lo-fi' environments project a person's attention inwards and as a result prevents interactions with others, leaving individuals feeling alienated or isolated (Truax,1984).

Extensive works on urban soundscape have shown that sound could enhance spaces and this theory is also applicable to hospital environments. This can be observed in the works of Thorgaard et al. (2005), which performed a questionnaire study investigating patient and staff opinion of specially design music environment through ceiling mounted speakers. Results demonstrated that there is a correlation between the positive attitude towards the music and relaxation experiences. Nevertheless, interpreting the opinions and perspectives towards the environment first would yield a more successful solution. This would identify the psychological response to the interventions in a clearer context and enable and interventions to be assessed against the views of the people within the space before they were carried out (Mackrill, 2013). At a theoretical level, a study has remarked that environmental features, such as the soundscape, can help people to determine salient elements in a space and cause them to learn, think, or remember in certain ways (Ochsner & Gross, 2005).

2.9 Soundscapes – Toward A Novel Paradigm for Understanding Hospital Noise

Soundscape studies is not a novel concept as such, it was first documented and defined in the acoustic ecology context as an environment of sound or sonic environment with emphasis on the way sound is perceived and understood by an individual or by a society (Truax, 1999). Individuals relate to their acoustic environment on an emotional level by perceiving the sensory information they meet, and this gives rise to the concept of soundscapes (Cain et al., 2013; Schafer, 1994). Environmental psychologists believe that the attributes of social or cultural factors, including other external attributes of physical surroundings, are interwoven and directly or indirectly affect human perception of sound (Gifford, 1997; Bell et al., 1996). Research has suggested that the control of hospital sounds requires closer investigation on the positive aspects (Dawson, 2005) which would provide scope for a better understanding of the variety of sounds and thereby create a more positive feeling of the hospital ward soundscape (Mackrill et al., 2013a).

Extensive effort has been made to understand how the perception of soundscape can be applied to improve urban experiences (Axelsson et al., 2010; Cain et al., 2013; Davies et al., 2013). This may move away from a negative impression of sounds, thereby building a richer positive approach to deal with sound environments, rather than only emphasizing sound level reduction (Mackrill et al., 2013b). In order to understand and ameliorate the emotional reaction to a soundscape setting, a framework was developed that enables soundscape interventions to be tested, with the notion of improving the perception of a hospital setting soundscapes (Cain et al., 2013; Mackrill et al., 2013c). Subjectively, much of the soundscape comprises information that is positive for both patients and nurses, but the physical, temporal or contextual variation in which the soundscape is heard imply that at a point in time, certain sounds might be considered negative noise and at another, they may be considered positive (Mackrill et al., 2013b). For example, there are several settings where the average sound level is excessive, but people perceive it as positive sounds or find it enjoyable (e.g., occupational sounds generated from a tea trolley, a busy market, a bustling square or a fountain), although this subjective preference depends on many factors (Mackrill et al., 2013b; Davies, 2013). There are, however, a number of factors influencing positive soundscape perception or experience, which includes an individual's preference, activity, demographics, time and space (Jennings & Cain, 2013), visual or hearing impairment, age, and gender (Kang & Zhang, 2010).

Most soundscape investigators have demonstrated a similar trend of human listeners preferring natural sounds such as birdsong and running water as positive soundscapes, and disapproving of sounds such as traffic noise or construction sounds (Nilsson and Berglund, 2006; Yang & Kang, 2005). Natural sounds have many positive aspects that could improve peoples' mental health when matched to a noisy urban environmental sound (Alvarsson et al., 2010). Similarly, studies have suggested that certain natural sounds such as the sound of birds may offer benefits that contribute to a positive feeling, perceived restoration of attention and stress recovery (Mackrill et al., 2014; Ratcliffe et al., 2013). Table 2.1 provides detailed information about the positive soundscape findings.

Likewise, this approach is considered to be complementary to other approaches to classifying soundscapes, including Schafer's use of keynote, sound signals, soundmark, lo-fi and hi-fi (Schafer, 1994). Truax (2001) believes that the 'hi-fi' environment presents a high stage of information interchange between its elements and the listener is involved in an interactive relationship with the surroundings. In this view, if sounds are clearly understandable, controllable and make sense in the healthcare settings, they may well not have a detrimental effect and might even bring about benefits in the overall ecosystem of the hospital for occupants (Brown et al., 2015). This is consistent with Per Thorgaard's calls for music intervention to be considered from both a therapeutic and ethical standpoint, and be implemented in clinical practice (Thorgaard, 2013). Complying with this call, studies have suggested that incorporating a certain kind of sound such as that of music into the hospital space can elicit positive emotions (Blood and Zatorre, 2001), and at the same time can induce an analgesic effect, thereby enhancing working memory task, reducing stress, anxiety, and pain, blood pressure and post-operative trauma when matched with silence conditions (Chafin et al., 2004; Evans, 2002; Nilsson et al., 2005).

Table 2.1. Selected studies that highlight positive soundscape intervention

Selected references	Main measured outcome(s)	Result on health-related outcome(s)
Schafer (1994); Truax (2001, 1999)	Relationships and interactions between humans and sounds in an environment, including musical composition, aural awareness, and acoustic design.	From a social and cultural aspect, soundscape presents a high stage of positive information interchange which creates an environmental comfort that influences an individuals' mood, emotion, appraisal, and restoration in a given space.
Cain et al. (2013); Davies et al. (2013)	Perceptual dimensions: Emotional response to a soundscape as its relates to cognitive responses and how a person feels towards that environment.	Emotional dimension of a soundscape can have a profound impact, thereby establishing a richer image of the persons' response to space or context. Calmness and vibrancy are the two principal dimensions of a soundscape emotional response.
Mackrill et al. (2013a)	Sound source information (SSI) within a cardiothoracic ward environment for patients' comfort.	Sound source information (SSI) can be beneficial for facilitating the sense of personal control, thereby helping patients to feel more comfortable.
Alvarsson et al. (2010)	Test whether auditory stimulation could facilitate recovery after psychological stress.	Nature sounds of fountains and tweeting birds reduced psychological stress and facilitated fast physiological recovery of sympathetic nervous system when matched with noisy urban environments.
Mackrill et al. (2013b, 2013c)	Soundscape perceptual models to describe patients and nurses' subjective responses of a hospital cardiothoracic ward soundscape.	Creating a positive soundscape within hospital spaces may facilitate coping methods, thereby evoking positive feelings of patients and nurses.
Ratcliffe et al. (2013)	Restorative perceptions of bird sound after stress and attention fatigue: affective appraisals, cognitive appraisals, and relationships with nature.	Natural sounds of birds and calls were found to offer benefits that contribute to perceived restoration of attention and stress recovery in adult participants.
Brown et al. (2015)	Noise, effects as it correlates with mental health care and the notion of a soundscape.	Conceptualizing sound in hospital settings as a soundscape may lead to socially meaningful information about the environments by encouraging a level of privacy and health in terms of mental health.

2.10 Chapter Summary

This chapter discusses the theoretical framework of this study. This reviewed the literature on the perception of sound as it relates to space and its effect on individual experience in architectural enclosed spaces. This chapter also highlights the theories sounding sound perception in architectural spaces. This covers auditory perception of space and spatial awareness, users aural experience of space and the psychology of music as it relates to architectural auditoria listening spaces. Soundscape theory and concepts are also described. This includes the notion of a soundscape as it relates to psychological discourse, concerning how individual understand sound by attentive listening in a given space. It also includes the relationships and interactions between humans and sounds in an environment, including musical composition, aural awareness, and acoustic design. The relationship between soundscape and landscape influence on noise pollution was also highlighted. This chapter concluded with positive soundscape intervention in hospitals. This includes tapping into the emotional aspect users by improving the hospital space experience with positive sound, thereby creating an environmental comfort that influences patients and patients care team mood, appraisal, and restoration. Hence, soundscape notion in hospital settings would be better understood when the role of sound perception in hospital physical environments is explored.

Chapter 3

EXPLORING THE ROLE OF SOUND PERCEPTION IN HOSPITAL PHYSICAL ENVIRONMENTS

3.1 The Hospital Physical Environments

It has been demonstrated that the quality of the physical environment of hospital rooms contributes to patients' well-being (Devlin & Arneill, 2003). The physical environment is not only vital for sound health, but can likewise be a critical stressor for hospital occupants (Dilani, 2001). Health has been defined as the state of complete physical, mental and social wellbeing and not just the absence of disease or infirmity (WHO, 1948), which suggests that hospital environment should be free from major health hazards and satisfy the basic requirements of healthy living, in addition to facilitating equitable social interaction (Grad, 2002). On the other hand, wellbeing has been conceptualised as an individual’s perception of their condition, which has a reflection on an individual’s physical, mental, emotional, spiritual and social characteristics (Law et al., 1998).

Specifically, it could be argued that an individual experience a high level of well-being as positive, whereas a low level of well-being is mostly connected with negative conditions. This supports Orem’s (1985) notion that well-being is a perceived state of harmony in all aspects of an individual’s life and characterised by the experiences of contentment, pleasure, spiritual, including a sense of happiness. Similarly, Law et al. (1998) pointed out that it is possible to be ill or not healthy, and still have a sense of well-being. Additional, wellbeing is generally compared with the experience of pleasure and the absence of discomfort over time (Tamir & Ford, 2012). Supporting the concept of health and wellbeing, it has been pointed out that a healthy hospital should create a healing space for patients, as well as a healthy workplace for staff in every sense and extend their role to focus on health and wellness, not just illness (Hancock, 1999).

Therefore, hospitals have been described as institutions to treat ill patients who require rest and recovery from injuring, sometimes including peculiar health care and treatment of medical and surgical with a medical specialist and adequate equipment for diagnosis of diseases (Pai, 2007). Research investigations on health and wellbeing have revealed that the designs of hospital environment have a strong influence on the enhancement of patients' experiences when they are treated and admitted in this space (Dijkstra et al., 2006). This is coherent with the notions that a well-planned hospital space integrates functional requirements that meet the demands of its diverse users (Wolf, 2003). Indeed, there is a growing body of literature on the impacts of the hospital physical environment design for improving occupants' health and wellbeing (Anderson et al., 2006; Ananth, 2008).

Donna (2009) argued that therapeutic environments create a shared environment that strengthens the self-healing capacity of both patients and hospital providers. In other words, a healing environment should reflect the values, beliefs, and philosophies of the patients served. This is also in harmony with the view that hospital design should provide a safety, comfortable environment, and reduce stress and confusion for patients, families, and care providers (Ulrich, 1984). Additionally, previous studies have acknowledged that when specific design approaches such as the soothing sounds of music, bird songs, water bodies, and a view of the natural landscape, are implemented in the hospital design potentially reduces related stress outcomes (Malkin, 2003; Ulrich et al., 2004). Interestingly, environments of care that incorporate the sounds of pleasant music in patients' rooms has also been described to enhance hospitalised surgical patients' recovery, most particularly in the areas of pain coping, stress, and anxiety (Laursen et al., 2014; Ulrich, 1984). Moreover, surveys have indicated that a healthy workplace environment that integrates physical environmental factors helps in producing a healing environment that improves hospital providers' efficiency as well as reduces the patient's hospital length of stay (Ulrich, 1992).

The meaning of the built environment for the patient's health and well-being and the provision and support of health care extend at least as far back as 400 BC (Codinhoto et al., 2009). In ancient times, Hippocrates who believed in the healing power of nature made some pertinent interpretation of this approach by arguing that illness can be inflicted through the product of environmental factors (Grammaticos & Diamantis, 2008) and in the 19th century by Nightingale (1860). For example, a research has described the relationship between symptoms of the Sick Building Syndrome (SBS) and the indoor environment of buildings (Redlich et al., 1997). The term Sick Building Syndrome (SBS) comprises a group of symptoms of unclear aetiology consisting of dry skin, gastrointestinal complaints and symptoms related to mucous membranes such as eyes, nose, and throat, as well as neurotoxic, which include fatigue, headache, and irritability (Burge, 2004). In an office setting, the symptoms of SBS can reduce productivity and increase absenteeism from work (Ahmadi et al., 2015). Similar to such problems could arise in other public buildings, for instance, the hospital context. As well, it has likewise been suggested that psychosocial, as considerably as the physical, biological and chemical factors in indoor environments influences the symptoms felt or experienced by building occupants (Vuokko et al., 2015). Consequently, these effects of the physical environment on patient’s healing outcomes, recapitulating process, and well-being has some profound consequences on the design of the environments of healthcare (Huisman et al., 2012).

3.1.1 Evidence-Based Design (EBD) For Healthcare Design

An exact definition of Evidence-Based Design (EBD) does not appear to exist specifically, as there is a vast definition in different literature work. In accordance with Nussbaumer (2009) definition, EBD research incorporates the collection of information through both fact finding and positioning of new evidence and using that evidence to a design solution. As the built environment has been proven to affect human health and behaviour, thus there are responsibilities for designers to acquire expertise and practical experience to protect the health and wellbeing of end-users (Kopec et al, 2012). The EBD is an approach that began in healthcare with Evidence-Based Medicine (EBM) as its base. EBM has been defined by Claridge and Fabian (2005) as a systematic process of assessing scientific research which is utilized as the foundation for clinical treatment choices. Similarly, research work has demonstrated that EBM is the conscientious, explicit and judicious utilisation of current best evidence in reaching decisions about the care of individual patients (Sackett et al., 1996), and has now become the theoretical conception of what is termed EBD approach, which links hospitals physical environments with health care outcomes.

The movement towards EBD in health care started with the concept that patients who viewed trees had shorter post-operative stays, took fewer pain relief drugs, and held a favourable response about their outcomes in medical notes when compared to those exposed to view a brick wall (Ulrich, 1984). Additionally, most often this is what Ulrich (1991) prefers to call supportive design, which focuses on the building’s significance in terms of stress reduction. Interestingly, Hamilton (2003) supporting this approach often published along with the meaning of evidence in practice, in which he uses to denote EBD and address designs that create environments which are therapeutic, as well as supportive of family engagement, effective for staff performance, and restorative for health care providers under stress. Similarly, studies finding has revealed subjectively that natural scenes and sounds can have a profound positive influence on patient's outcomes (Lechtzin et al., 2010).

More recently, the EBD approach has received extensive academic recognition and has been utilised by architects, designers and facility managers in the planning, design, and construction of commercial buildings, however, particularly well-matched to the physical environment of the hospital on the wellbeing and health of the users (Huisman et al., 2012). It is worthwhile to mention that architects have always designed buildings using the best available evidence from engineering and other numerous related fields founded on sound data (Hamilton & Watkins, 2009), but the divergence here is that EBD is the increasing usage of evidence from disciplines outside of the traditional architectural arena such as research on how health is affected by the built environment published in medical journals, for example, Health Environments Research & Design (HERD) Journal (see Laursen et al., 2014; Ulrich et al., 2010). Currently, EBD has become the theoretical concept of what are called healing environments. As a result, evidence-based healthcare design (EBHD) has become well documented and has grown rapidly in recent years to extend to the creation of spaces termed as healing environments or healing spaces (Sakallaris et al., 2015).

3.1.2 Theoretical Approaches to Healing Environments

Architecture holds the potential to do much more than just supporting functional organisation. It seems to have a direct and arguably influence on people's well-being.

The ideology behind healing is the psychological and spiritual concept of wellness. The healing environments approach in hospitals is, however, not a novel concept as such. It begins with the healing presence of the healthcare providers. Healthcare providers create a healing environment by incorporating an atmosphere of safety, trust, and openness that allows for compassion, clarity, and truth. To achieve this, hospital providers must maintain a non-judgmental relationship to invite those same qualities to flow from others.

There has been research interest in healing environments for promoting the patient's wellness and wellbeing (Codinhoto et al., 2009), although it was mainly employing diverse methodologies such as holistic and spiritual (Huelat, 2003). Healing environments can be regarded as smart investments because they are cost effective, increase staff efficiency, and reduce the patient hospital length of stay through promoting less stressful outcomes (Ulrich, 1992). Established on the definitions of various academic researchers, a healing environment can be delineated as space where the interaction between patient and staff produce positive health outcomes within the physical environments (Devlin & Arneill, 2003).

In recent decades, a growing awareness has developed globally among healthcare practitioners, architects and designers of the need to create a therapeutic environment with more human-friendly, cheerful, safe and supportive characteristics that promote patients, families, and staff satisfaction (Monti et al., 2012). The characteristics of the physical environment in which a patient receives care play a significant role in their outcomes. Similarly, a study by Ananth (2008) reported that hospital environments promote wellness if they are designed to foster social, psychological, physical, spiritual, and behavioural components of healthcare support and stimulate the body's innate capacity to heal itself. Indeed, patients experience a positive satisfaction and better recovery in an environment that incorporates various aspects of the physical environmental factors, including art gallery, natural light, inviting natural elements, blended colours and decor, soothing music, pleasant sound and views, access to gardens and easy access to staff (Gross et al., 1998). Similarly, Laursen et al. (2014) findings suggest that natural design in patients' rooms or recovery rooms could enhance hospitalised surgical patients' recovery, particularly in the areas of pain, stress, and anxiety. As set out in Figure 3.1, the physical setting has the potential to be therapeutic if it achieves attributes that heals (Malkin, 2003).

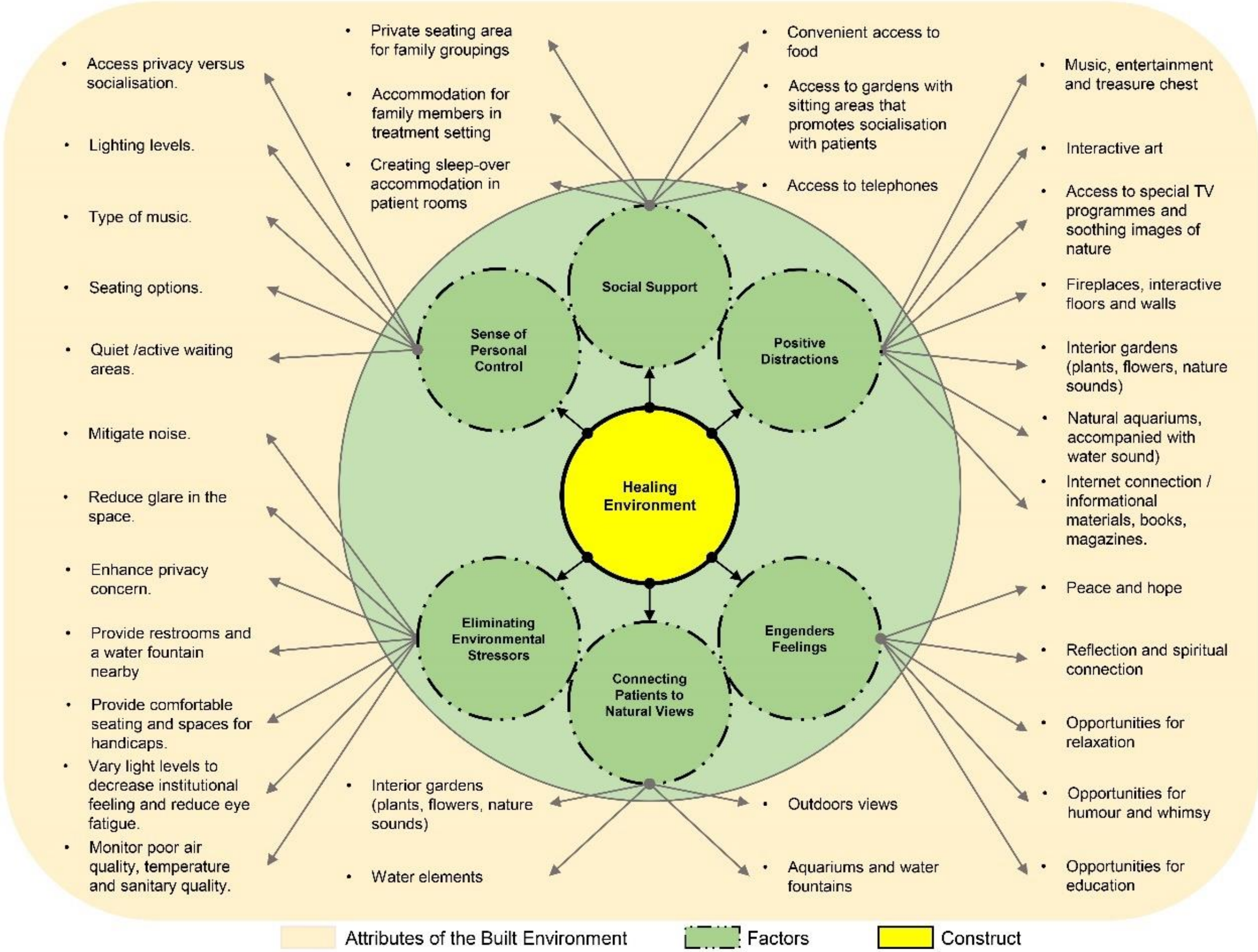


Figure 3.1. A model for understanding therapeutic environment (adapted from Malkin, 2003; Ulrich, 1999; Ulrich, 1992).

Thus, the primary goal of bringing in healing environments is to enlist patients in the conscious process of self-healing and spiritual development. This means that spaces should be planned to be nurturing and therapeutic and most importantly, should reduce stress. In addition, this approach is a research-based approach to design that is also termed as Evidence-based design (EBD), which intended at eliminating environmental stressors and putting patients in contact with nature in the hospital environment (Ulrich, 1984). An investigation has shown that viewing a nature video positively affected physiological measures such as pulse rate when having blood drawn at a blood donor bank (Ulrich et al. 2003). Many other studies have followed, for example, one such study showing the impact of several environmental factors on several health outcomes include (Dijkstra et al., 2006; Zhao & Mourshed, 2012).

A more recent study by Andrade and Devlin (2015) study identifies some of the modelling variables involved in the relationship between the quality of hospital rooms and patients' well-being, through testing the mediating role of perceived control, social support, and positive distraction theorised by (Ulrich, 1991). In correlation with the potential of providing a positive distraction, studies have shown that using appropriate art, nature imagery, and music is found to improve the experience of the patient in terms of stress reduction (Mazer, 2009; Olson, 1998). A similar investigation by Ulrich (1991) advocated that health care physical and social environments promote wellness if they are designed to foster the reduction of environmental stressors such as the sense of control over physical-social surroundings, access to social support, connection to nature, and access to positive distractions.

3.1.3 Sense of Personal Control

Personal control is associated with the ability of an individual to have influence over a particular situation or environment. Investigators have explored the impact of the hospital environment on patients' perceptions of personal control and found that optimising personal control contributes to emotional comfort, facilitating the therapeutic process of hospitalised patients (Williams et al., 2008). Greater sense of control cannot be achieved when patients are not offered access to privacy, bedside dimmers that enable control over lighting, headphones that support patients to select their choice of music, control over televisions, architectural design that supports active waiting areas and accessibilities for handicapped (e.g. wheelchair) patients (Ulrich et al., 2004).

It has been demonstrated that patients in hospital felt greater personal control and emotional comfort when they felt secure, informed, and valued. Moreover, the patients felt insecure and experienced emotional discomfort when assistance was not rendered (Lauck, 2009). One early study supported that unavoidable and painful medical routines, lack of information and uncertainty, long waiting times, and loss of control over eating and sleeping times can debilitate feelings of control (Taylor, 1979). Another study proponent claims that unsupportively designed environments can lead to privacy deprivation, noisy environments, isolated patients' rooms that do not permit a view out of the windows, staring at glaring ceiling lights by patients, and inappropriate and confusing way-finding (Ulrich, 1999).

3.1.4 Access to Social Support

An extensive amount of research has shown that support from family and close friends can help in healing. For example, an investigation has demonstrated that having social support accelerates recovery in heart patients and improves the emotional well-being as well as the quality of life in the late-stage of cancer patients (Uchino & Garvey, 1997). Social support from family and friends improves the health outcome of patients. One survey has described that both healthy and not- healthy people with a high level of social support have less stress and exhibit higher levels of wellness compared to people with lower support (Stouffer, 2001). Hospitals can promote social support by providing waiting rooms and lounges with comfortable furniture, designing patient rooms that accommodate visitors, and providing amenities that make it easier for family members to stay overnight. Furthermore, the design of social, and supportive areas is paramount to provide areas of privacy. Ulrich et al. (2008) indicated that an environment that abdicates privacy could be very stressful for patients. A design that promotes social support for patients can mitigate stress and improve other associated outcomes (Ulrich, 1997).

3.1.5 Positive Distraction

Positive distraction was propounded by Ulrich (1991) as environmental features that elicit positive feelings and holds attention without taxing or stressing the individual, thereby blocking worrisome thoughts. This theory was early supported by McCaul and Malott (1984) who likewise advocated that in distraction theory, pain requires considerable conscious attention, which indicates that patients become diverted or engrossed in a pleasant distraction that consists of pleasant sound, nature view or work of artistry. The authors further argued that patients have less attention to steering their pain, and the experienced pain, therefore, will decrease. This theory also predicts that the more engrossing an environmental distraction is, the more the pain reduction (McCaul & Malott, 1984). Moreover, study investigation has demonstrated that distraction and gate control theory of pain predict that the more engrossing a nature distraction is, the more the pain alleviation, which suggest that nature exposures may tend to be more diverting and hence pain reducing if they involve sound as well as visual stimulation, and are high in realism and immersion (Wismeijer &Vingerhoets, 2005).

Furthermore, Andrade et al. (2012) support the positive distraction theory by when their research findings meant that hospital ecosystems have a quality benchmark, which evaluates aspects fostering spatial-physical comforts, such as orientation, noiselessness, views of nature, and social functional aspects. Similar study findings remark that it is worthwhile to take into account a user-based perspective to the interpretations and perceptions of these components (Fornara et al., 2006). This underpins that it is important to take into consideration these components or attributes and consider their impact on hospital occupant’s outcomes. However, it is not within the scope of this present study to explore all these attributes, as this investigation based its foci on sound perception, its meaning, and role in hospital ecosystems.

3.2 Sound in Hospitals

Sound is what we hear, however, it could be perceived negative or positive by individuals, whereas noise is unwanted sound, and the difference between them depends on upon the listener and the conditions. For example, rock music can be pleasurable sound to one individual and an annoying noise to another. In either instance, it can be detrimental to a person's hearing if the sound is loud and if the person is exposed long and frequently enough. However, sound and music exert an inescapable influence on contemporary design, particularly in a hospital environment, from the impact of sound on individuals to the effect of music on healing (Born, 2013, p. 1). Conversely, Ulrich's theory of positive distraction advocated that incorporating soothing sounds (e.g., music, bird song, and water bodies) into hospital design would alleviate stress-related outcomes (Ulrich et al., 2004; Ulrich, 1991). Similarly, the role of sound masking, for example, using music, ocean sounds and random sounds has been suggested to improve the aural quality of hospital ward design (Salandin et al., 2011).

An early study by Florence Nightingale revealed that patients had quick recovery rates from illnesses when cared for in a hospital designed with reduced sound levels (Nightingale, 1860). This shows that there has been an interest in research into hospital sound environments and their effects on a patients' recuperating process, since the 1860s (McCarthy et al., 1999). Furthermore, Florence Nightingale in the *'Notes on Nursing'* first documented and published the detrimental effect of noise on patients' therapeutic process in the 1960s. In the same book, Florence Nightingale postulated that:

> "Unnecessary noise is the cruellest absence of care that can be imposed upon sick or well". Therefore, revealing the problems of excessive noise in healthcare and its detrimental effects on patients' recuperating process, as considerably as the basic understanding of sound transmission and measurement significance in a realistic assessment of a healthcare facility sound environment (Nightingale, 1860).

Since then noise has continued to be a worldwide problem. Noise is generally defined as any unwanted sound (see Plack, 2013), and is often considered to be a stress stimulus that can produce negative psychological and physiological outcomes on individual health (Stansfeld & Matheson, 2003; Choiniere, 2010). An array of studies has shown that offensive sound is a significant barrier to sleep for hospitalized patients (Monsén & Edéll-Gustafsson, 2005; Drouot et al., 2008). Likewise, it has been postulated that excessive sound levels could prolong wound healing (Wysocki, 1996), increases annoyance rate, levels of urinary cortisol, irritability, headaches, and sensitivity to pain, as well as increases length of hospital stay (Melamed & Bruhis, 1996; Bailey & Timmons, 2005; Fife & Rappaport, 1976). Undesirable sound activates stress hormones, elevates blood pressure, increases the risk of ischemic heart disease, cardiovascular disease, and neonate defects, and can cause changes in the immune system (Passchier-Vermeer & Passchier, 2000). Similarly, studies suggest that bothersome sounds can build up tension, increase agitation and anxiety, as well as increase other negative behaviour (Short et al., 2011). Noise-induced subjective stress has been reported to affect health workers' performance and their ability to track and monitor tasks, to increase workplace accident rates and calculation errors and omissions, and cause failure to comprehend or memorize the spoken word (Juang et al., 2010; Smith, 1990).

Music psychology studies have also shown that music intervention in health care can have a positive effect on patient's emotions and recuperating processes. On the other hand, music has been used for hundreds of years to treat illnesses and restore both physical and mental harmony and has been shown to evoke positive effects on individuals, psychologically, physiologically and socially (Sendelbach et al., 2006). Although, the underlying mechanism as to why an individual respond in a certain way when exposed to music or why music could be either beneficial or harmful, is difficult to debate (Mazer, 2010b). More recently, studies attempting to measure the potential benefits of music in hospital environments, have supported the theory that certain music could be used as an effective stress management tool to enhance physical relaxation, assist in stress relief and reduce negative emotions (Labbé et al., 2007). Investigations have indicated that high priority should be given to music, because of its potential ability to invoke emotion in its listeners, referring to intense responses such as excitement and weeping (Stephanie et al., 2002). Music has always functioned as a means of shifting our emotional state, be it relaxation, excitement, arousal, or tranquillity, and it has been reported that it interacts with brain substrates that are associated with rewards and emotions (Levitin, 2006), which might also alter the way the brain processes speech or distinguishes speech sounds (Reed et al., 2014).

Interestingly, not all types of music have favourable effects, due to influencing factors such as life experience, different musical tastes, and preferences. Liu and Tan (2000) revealed that listening tastes of music on the radio differed between patients and staff, which raised the possibility that responses to music could be perceived as positive to staff and negative to patients/elderly patients (Mackrill et al., 2013b). Furthermore, it has been suggested that music generates healing spaces within a hospital setting (Dijkstra et al., 2006), which can subsequently induce positive changes on patient outcomes. Indeed, music can either distract or facilitate the performance of cognitive tasks, contingent on the type of music listened to. It is generally accepted that sound of above 85 dB(A) could cause detrimental effects on humans, equivalent to the noise of heavy truck traffic on a busy road (Berglund et al., 1999), but is also dependent on the duration of exposure. This supports the notion that loud music could lead to hearing loss (Petrescu, 2008; Figueiredo, 2011), and can negatively affect concentration levels (Dobbs et al., 2011).

Many of the existing epidemiological and psychological studies have shown that therapeutic use of music in hospitals can facilitate a patient's healing process (Brown et al., 2001), and improve mental illnesses, social cognitive performance, and communication skills (Ulfarsdottir & Erwin, 1999). Moreover, music enhances sleep quality, decreases pain and anxiety levels, relieves postoperative pain (Chaput-McGovern & Silverman, 2012), and lowers tension/heart rate (Jiang et al., 2013).

Furthermore, investigators have shown that music psychology improves patients' postoperative experience by increasing environmental noise satisfaction (Comeaux & Steele-Moses, 2013), supports cancer and cardiac patients (Bruscia et al., 2009), reduces anger and psychological problems (Castillo-Pérez et al., 2010), and enhances positive feelings in patients with severe traumatic brain injury (Glassman, 1991).

3.3 The Psychological Perspective of Music and Emotion

Drawing from a wealth of research in music psychology, music has shown to be an efficient treatment for various ailments and involves eliciting emotions by listening to music, composing music or lyrics, and performing music (Keen, 2005). As set out in Figure 3.2, investigators have used music to attempt distraction from ambient stressors including noise annoyance, and to cure individuals suffering from both psychological and physiological illnesses (Baumgartner et al., 2006; Bernatzky et al., 2004; Blood and Ferriss, 1993; Chan et al., 1998; Chapados and Levitin, 2008; de Niet et al., 2009; Enk et al., 2008; Field et al., 1998; Fox & Embrey, 1972; Fried, 1990; George et al., 2011; Grossman et al., 2001; Harmat et al., 2008; Hirokawa & Ohira, 2003; Ho et al., 2003; Karageorghis & Priest, 2012; Kim et al., 2011; Koelsch, 2005; Krout, 2007; Ladenberger-Leo, 1986; Lai & Good, 2005; Lazic & Ogilvie, 2007; Lee et al., 2005; Mammarella et al., 2007; McKinney et al., 1997; Metera & Metera, 1975; Modesti et al., 2010; Mok & Wong, 2003; Núñez et al., 2002; Pavlygina et al., 1999; Pinquart et al., 2007; Rosenkranz et al., 2007; Sand-Jecklin & Emerson, 2010; Sang et al., 2003; Siedliecki & Good, 2006; Smith et al., 2010; Tan et al., 2010), especially in the hospital environment. However, it has been shown across studies that music has a twofold effect, having potentially either a positive or negative impact on human outcomes (Pelletier, 2004). Table 3.1 provides detailed information about the findings of psychology of music and emotion.

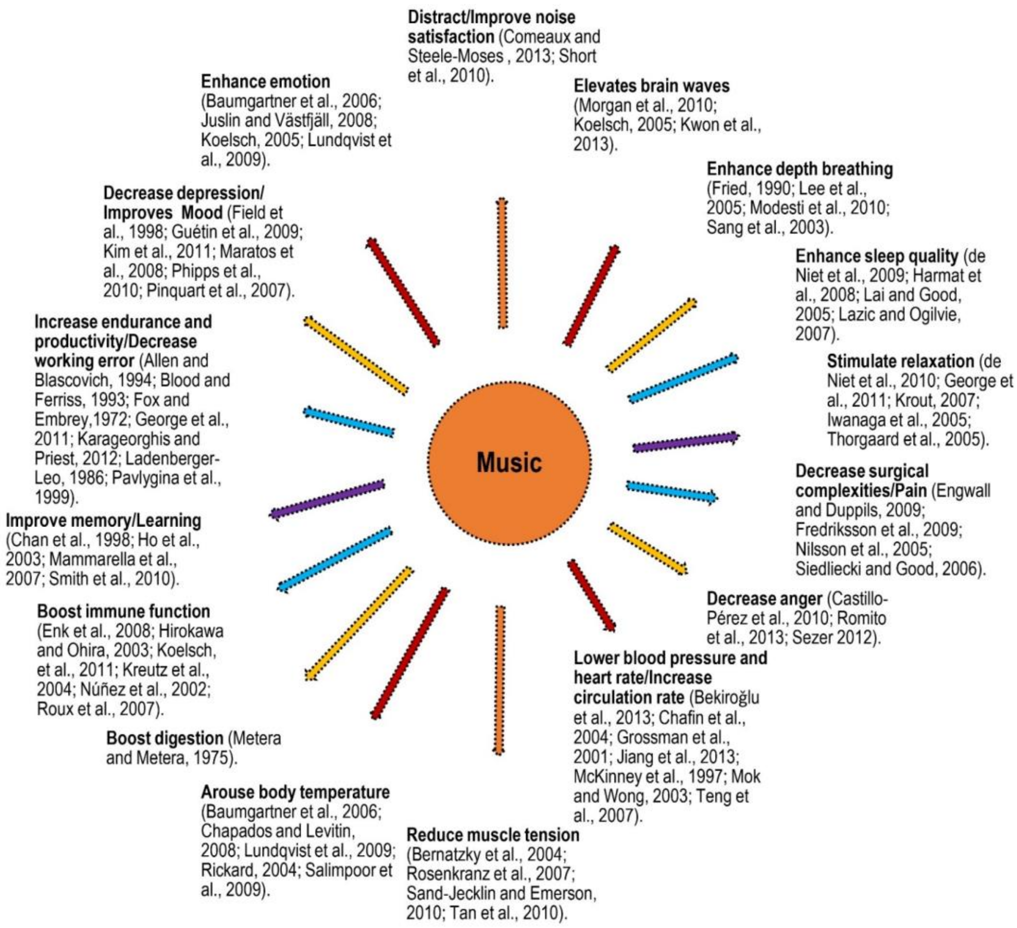


Figure 3.2. Selected positive effects of music on stress outcomes (Compiled by the author).

3.3.1 Emotional Responses to Music

Music elicits real emotional responses in the listener (Scherer & Zentner, 2001). However, the notion of musical emotions remains controversial, as investigators have so far been unable to provide a satisfactory explanation of such emotions (Juslin & Sloboda, 2011). Emotional response has been defined as an abrupt response to certain stimuli with a duration ranging from between a few seconds to minutes (Murray & Arnott, 1993). As music has become a large part of people's everyday life, much effort has been made to understand various ways in which music can evoke emotional outcomes (Gerra et al., 1988; Liljeström et al., 2013; Lundqvist et al., 2009). To understand these mechanisms, psychologists have developed models such as the

‘BRECVEM model’, which includes cognitive appraisal, episodic memory, emotional contagion, brain stem reflex, and visual imagery, as well as musical expectancy and evaluative conditioning (Juslin & Sloboda, 2011; Juslin & Västfjäll, 2008). Likewise, studies have implemented the theory of basic emotions (which employs the discrete or categorical emotion theory) and the dimensional model of emotion, also called the affective circumplex model (Ortony & Turner, 1990; Zentner & Eerola, 2010).

Furthermore, elicited and conveyed emotion in music is usually seen from three fundamental perspectives, which include self-report, physiological responses, and expressive behavior, and one or a combination of these methods have been used to investigate emotional responses to music (Peretz et al., 2008; Scherer & Zentner, 2001). Emotional experiences in listening to music differ empirically, and this includes perceived or felt emotion. Musical emotion refers both to the perceived emotion that appears to be represented, communicated or expressed by pieces of music, and to the felt emotion or emotional reactions that music induces in the listener (Evans & Schubert, 2008; Kallinen & Ravaja, 2006; Zentner et al., 2008). A variety of positive emotions can be stimulated and perceived by music, but in certain situations, there is a tendency for negative emotions to be perceived more than felt (i.e., scary music may be perceived as negative, but felt as positive). This gives the notion that sad and scary music is likely to strike a listener in a positive way (Kawakami et al., 2013; Kallinen & Ravaja, 2006). For example, one study has demonstrated that after listening to a short piece of music, participants were likely to interpret a neutral expression as either happy or sad, depending on the tone of the music they had been listening to (Logeswaran & Bhattacharya, 2009). It has been shown that any stimuli that are pleasant (e.g., music), can induce a positive effect that may lead to improved performance on cognitive tasks (Thompson et al., 2001).

In recent years, neuroimaging studies on music and emotions have been attempting to understand the underlying neural mechanisms facilitating these positive effects in humans (Koelsch, 2014). The majority of these studies have shown that listening to enjoyable music triggers an interrelated system of subcortical and cortical areas of the brain. This includes the ventral striatum, nucleus accumbens, amygdala, insula, hippocampus, hypothalamus, ventral tegmental area, anterior cingulate, orbitofrontal cortex and ventral medial prefrontal cortex (Blood & Zatorre, 2001; Brown et al., 2004; Koelsch et al., 2006; Menon & Levitin, 2005). Indeed, listening to a particular kind of music can create a positive and profound emotional experience, which in turn leads to secretion of immune-boosting hormones and decreases levels of the stress-related hormone cortisol (Kreutz et al., 2004; Kuhn, 2002; Roux, 2007). In addition, studies have shown music application to be effective in eliciting positive emotions in individuals with autism and patients who require extended stays in hospital (Heaton, 2009; Robb, 2000).

3.3.2 Musical Auditory Pathways

The primary auditory pathway begins with auditory receptors in the inner ear, which lead to the cochlear nucleus, the superior olive, the inferior colliculus, the medial geniculate nucleus, and finally on to the auditory cortex (see Deutsch, 1999). Similarly, the human brain can dynamically adjust to a changing environment or to different sensory channels, supporting the notion that human brains are predisposed by design to the information processing elicited through music (Van den Stock et al., 2009; Wu et al., 2013). In response to music, complex spectral and temporal patterns, including their activities help activate the brain and bind the senses, affecting our perceptual experience (Kraus & Chandrasekaran, 2010). Studies have shown that musical training can change the brain's anatomical structures. For an instant, in the improvement of short-term spatial-temporal learning and in the functional magnetic resonance imaging of musicians (Herholz & Zatorre, 2012; Hyde et al., 2009).

More recently, functional neuroimaging studies on music and emotion suggests that music can modulate activity in brain structures that are known to be crucially involved in emotion, (see Figure 3.3) such as the amygdala, nucleus accumbens, hypothalamus, hippocampus, insula, cingulate cortex and orbitofrontal cortex (Gosselin et al., 2007; Koelsch, 2014, 2010). For instance, surveys have demonstrated that listening to music activates parts of the motor cortex, even when a stroke patient is lying fixed in a scanner and unable to move (Chen et al., 2008; Meister et al., 2004). Studies have shown that listening to music has a notable ability to affect a large number of distinct brain regions specialized for auditory processing, rhythm and motor coordination, arousal regulation, emotions and pleasure, and cognitive processing, including tempo, timbre, and pitch (Levitin & Tirovolas, 2009; Peretz & Zatorre, 2005; Trainor & Schmidt, 2003).

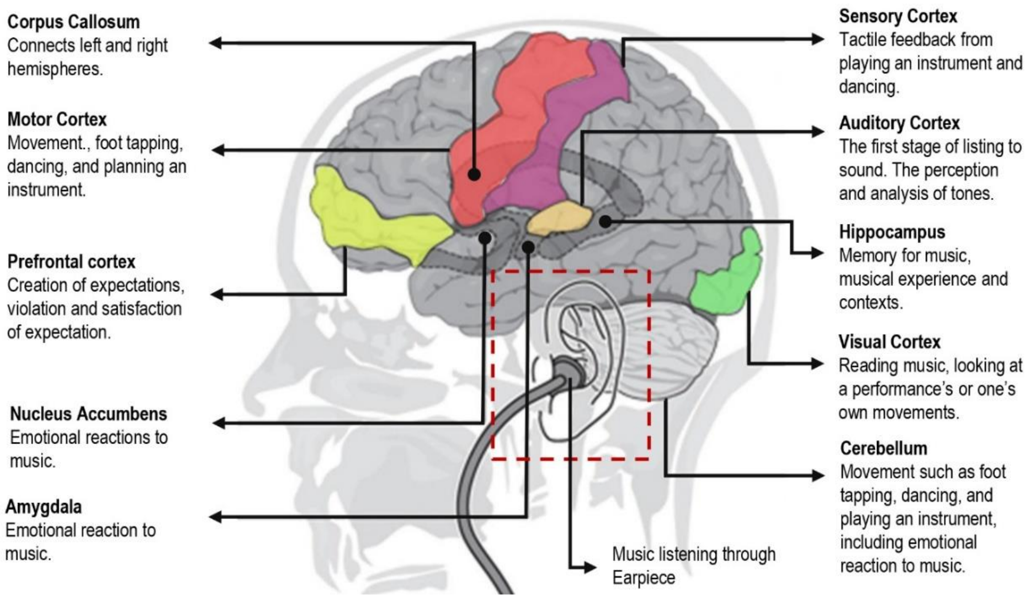


Figure 3.3. Musical perception effect on different part of the brain (adapted from Levitin, 2006).

Research into the interaction between music and the brain (e.g., functional imaging, electroencephalography, and positron emission tomography), has proved that the human brain changes in response to experiences, and is fundamentally a plastic organ (Seppänen et al., 2012; Wan & Schlaug, 2010; Zatorre, 2013), and is currently attracting interest from a vast array of disciplines. Thus, Wan & Schlaug (2010) defined plasticity as a fundamental organizational feature of human brain function. Johansson (2006) argued that attentive listening to music for as little as three hours could temporarily alter the auditory cortex. Pape et al. (2014) advocated that active listening to tailor-made notched music induces greater neuroplasticity changes in the maladaptive reorganized cortical network of tinnitus patients while additional integration of other sensory modalities during training reduces these neuroplasticity effects. Grapp et al. (2013) found that listening to music at the initial stage of tinnitus can make a significant contribution towards preventing it from becoming a chronic condition. Similarly, music has the ability to influence the neurochemical balance of the central and peripheral nervous system, modulating bodily and emotional arousal (Chanda & Levitin, 2013; Rickard, 2004; Salimpoor et al., 2009). Specifically, researchers have acknowledged that music has the ability to positively influence the treatment of various disorders, such as enhanced auditory hallucinations (Zarghami et al., 2012), working memory in children with cochlear implants (Torppa et al., 2014), and social skills in children with autism (LaGasse, 2014).

3.3.3 Music and Locus of Control

Locus of control as a principle was originated by Julian Rotter in 1954 (Rotter, 1954), to describe how an individual viewed their relationship to their environment and has since been extended to include the extent to which people believe they can control events affecting them. Likewise, social learning theorists have proposed that an internal locus of control is connected to better psychologically adjusted persons while an external locus of control is associated with maladjustment (Schubert, 1996; Rotter, 1990; Rotter et al., 1972). Many measures of locus of control have appeared since Rotter's scale. One such study supporting this trait (Bryant, 1989), advocates that people evaluate their control over events and over feelings separately with regard to both positive and negative experiences.

Similarly, locus of control has been linked to a patient's recovery, health behavior, and well-being (Steptoe & Wardle, 2001; Tokuda et al., 2007; Wallston, 2005). Additionally, critically ill patients might experience a lack of control due to physical, psychological (self-efficacy, anxiety distrusts, depression, risk aversion, and future time perspective), and demographic (age, sex, marital status, and education) variables that restrict their activities or lifestyle (Brincks et al., 2010; Jacobs-Lawson et al., 2011). Interestingly, Freeman et al. (2006) suggest the application of prescriptive harp music for dying patients, who have discovered they have little control left over their lives and choices and found that it enables them to cope better and gives them emotional strength. James (1988) explored the effects of music listening on adolescents who were chemically dependent and found that analysis of lyrics improved the participants' internal locus of control, as it permitted adolescents to develop a positive, and healthy attitude toward themselves. A similar study by Silverman (2010) evaluated the effects of the analysis of lyrics for withdrawal symptoms and locus of control in patients who were in a detoxification unit, and noted that the experimental group that listens to music had lower withdrawal and a higher external locus of control scores than the control group that did not listen to music. Likewise, Kwon et al. (2013) studied the effect of group music intervention on brain waves, behavior, and cognitive function among patients with chronic schizophrenia and observed that the experimental group experienced higher emotional satisfaction, improved cognitive function, more positive behavior and less negative behavior than the control group. On the other hand, Ceccato et al. (2006) looked into the potential effects of specific musical training protocols on certain components of attention and memory in schizophrenic patients and remarked that the memory and life skills of the experimental group improved significantly more than the control group.

Table 3.1. Selected studies that highlight the psychological perspective of music and emotion

Theme	Selected references	Main emotional component outcome(s)	Result on health-related outcome(s)
Emotional responses to music	Evans and Schubert (2008); Juslin and Västfjäll (2008); Kallinen and Ravaja (2006); Kawakami et al. (2013); Liljeström et al. (2013); Lundqvist et al. (2009); Murray and Arnott (1993); Peretz et al. (2008); Rawlings and Leow (2008); Sandstrom et al. (2013); Waterman (1996); Zentner and Eerola (2010); Zentner et al. (2008)	Listening to music elicits real emotional responses in the listener	Listening to music elicits emotion that makes people feel happy, sad, and scared, neutral, including calmness, peacefulness, excitement, weeping, laughing, as shown by physiological responses, expressive behavior, observation, and self-reports.
	Blood & Zatorre (2001); Brown et al. (2004); Gerra et al. (1988); Koelsch (2014); Koelsch et al. (2006); Menon & Levitin (2005); Thompson et al. (2001)	Listening to music activates the brain regions that triggers positive feelings	Music correlates with activity in some brain regions and has been reported by previous researches to trigger an interrelated system of subcortical and cortical areas of the brain, including the ventral striatum, nucleus accumbens (NAc), amygdala, insula, hippocampus, hypothalamus, ventral tegmental area (VTA), anterior cingulate, orbitofrontal cortex and ventral medial prefrontal cortex
	Bekiroğlu et al. (2013); Chafin et al. (2004); Jiang et al. (2013); Kreutz et al. (2004); Kuhn (2002); Roux (2007); Teng et al. (2007)	Listening to music evokes positive psychophysiology responses	Music listening may produce physiological responses similar to those presented in other emotional stimuli, including changes in heart rate, secretion of immune-promoting hormones, decreased levels of the

			stress-related hormone cortisol; and facilitate blood pressure recovery from stress
Musical auditory pathways	Grapp et al. (2013); Pape et al. (2014); Torppa et al. (2014); Zarghami et al. (2012)	Listening to musical sound improves auditory processing disorders	Musical perception can positively influence the treatment of several disorders, such as at the initial stage of tinnitus, reduce the tendency of it becoming chronic, improve auditory hallucination and working memory of individuals with cochlear implants
	Chanda & Levitin (2013); Chen et al. (2008); Gosselin et al. (2007); Herholz & Zatorre (2012); Hyde et al. (2009); Koelsch (2010); Kraus & Chandrasekaran (2010); Levitin & Tirovolas (2009); Meister et al. (2004); Peretz & Zatorre (2005); Rickard (2004); Salimpoor et al. (2009); Seppänen et al. (2012); Van den Stock et al. (2009); Wu et al. (2013); Zatorre, (2013)	Neurophysiological (neuroplasticity) and behavioral changes of the brain to music perception	Music-evoked emotions can modulate activity in the brain regions specialized for modulating bodily and emotional arousal, synchronization of neural activity, initiation, generation, detection, maintenance, cognitive and auditory processing, arousal regulation, rhythm and motor coordination, termination of emotions, focusing and regaining of bodily function due to stroke or brain trauma, enhancing body language and improving short-term spatial-temporal learning
Music and locus of control	Bryant (1989); Rotter (1990, 1954); Rotter et al. (1972); Schubert (1996)	Emotional control over events or feelings	Listeners attempt to control or regulate their own emotional responses to perceived music, e.g., with respect to the extent to which they evaluate their control over events and feelings affecting them in a certain context. Experiences and feelings are often evaluated as either positive or negative, however, positive emotions (internal locus of control) are more generally conveyed than negative emotions (external locus of control)

Brincks et al. (2010); Jacobs-Lawson et al. (2011); Steptoe & Wardle (2001); Tokuda et al. (2007); Wallston (2005)	Health locus of control	Locus of control has been linked to patient's recovery, health behavior, and well-being. Health-related (chronic illness, aging), psychological (self-efficacy, anxiety distrustfulness, depression, risk aversion, and future time perspective), and demographic (age, sex, marital status, and education) variables might affect or restrict patients' health locus of control
Ceccato et al. (2006); Freeman et al. (2006); James (1988); Kwon et al. (2013); Silverman (2010)	Listening to music regulates emotion to evaluate control over events or feelings	Listeners with a strong internal locus of control tended to have experienced higher emotional satisfaction, coped better, and had higher ratings of willingness to participate in social activities, showed improved analysis of lyrics, developed a positive and healthy attitude or behavior, improved cognitive function, less negative behavior, improved memory and skills in individuals with abnormal social behavior

3.4 Music as a Complementary Medicine for Improving Health Care

Music as a medicine may be described in several ways, such that the use of it does not change. Indeed, the primary thought of practicing music medicine is to gain from the healing aspects of music. Conversely, Stanczyk (2011) reported that the music medicine approach uses music to address physical, emotional, cognitive, and social needs of patients of all ages and abilities. This indicates that music medicine interventions can be designed to influence our auditory environment (Rubert et al. 2007), promote wellness, manage stress, alleviate pain, express feelings, enhance memory, improve communication, and promote physical rehabilitation (Stanczyk, 2011). For example, from both a therapeutic and ethical point of view, Thorgaard (2013) recommended that music should be implemented into clinical praxis to improve patient well-being. Therefore, it seems that music can be used as a healing tool for the improvement of patient care within the hospital environment (Table 3.2).

Music and Mental Health Care

Music as an adjunct to traditional medicine for the treatment of those with mental health needs has been supported by evidence to be an effective intervention for promoting mental illness (Edwards, 2006). A systematic review and meta-analysis have demonstrated that music is effective for the management of behavioural and psychological symptoms of dementia patients (Ueda et al., 2013). Likewise, a survey conducted on three psychiatric wards in the Netherlands using two fundamental interventions involving ‘stimulus control’ and ‘music-assisted relaxation’, strongly recommended ‘music-assisted relaxation’ to mental health nurses for the enhancement of sleep quality for psychiatric inpatients. However, there were no significant findings ascertained for ‘stimulus control’ (de Niet et al., 2010). Research in music psychology has shown that music is not solely an object for entertainment or a cultural phenomenon but possesses the ability to cure psychiatric disorders (Solanki et al., 2013), including dementia, although more scientific investigation is still needed to validate these postulations (Hakvoort & Bogaerts, 2013). Music played on the Ney (traditional Turkish flute) has been demonstrated to have the ability to decrease anger and other psychological symptoms (Sezer, 2012). Further studies support the notion that music has the ability to calm the state of anger and accordingly delivers positive health benefits that might modulate anger and evoke physiological arousal resulting in improved positive emotions (Sharman & Dingle, 2015). In addition, research has reported that popular music such as 'techno-music' significantly increased heart rate and systolic blood pressure and significantly induced changes in self-rated emotional states. Whilst classical music elevated endorphin and cortisol levels, including improvement in emotional state, no meaningful changes were found in hormonal concentrations (Guétin et al., 2009). Research in the psychology of music has established that listening to music changes the brain chemistry and brings about positive health results. Thaut et al. (2009) found that the rhythmically organized coding of sound (e.g., music) over time, stimulates the rhythmic neural synchronization required to process information in the brain. Neuroscience research workers have also identified that music can alter brain wave electroencephalography oscillations (Kwon et al., 2013). Similarly, Birbaumer et al.'s (1996) experiment on musically sophisticated and less sophisticated subjects revealed that sophisticated subjects who favoured classical music demonstrated a higher level of electroencephalography dimensions than the less sophisticated group who reported a decrease in brain wave complexity due to rhythmical weak and chaotic music. Morgan et al. (2010) concluded that listening to music when the eyes are closed can significantly decrease delta, alpha and beta waves in patients with acute psychotic episodes, compared to resting condition when the eyes are shut.

Music, Pain, and Anxiety

Pain, stress, and anxiety are often connected to music, particularly for patients in surgical situations. Moreover, well-documented effects of music interventions have been found to be the reduction of pain thresholds such as pain and anxiety, neuropathic pain, pain in palliative care patients, cancer pain and postoperative surgical pain (Allred et al., 2010; Engwall & Duppils, 2009; Gutgsell et al., 2013; Huang et al., 2010; Korhan et al., 2014). Similarly, a study has demonstrated that listening to soft instrumental music in the first 3 hours of the active phase of labour decreases both anxiety and the level of pain (Phumdoung et al., 2003). This contradicts Ajori et al.'s (2013) findings that listening to fast music at any time, except during 1st, 4th and 5th hours of the active phase of labour, decreased pain and duration of labour in the music group. Furthermore, a study concluded that when patients listened to music in the emergency department, it resulted in a decreased pain and anxiety score and an increased satisfaction score (Parlar et al., 2015). Music listening interventions have been encouraged for reduction of anxiety before, during and after surgical procedures (Bradt et al., 2013; Cepeda et al., 2006; Chang & Chen, 2005; Gillen et al., 2008). Hamel (2001) explored the effect of music listening on anxiety levels, including heart rate and arterial blood pressure in patients undergoing cardiac catheterization and revealed that control group demonstrated a statistically significant increase in blood pressure and pulse rate, whilst the test group demonstrated a decrease. A similar study by Lepage et al. (2001) concluded that patients who listened to music throughout spinal anaesthesia required less sedation to achieve a level of relaxation when matched with control group who did not.

Music and Stress

Listening to relaxing music decreases stress and anxiety, and reduces cortisol levels, heart rate, and blood pressure in people across all ages (Knight & Rickard, 2001; Pelletier, 2004; Tansik & Routhieaux, 1999). Music interventions have also been shown to reduce cortisol levels before, during and after invasive surgical procedures (Nilsson et al., 2005). Research has shown that listening to self-select or classical music after exposure to stress-associated problems, meaningfully decreases negative emotional states and physiological arousal compared to listening to heavy metal music or sitting in silence (Labbé et al., 2007). Similarly, a randomized controlled trial that assessed the effects of music on immune markers of stress among nurses who had been assigned to either stimulating music, sedating music or rest groups for 30 minutes found that music of different tempo had little effect on the mean arterial pressure of the stimulating music group when matched to the sedating music group (Lai et al., 2013). A study conducted by Iwanaga et al. (2005) discovered that both 'Sedative Music' and no music accelerated high relaxation and low tension. Moreover, the results show that 'Excitative Music' reduced perceived tension and amplified relaxation sensitivity. In the same study, the authors articulated that 'Excitative Music' lessened the activation of the parasympathetic nervous system. A similar study by Phipps et al. (2010) found music as an effective medicine for reducing heart rate, respiration rate, perceived anxiety, depression, negative mood and the emotional burden of patients admitted in a neuroscience unit.

Music and Stroke

Studies have revealed that listening to favourite music for a couple of hours each day had the effect of improving verbal memory and focusing attention, as well as significantly decreasing depression in patients with middle cerebral artery stroke compared to patients who received no musical stimulation, or who listened only to stories read out loud (Särkämö et al., 2014, 2008). Similarly, another study showed that compared to non-amusic stroke patients, amusic stroke patients performed poorer on a simple auditory reaction time test and had reduced P3a responses to novel sounds, revealing deficits in orienting of attention. Results further revealed decreased P3b in both patient groups reflecting deficits of generic rather than music-specific cognitive processes as the underlying cause (Münte et al., 1998). Moreover, researchers have shown the effects of rhythmic cueing on stride symmetry, gait velocity, weight bearing on the paretic leg, knee angle control, including increased motion and flexibility, positive moods, frequency and quality of interpersonal relationships (Jeong & Kim, 2007), as well as improved intelligibility and naturalness of speech in patients with aphasia (Johansson, 2011).

Music and Ambient Sound

Music has the ability to distract from hospital noise, thereby reducing emotional anxiety, pain, and make staff feel calmer and more effective in operating rooms (Ullmann et al., 2008). Research has likewise indicated that patients who listened to music after cardiac surgery reported lower levels of noise annoyance, heart rate, and systolic blood pressure (Byers & Smyth, 1997). Additionally, Cutshall et al. (2011) found that listening to comforting music and sounds of nature during post-operative cardiac surgery significantly increased patient's experience and reduced levels of pain and anxiety. Similar research by Comeaux & Steele-Moses (2013) reported that listening to a non-lyrical low decibel (less than 60 decibels) music reduced levels of postoperative pain and enhanced white/environmental noise satisfaction. Likewise, studies that measured patients' and staff perceptions of designed music played through ceiling speakers in five post-anaesthesia recovering care units demonstrated that the majority of staff and patients experienced reduced noise level, a less distressing environment and felt a degree of satisfaction during the period that music was played (Thorgaard et al., 2005). A study of patients undergoing urological surgery reported that music played intraoperatively, decreased Propofol requirements and at the same time rendered operation room noise unnoticeable (Ayoub et al. 2005). This supports the notion that music played at a low level and aided by hearing protection improves sound level satisfaction in the operating room (Chen et al. 2012). Short et al. (2010) concluded that music might render emergency department noise unnoticeable and suggested that further research is needed to validate the results obtained. This supports the opinion that music has the potential to enhance the environment of patients recovering from an operation (Fredriksson et al., 2009). Studies have found that music intervention with noise control could contribute to improved perceptions of noise experience and lower noise-induced stress (Cabrera & Lee, 2000; Shertzer & Keck, 2001).

Music and Cancer

Music interventions have a positive impact on acute pain, anxiety, and mood, as well as quality of life in cancer patients (Archie et al., 2013). Researchers have attributed music as being an effective instrument for supporting patients recovering from cancer surgery (Stanczyk, 2011; Romito et al., 2013). Music listening has also shown to be effective for rehabilitating anthracycline-treated breast cancer survivors/patients when played regularly over a long period, however, further research is needed to ascertain whether long-term music interventions can support autonomic function after music treatment is discontinued (Chuang et al., 2011).

Music and Parkinsons Disease

Research has demonstrated that music interventions improve motor function, speech production, and emotional symptoms in patients with Parkinson's disease (Pacchetti et al., 2000; Pohl et al., 2013). Studies have found rhythmic auditory stimulation to be significantly effective in enhancing motor control for speech, gait velocity, stride length, and cadence in Parkinson's patients (McIntosh et al., 1997; Thaut et al., 1996).

Table 3.2. Selected studies on music as a complementary medicine for improving health care

Theme	Selected references	Main measured outcome(s)	Result on health-related outcome(s)
Music and mental health	Ueda et al. (2013)	Behavioural and psychological symptoms of dementia (BPSD), cognitive function, and activities of daily living	Music reduced anxiety, depression and positively influenced BPSD in patients with dementia
	de Niet et al. (2010)	Psychiatric and sleep quality: Psychotic, mood or anxiety disorders	Music showed a significant improvement of sleep quality in psychiatric inpatients
	Solanki et al. (2013)	Patients' with psychiatric disorders	Music is beneficial for the treatment of psychiatric disorders
	Guétin et al. (2009)	Mood, anxiety, and depression in institutionalized patients with traumatic brain injury	Enhanced mood, lowered anxiety/depression and elevated endorphin and cortisol levels.
	Hakvoort & Bogaerts (2013)	Forensic psychiatric problems	Improved emotions, cognitions, attunement, relaxation and positive behavioural change of forensic psychiatric patients
	Kwon et al. (2013)	Brain waves, behavior, and cognitive function among patients with chronic schizophrenia	Improved emotional relaxation, cognitive processing abilities, and positive behavioural changes
	Morgan et al. (2010)	Compared two scenarios of brain wave functioning by (qEEG): when eyes are closed resting and eyes closed listening to music	Acute psychotic episode subjects reported decreased delta, alpha and beta waves in listening condition compared to resting condition
Music, pain, and anxiety	Korhan et al. (2014)	Pain intensity in patients with neuropathic pain	Classical Turkish Music diminished pain intensity
	Gutgsell et al. (2013)	Pain in palliative care patients	Music significantly reduced pain
	Huang et al. (2010)	Sedative music listening on cancer and cancer pain (distress)	Control group cancer pain demonstrated a significant reduction in pain as compared to analgesics alone
	Engwall & Duppils (2009)	Postoperative pain	Intervention groups reported significant relief of postoperative pain
	Allred et al. (2010)	Observed if listening to music or having a quiet rest period before and after a total knee arthroplasty surgical procedure can reduce pain and anxiety in patients	Results showed that music listening and a quiet rest period intervention decreased pain and anxiety in patients
	Ajori et al. (2013)	Evaluated whether listening to fast music could reduce pain and duration of labour	Fast Music Group reported decreased pain and duration of labour than Control Group
	Parlar et al. (2015)	Pain, anxiety, and patient's emergency department satisfaction	Results showed lowered pain and anxiety and improved satisfaction
	Bradt et al. (2013); Cepeda et al. (2006); Chang & Chen (2005); Gillen et al. (2008); Hamel (2001); Lepage et al. (2001)	Music listening interventions for reducing preoperative anxiety in surgical patients/adult patient's in healthcare	Music listening during and after surgical procedures may have a profound effect in reducing psychological parameters associated with preoperative anxiety and stress in patients, including sedative requirements during spinal anaesthesia, and improving the level of satisfaction during caesarean

			procedures
Music and stress	Knight & Rickard (2001); Pelletier (2004)	Music listening on physiological response to stress and arousal (e.g., subjective anxiety, heart rate, blood pressure, cortisol, and salivary IgA)	Showed to be an effective anxiolytic treatment for assisting relaxation and reducing stress-induced effects, including subjective anxiety, systolic blood pressure, and heart rate
	Nilsson et al. (2005)	Music listening on patient’s stress and immune response during and after general anaesthesia	Intraoperative music reduced postoperative pain, whilst postoperative music reduced stress/anxiety, pain and morphine intake
	Tansik & Routhieaux (1999)	Music listening on stress/anxiety of individuals waiting for their surgery patients in a surgery waiting room	Self-reported results showed decreased stress and increased relaxation in comparison to times when no music was used
	Lai et al. (2013)	Music and quiet rest on heart rate, mean arterial pressure, interleukin-6 (IL-6), tumour necrosis factor-α (TNF-α), interleukin-10 (IL-10)	Healthcare workers in the music group had significantly higher mean arterial pressure levels than the sedating music group
	Phipps et al. (2010)	Music listening blood pressure, heart rate, respiration, peripheral skin temperature, pain perception, and mood states	Results showed reduced heart rate, respiration rate anxiety, depression, and emotional burden in the treatment group
Music and stroke	Särkämö et al. (2014; 2008)	Music listening effect on patients with middle cerebral artery stroke	Listening to music on a daily basis, enhanced cognitive behavioural recovery, improved mood, decreased depression and induced fine-grained neuroanatomical changes in the recovering brain
	Jeong & Kim (2007)	Music listening effect on stroke survivors recruited from a community health centre	The experimental group showed improved motion and flexibility, had more positive moods, and reported increased frequency and quality of life
Music and ambient sound	Cutshall et al. (2011)	Efficacy and feasibility of music, and nature sounds on pain and anxiety in postoperative cardiovascular surgery patients	Music group reported decreased pain, anxiety and increased relaxation and overall satisfaction
	Comeaux & Steele-Moses (2013)	Music listening on patient's postoperative state anxiety, pain and noise perception	Results showed improved experience, decreased pain and improved white noise satisfaction
	Byers & Smyth (1997)	Music listening on noise annoyance, heart rate, and blood pressure in cardiac surgery patients	Patients reported lowered levels of noise annoyance, heart rate, and systolic blood pressure during music listening
	Thorgaard et al. (2005)	Patients and staff opinion of a designed music environment on anaesthesia recovering in postaesthesia care units	Results confirmed reduced sound level and less distressing environment
	Ayoub et al. (2005)	Intraoperative music on patients undergoing urological procedures with spinal anaesthesia (Spinal surgery/propofol sedation)	Intraoperative music decreased propofol sedation requirements in patients who undergo urological surgery under spinal anaesthesia

	Chen et al. (2012)	Full-shift noise exposure perception in hospital operating rooms	Low level music and hearing protection improved noise levels
	Short et al. (2010)	Patients perception of noise stress and noise annoyance (stress) in a hospital emergency department	Music listening through headphones distracted and reduced emergency department noise-stress
	Fredriksson et al. (2009)	Patients perception of music versus ordinary sound in a post-aesthesia care unit	Listening to music to improved environment sound perception and patient's experiences
	Shertzer & Keck (2001)	Music listening on patient's postoperative pain experience during post-anaesthesia care stay	Post-anaesthesia care unit patients reported reduced pain and improved perception experiences
	Cabrera & Lee (2000)	Proposed department of sound in hospital to reduce stress (pain and anxiety) and noise	Establishing the department of sound (music) may reduce noise that trigger off stress responses
Music and cancer	Stanczyk (2011)	Music listening on cancer care	Listening to recorded or live music decreased stress, pain, anxiety level and improved mood, relaxation, and quality of life
	Romito et al. (2013)	Listening to music during breast cancer chemotherapy treatment	Listening to music lowered negative emotions (anxiety, depression, and anger) in experimental group
	Chuang et al. (2011)	Music listening on anthracycline-treated breast cancer patients	Music played regularly over a long period improved autonomic function in anthracycline-treated breast cancer patients
Music and Parkinson's disease	Pacchetti et al. (2000)	Music perception on motor and emotional functions in patients with Parkinson disease	Improved behavioural functions, motor abilities, emotional status (happiness) and quality of life
	Pohl et al. (2013)	Music listening on Parkinson disease (Ronnie Gardiner Rhythm and Music Method)	Enhanced mobility, cognition, and quality of life in intervention group patients than control group
	McIntosh et al., (1997)	Effect of rhythmic auditory stimulation on gait velocity, cadence, stride length, and symmetry in patients with idiopathic Parkinson's disease	Faster rhythmic auditory stimulation (e.g., music) enhanced brain synchronization, gait velocity, cadence, and stride length in all groups

Contradictory Arguments Concerning the Uses of Music in Health Care

There is also a growing body of research on the detrimental effect of loud noises and music on surgeons in the operating rooms, particularly among a minority of experienced surgeons. For example, the results of recent research show that surgeons attested to poorer auditory performance in the operating environment with music than in a quiet operating room or an operating room with ordinary levels of noise. The conclusion reached was that music contributes to communication difficulties in the operating room, especially in conversations involving critical information (Way et al., 2013). Similarly, Schneider and Biebuyck (1990) argued that music may distract and may make it difficult to listen to heart and breath sounds during surgical procedures. In another recent study, 57% of respondents admitted that regularly played music in the operating room might be a potential detractor in operating rooms during urological procedures (Lee et al., 2013). One earlier study reported that music could add up to 87 dB(A) or even more to already existing noise levels in the operation room (Gloag, 1980). It has been suggested that surgeons were able to effectively block out noise and music, which was likely due to the high level of concentration required for the operation of a complex surgical task (Moorthy et al., 2004). In addition, Kang et al.'s (2008) study concluded that blocking noise is more effectual than playing music in diminishing bispectral index scores during propofol sedation in a noisy operating room. Previous studies concerning music listening have shown that there was no statistically significant reduction in anxiety levels, blood pressure, respiratory rate and electro-dermal activity in patients undergoing cardiac surgical procedures (Cooke et al., 2005; Taylor-Piliae & Chair, 2002).

However, the postulation that music impairs the auditory performance of surgeons in the hospital operating room has been challenged (MacLean et al., 2013), suggesting that the methodology and data are inconsistent and misleading. They argued against such research by citing substantial works (e.g., Allen & Blascovich, 1994; Chetta, 1981; Way et al., 2013), which argued that music decreases stress, enhances concentration, can improve motor skill performance, and often diminishes patient anxiety. They concluded by promoting the use of appropriate music in operating room settings. Music is a special type of noise, which, when carefully selected has a recognized calming effect during stressful conditions. Yet, the role of music in the operating room remains controversial.

Implications for Music Clinical Design Practice

Music medicine should be considered as an initiatory step to alleviate stress, including psychological and physiological associated stress responses, as well as patients recovering from surgical pain threshold. The application of music in the context of health care appears promising as an adjunctive medicine for promoting comfort level, reducing pain, ambient stressors, and enhancing behavioural changes, including psychiatric disorders, as well as providing a level of distraction that increases environmental sound satisfaction in healthcare facilities. Healthcare practitioners and their collaborators should work towards incorporating music medicine in the routine care of patients and in treatment models to promote wellness. Health care practitioners should purposely introduce sounds such as those of birds, background music, ocean waves, rain showers in the clinical environment for both patients and staff to elicit their emotional feelings, reduce stress correlated outcomes and strengthen coping strategies.

3.5 Sound Sources and Levels in Hospital Settings

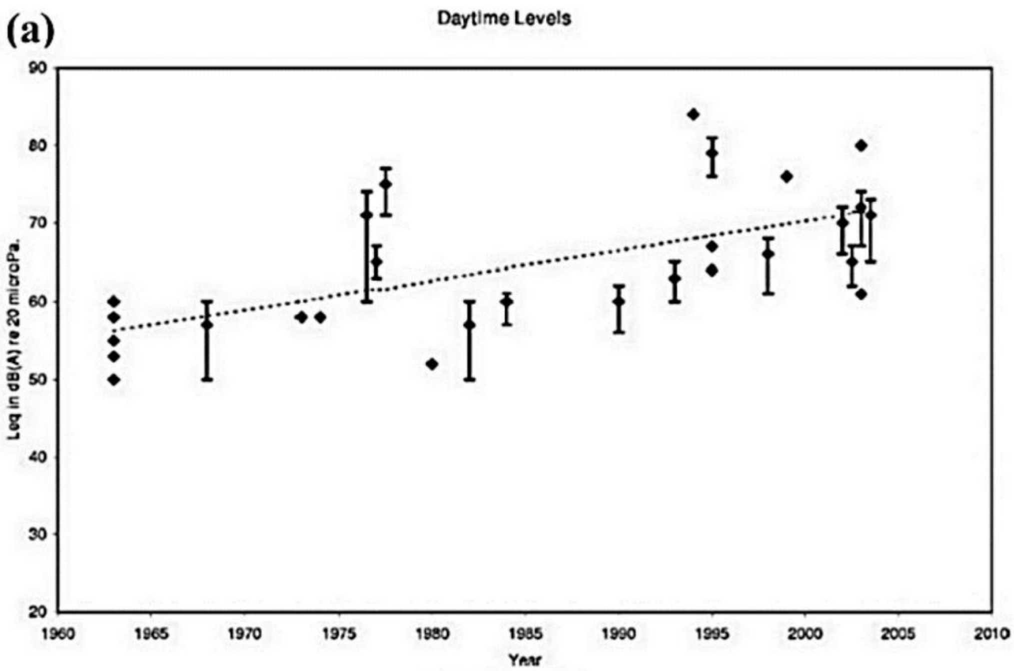
Undesirable sound experience is a major complaint among patients and staff because of diverse mechanical sounds, and a wide range of services and functional units present in these spaces (Ryherd et al., 2011). Sound pressure levels in hospital environments have increased progressively since the 1960s (see Table 3.3 and Figure 3.4), with dramatic increases of 57 – 72 dB(A) during the day and 42 – 60 dB(A) at night (Busch-Vishniac et al., 2005). These exceed the World Health Organization (WHO) guideline limits for background sound (LAeq) in wards (Berglund et al., 1999) or the UK Government department of health by around 20 – 30 dB(A) (Department of Health, 2008).

Sound that affects hospital occupants emanates from numerous sources such as low-frequency sounds from heating, ventilating, and air-conditioning (HVAC) systems (Busch-Vishniac et al., 2005) and medical audible alarms (Edworthy, 2013). Low-frequency sounds range from about 10 Hertz to 200 Hertz and are widely known as a specific environmental noise problem, especially for sensitive individuals (Leventhall, 2004).

Table 3.3. Equivalent sound pressure levels (Leq) published from 1960 – 2010 for daytime/ nighttime

Daytime/ Nighttime	Publication/ Measurement Date	Max Range of (Leq) Published in dB (A)	Average Range of Leq Published in dB (A)
Daytime	1960 – 2004	14	8
Daytime	2005 – 2010	32	27
Nighttime	1960 – 2004	12	8
Nighttime	2005 – 2010	33	28

(Adapted from Busch-Vishniac et al., 2005)



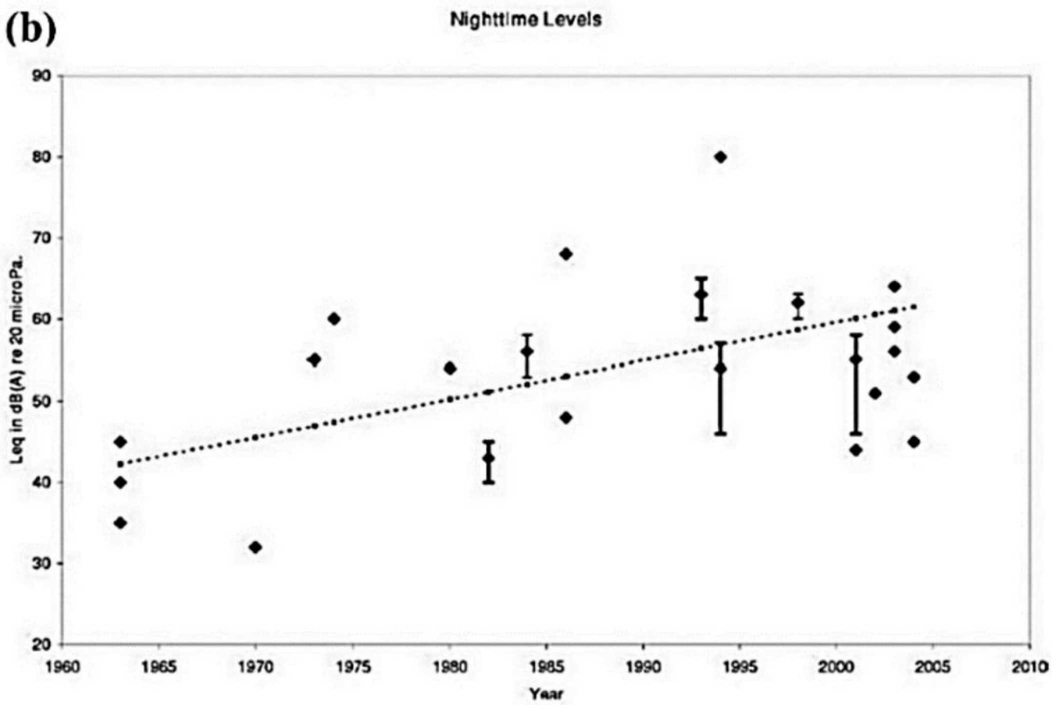


Figure 3.4. (a) Daytime level noise studies results-1960-20101; (b) Night-time level noise studies result from 1960-2010 (Busch-Vishniac et al., 2005)[2].

[1]"A-weighted equivalent sound pressure levels measured in hospitals during daytime hours as a function of the year of study publication. Error bars indicate that data were given as a range spanned by the error bar. In these cases, the data point is shown as the logarithmic average of the range extreme values" (Busch-Vishniac et al. 2005).
[2]A-weighted sound pressure levels equivalent measured in hospitals during night-time hours as a function of the year of study publication.

The detrimental effects of low-frequency sounds seem to have an impact on people and are more intolerable than other forms of sound (Berglund et al., 1996). These are of special concern because of their pervasive nature, numerous sources, and efficient propagation, which is fundamentally unhindered by conventional methods of building or ear protection (Goines & Hagler, 2007). Other sources of sound that contribute to hospital noise include paging systems, suction apparatus, heart monitor alarms, nebulizers, pulse oximeter tones, telephones, televisions and radios, banging of objects, rubbish bin and trolley sounds, intercoms, staff bleeps, and conversation (Xie et al., 2009).

Studies experimentation have revealed that the overwhelming audible monitor alarms and people talking are the two major sources of noises in hospitals, especially in the critical care wards (Xie & Kang, 2010). According to Katz (2014), extensive studies have demonstrated that noise within the operating rooms emanates from both staff and equipment in use, such as electric or air-powered surgical instruments, hammers, suction apparatus, monitors, alarms, and forced-air warming units which can build up noise as high as 120 dB(A). Additionally, another study found staff associated activities and conversation to be the main factors that contribute to noise in the operating rooms and can generate noise levels as high as 78dBA (Shankar et al., 2001). Similarly, Hasfeldt et al. (2010) categorised sources of ambient noise in the operating room environment as monitors, surgical equipment, ventilators, alarms, heat vacuum and air conditioning systems, as considerably as conversation, telephones, and pagers. In addition, an investigation in Greek hospital ICUs found the major sources of noises to be human activity, talking among the staffs and patients' family members, operating equipment and hospital building projects. The study suggested that raising the awareness and sensitivity of the staff in the ICUs could significantly minimise noise pollution (Tsiou et al., 1998).

As set out in Figure 3.5, MacKenzie and Galbrun (2007) classified noise sources in the acute care hospital wards into 30 most usual noise sources that correspond to 92% of all occurrences. The study result shows rubbish bins (13.9%), general activities (13.2%), and talking (12.3%) as the most occurrence sources of noise. There was an indication that 34% of the noise sources were completely avoidable and 28% of the noise sources identified were partially avoidable. However, the practical intervention, affected 48% of the noise sources, while staff education affected 14% of the noise sources.

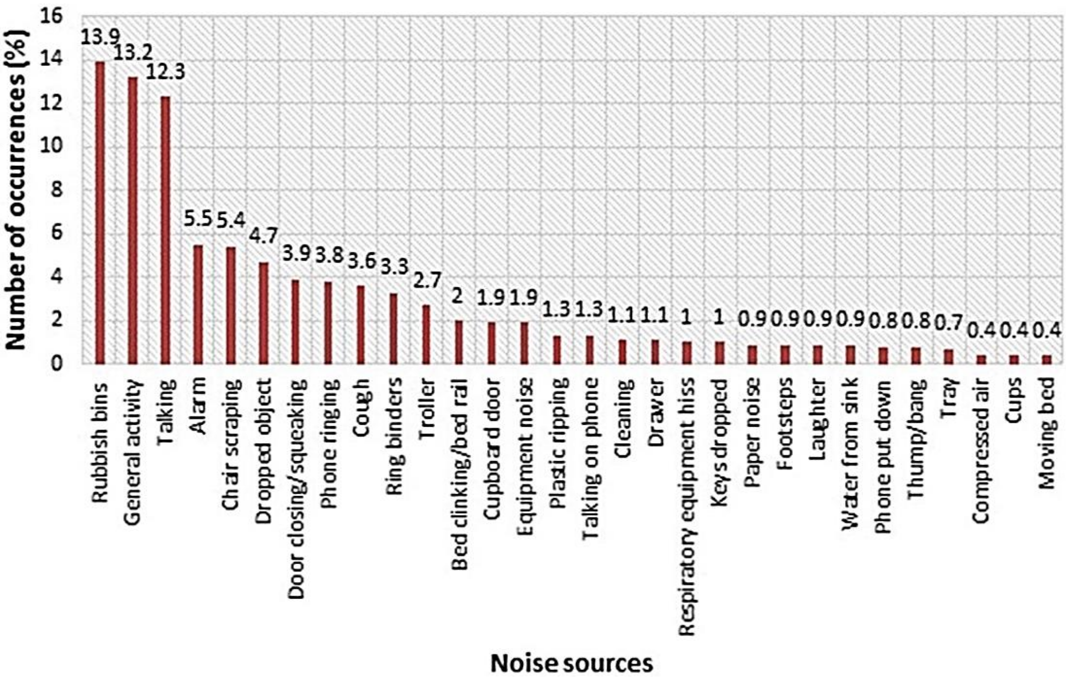


Figure 3.5. Noise source classification as a function of the number of occurrences (Adapted from MacKenzie & Galbrun, 2007).

On the other hand, Goncalves (2008) identifies traffic and air conditioning machines as the most dominate noise that has an influence on the Hospital environment and neighbouring buildings. In a critical review regarding the effective measure to reduce noise exposure on patients sleep quality, associated the major factors that contribute to noises with ventilator noise and alarm, suctioning, heart monitor alarm, nebulizer, pulse oximeter tones and alarm. In addition, other factors that contribute to noise within the healthcare include telephones in use, air conditioning, television, and radio, banging of objects, rubbish bin or trolley noises, intercom, staff bleeps, a conversation between hospital occupants (Xie et al., 2009). As designated in Figure 3.6, a survey conducted on the nurses' perception of noise sources in a cancer unit using a questionnaire and extensive acoustical measurements described HVAC noise perception by the nurses to be least bothersome noise source, and alarms as well as phones ringing, as extremely bothersome (Hsu et al., 2010).

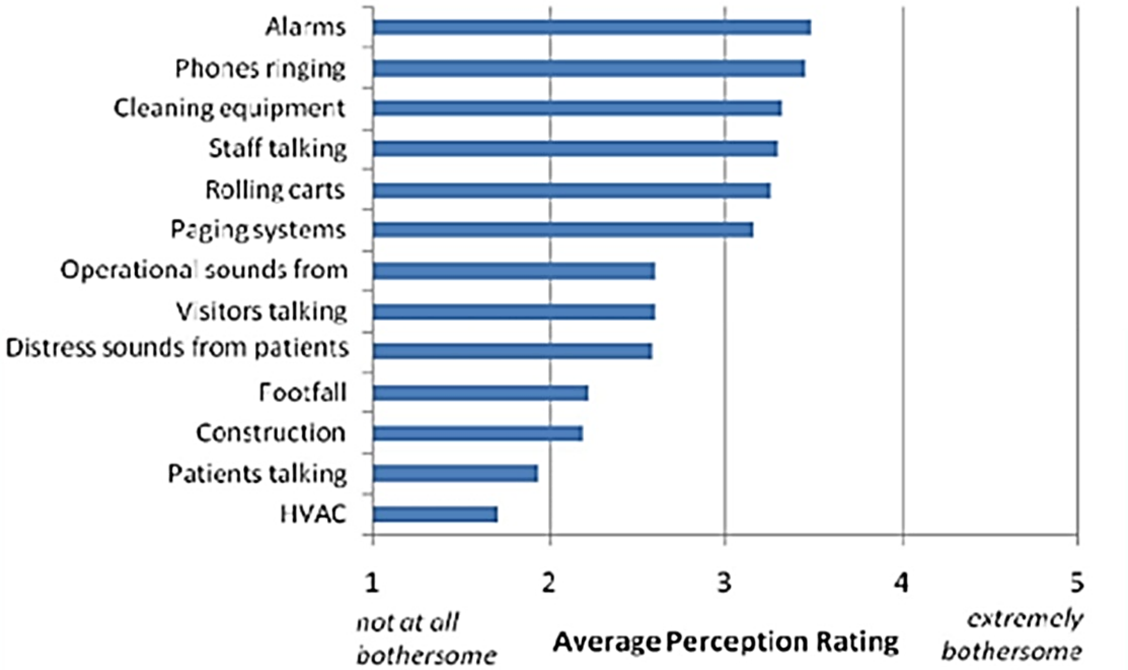


Figure 3.6. Nurse perceptual experience of different noise sources in a cancer unit (Hsu et al., 2010).

One important study has argued that besides the sound emanating from all the machines/equipment in use and hospital caregivers that are nursing and promoting patient therapeutic process, the main cause of noisy hospital environments is the built environment itself (Johnson & Thornhill, 2006). Moreover, healthcare indoor spaces and furnishings are often constructed with hard reflective materials to avoid infectious organisms and promote easy cleaning. Indeed, sound-reflecting surfaces disseminate noise from hallways within the hospital spaces and into patient rooms, inducing sounds to echo, overlap, and linger. Other sources of noise that have been being documented to be a complaint among hospital occupants are rolling equipment such as procedure carts and housekeeping dollies, moving across uncarpeted floors, metal chart holders, elevator doors and alarms (Johnson & Thornhill, 2006). In line with this augment, Taylor-Ford (2008) investigation in a medical surgical suit found that the major noise sources are opening and closing of doors, falling objects, paging system, phones, television and people talking. In the same study, personal conversation has been accounted to be one of the major noise sources that conduce high mean sound pressure levels (SPL) within the hospital environments.

Similarly, one investigation that evaluated the effect of noise in 35 ICUs through a questionnaire survey and a sound level meter, and found the common sounds to be talking 74dB(A) placed as the highest observed sound levels over others sounds including pumps, monitor alarms, phones, and footfalls (Akansel & Kaymakci, 2008). This corresponds with Dube et al (2008) findings that observed the main noise sources to be people’s voices, cart travelling in the hall, footfalls, and warning devices (e.g. cardiac monitor and pulse oximeter alarms). In correlation, an early intensive study pointed out that noise has long been placed as a major source of annoyance that can detrimentally trigger patients physiologically and psychologically responds in the hospital environments, and further classified hospital interior noise sources under mechanical equipment, operational facilities, patient service facilities, personnel activities and patients and visitors (Haldeman, 1963). In the same way, Siebein et al., (2009) reported similar sound sources that include building equipment noise, occupational sounds, medical equipment sounds, conversation sounds, and outdoor sounds. Moreover, in the same study results demonstrated that conversational noise amounts to the primary sources of noise identified, accompanied by medical equipment noise in the unit. From the works of (Akansel & Kaymakçi, 2008; Guastavino et al., 2006; and Topf, 2000) on sound classification, as set out in Figure 3.7, Mackrell et al. (2014) were able to suggest a broader classification of domineering sounds in hospital wards that falls under 12 soundscape clip stimuli. In the same study, the sound sources derived from within the 12-soundscape clip that was used for the sound sources information intervention includes blood pressure monitors beeping for patient's observations, nurse's conversation to patients about how they feel, trolleys moving equipment around the ward. As well as cleaning machines to keep the ward tidy, general bustling of the ward, patients going for treatments, phones ringing, sound of trolleys supplying food, the jingling of cups, patients talking and moving around including staff talking.

As set out in Table 3.4, Mackrill (2013) classified and documented the rank order of the most prevalent hospital sound source through the combination of investigators works (e.g. Topf, 1985; Akansel & Kaymakçi, 2008; Siebein et al., 2009) and coded the sources noises accordingly. From this classification, for clearer understanding, it is patent to support noise sources coded by Haldeman (1963) on hospital environment noise sources categorisation. Moreover, this is because most investigators ultimate concern is to understand the best approaches to mitigate sound in the hospital environment.

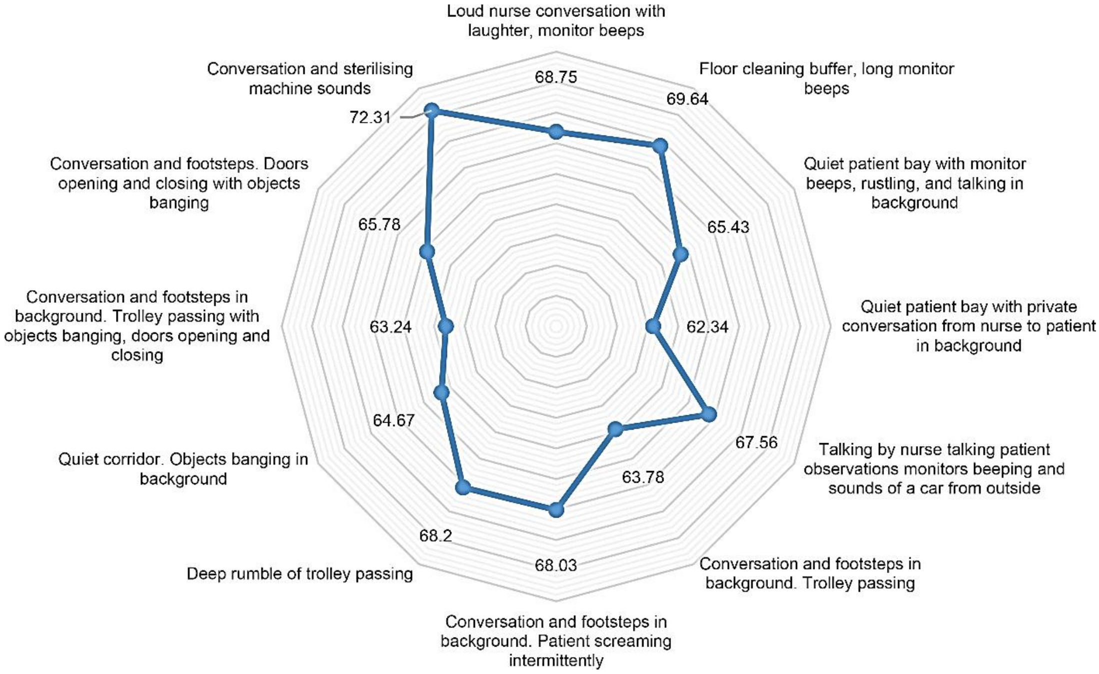


Figure 3.7. A broad classification of dominant sound in Cardiothoracic wards. Payback of the 12 soundscapes clip stimuli is in dBA (adapted from Mackrill et al., 2014).

Table 3.4. The rank order of the most prevalent sources of hospital noises as derived from the combination of (Akansel & Kaymakçi, 2008; Topf, 1985; Haldeman, 1963) and grouped under (Siebein et al., 2009) sources of noises classification

Rank order	Most prevalent hospital sound source classification and coding through the combination of investigators work	Siebein, Skelton and McCloud (2009)	
		Building equipment noise	
		Occupational sounds	
		Medical equipment sounds	
		Conversational sounds	
		Sounds from outside	
	Akansel and Kaymakçi (2008)	Topf (1985)	Haldeman (1963)
1	Noises of other patients (snoring, crying)	Loud talking in the hallway at night	Radios or television sets
2	Patients admitted from operating room into ICU	Patient sounds such as snoring, coughing, gagging, moaning	Staff talks in corridors
3	Monitor Alarms	Talking in the hallway	Other patients in distress
4	Conversation among staff	Doors opening, closing, slamming	Voice paging
5	Noise of vacuum cleaner	Falling objects such a patient charts	Talk in other patients' rooms
6	Removing garbage, medical Waste	Socialising at the nursing stations	Babies or children crying
7	Visitors	Squeaking parts on the bed or equipment	Telephones
8	Telephone ringing	Alarms or equipment	Pantry, kitchen, utility room
9	Replacement beds	Conversation between hospital personnel at bedside	Visitors' talk in corridors
10	Using X-ray equipment	Air conditioning, heating, or ventilation systems	Cleaning equipment (buckets, trash container)
11	Placing equipment in their places	Telephones	Walking in corridors
12	Staff entering or leaving ICU	Cleaning equipment such as vacuum cleaners	Foodservice (dish and tray clatter)
13	Staff wondering around	Intercom and call lights	Carts (medicine, linen, others)
14	Sudden voices	Paging systems	Toilet flushing
15	Chairs/stables replaced by working staff	Radios	Traffic noise

(Adapted from Mackrill, 2013)

3.5.1 Hospital Sound Metrics

Past exploration has utilised distinctive measurements to gauge and portray the hospital sound environment. Most present and previous research have concentrated on portraying general noise levels. Mostly reported metrics that has been used for hospital measures are Equivalent (L_{eq}), minimum (L_{min}), maximum (L_{max}), and peak (L_{peak}) sound pressure levels, which may be due to the practicality and convenience of these measures, as well as being integrated into various guidelines such as (WHO) and several other important rules of thumb. For example, L_{eq}, L_{min}, $L_{max,}$ and L_{peak} sound levels give an effective general outline of the sound environment, yet are sometimes constrained in usefulness. Furthermore, comprehensive acoustic measures, for example, the exceedance level (L_n), the reverberation time (RT), speech intelligibility (SI), and frequency analysis or noise criteria indicators of spectral have been less regularly reported in hospital research. In the hospital, intensive care units (ICU), assorted noise sources add to an intricate, changing sound environment, which calls for detailed acoustic measures to understand fully about the spectral characteristics of the sound environment, its behaviour over time and the potential to interfere with speech.

3.5.2 Sound Level Measurements in Hospitals

In previous studies, researchers have used numerous methods in sound sample or data collections on ICUs, which argues that noise levels in the ICU patient rooms have been extensively attested compared to other spaces within the hospital environments. For instance, investigators have carried out measurements in different hospital patient room, considering different characteristics including occupied and unoccupied, distance to the nurse station, as well as a number of patient beds (Meyer et al., 1994; Morrison et al., 2003).

It is commonly accepted that the previous research demonstrates a universal consistency in the placement of the sound meter, such as putting the microphone as close as possible or near the patient's head to obtain their sound perception, without compromising it with nurse’s procedures. In line with this, a study has suggested hanging off the microphone from the top of the medical tower in the patient room as a pragmatic solution to place the microphone without compromising its efficiency by nurse’s events (Ryherd et al., 2008). From several research findings, different duration has been practiced in hospital sound measurements, which varies from a few minutes to 16h, and 24h recordings most universally used in the hospital ICUs measures. A couple of intensive care unit (ICU) noise studies have continuously measured the nurses’ stations applying 24h or 16h duration of sound measurements (Dube et al., 2007; Milette, 2010).

It is also important to note that there are also differences in the sound level meter response times used. Quite a number of researchers have applied the slow reaction time (1s) suggested by Occupational Safety and Health Administration (OSHA) for typical occupational noise measurements (Williams et al, 2007). However, Ryherd et al. (2008) have applied the fast response time (0.125s) as recommended by WHO for effective capturing of sound fluctuations. Averaging intervals of 5s to 24h are often common, although the 1min averaging intervals are frequently applied in ICU noise investigations. Measurements were often analysed as a mapping of time, with daytime and night-time average sound levels commonly reported. Contrasted with weekdays that are mostly measured and reported, investigators do not frequently cover weekend's estimation duration data. The majority of hospital noise measurements have often conducted daytime and night-time duration. For example, a study applied the day and night time based on twelve-hour nurse shifts including (daytime: 7am-7pm; night-time: 7pm-7am) (Morrison et al. 2003). Similarly, another study applied the day and night-time periods based on the World Health Organization (WHO) rules of thumb (16h daytime: 7am-11pm; 8hr night-time: 11pm-7am) (MacKenzie & Galbrun, 2007).

3.6 The Psychophysiological Effect of Sounds in Clinical settings

The World Health Organization (WHO) has defined environmental noise, as a menace to public health. Studies have reported divergent outcomes connected with detrimental health effects of noise, such as impairment of hearing, interference with oral communication, sleep awaking/interruption, cardiovascular disturbances, quality of task performance, psychophysiological effects, psychiatric symptoms, fetal development, immune function, cognitive impairment, as well as negative social behaviour and annoyance reactions (Babisch, 2005). It has been generally accepted that excessive sound exposure can trigger off two different kinds of effects on health. These include non-auditory effects and auditory effects. Auditory effects of elevated sound have been conceived to include hearing impairment resulting from excessive noise exposure, whilst non-auditory effects include stress, related physiological and behavioural effects, as well as safety concerns (Stansfeld & Matheson, 2003). Basner et al (2014) supported that the mostly studied non-auditory effects of noise on health include perceived disturbance and annoyance, as well as cognitive impairment (mostly in children), sleep disturbances and cardiovascular health effects. But, several other studies have shown that noise-induced permanent hearing loss is a major factor associated with occupational noise exposure. Additionally, a number of researchers have attributed noise to be an environmental stressor that affects both the physiology and psychology of patients, their families, and the well-being of health care providers (Wallenius, 2004; Choiniere, 2010). Therefore, bothersome sound can alter memory, increase agitation, aggressive behavior, and depression or anxiety (Ryherd et al., 2008;

Short et al., 2011). Research has shown that excessive sound is a significant barrier to sleep for hospitalized patients (Persson Waye et al., 2013). Similarly, sound distracts, alters concentration, and increases fatigue, emotional exhaustion as well as burnout among patients' care teams (Joseph & Ulrich, 2007). Sound can significantly influence word identification, word recall, and performance among acutely ill inpatients on surgical hospital wards (Pope et al., 2013) and may also have a negative effect on the efficiency and safety of medical care staff (Juang et al., 2010), including patients and visitors physiological and psychological responses (Smith, 1990).

3.6.1 Sound, Stress, and Health

Hospitals can be an exceedingly stressful place, and for patients being in a hospital can be a stressful experience. Not all individuals perceive sound stimuli similarly, some may find it disturbing and others not (Jennings & Cain, 2013). Groups at risk most often cited in the literature are children, the elderly, the chronically sick, people with a hearing disability, shift workers, people with mental illness (e.g., schizophrenia or autism), and people suffering from tinnitus, as well as foetuses and neonates (Goines & Hagler, 2007). This also depends on individual differences, such as age, gender, inherited genetic defects (Van Kamp & Davies, 2013), and sensitivity or attitude to the noise source (Job, 1999; Stansfeld, 1992). Indeed, excessive amounts of noise-induced stress may lead to bodily harm (see Figure 3.8).

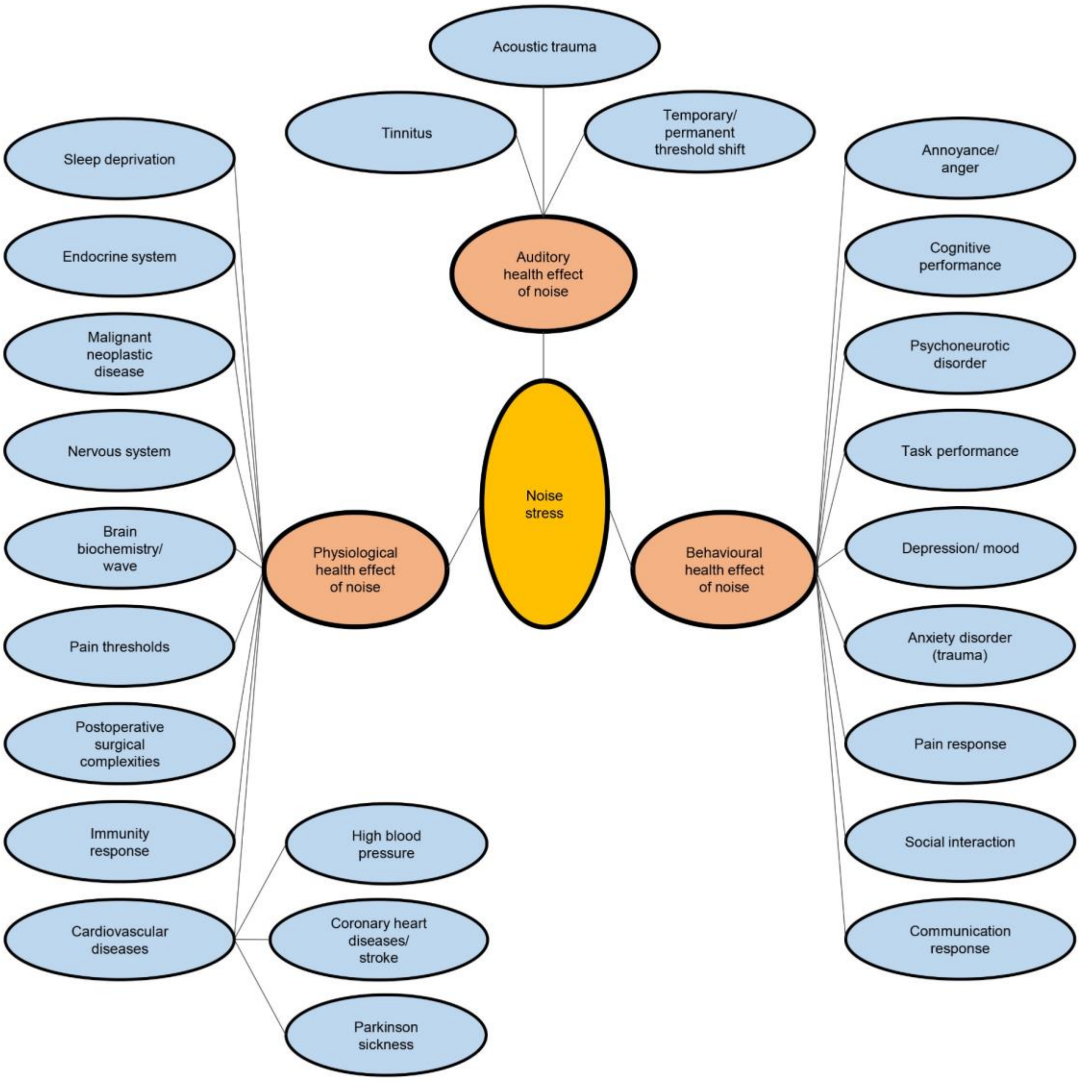


Figure 3.8. Pathways for noise-induced stressors (Compiled by the author).

In an earlier study, it was argued that sound can be objectively or subjectively stressful and both can cause annoyance (Topf, 2000; Westman & Walters, 1981). Stress has been conceived as a response to a stimulus that disturbs the physical or mental equilibrium of an individual and can be perceived as either positive or negative by an individual (Lazarus & Folkman, 1984). Indeed, psychological stress occurs when an individual perceives that environmental demands tax or exceed their adaptive capacity (Cohen et al., 2007). Perceived chronic stress may contribute to negative behavioural change, physiological and psychological responses (Schneiderman et al., 2005). Therefore, ambient stressors have been characterized as chronic environmental conditions that place an adaptive strain on individuals, yet are not urgent, but are negatively valued and are difficult to change. For example, ambient stressors include environmental noise, air pollution, crowding, and traffic (Campbell, 1983).

Conversely, Topf (2000) described stressors as events with the ability to trigger stress that includes major personal and cataclysmic events. The major cause of environmental ambient stressors in hospital settings could be associated with excessive sound, glare, and inadequate air quality (Slevin et al., 2000). Indeed, nocturnal sound activates cortisol, awakening the response and release of different stress hormones, such as corticotrophin releasing hormone (CRH) and adrenocorticotropic hormone (ACTH) (Griefahn & Robens, 2010; Spreng, 2000). Excessive sound contributes to staff stress and has an impact on health care provider's caregiving abilities (Mahmood et al., 2011). Noise-induced subjective stress triggers the levels of urinary cortisol, irritability, headaches, and sensitivity to pain (Melamed & Bruhis, 1996). Excessive sound activates stress hormones, elevates blood pressure, increases the risk of cardiovascular disease, neonate defects, and can cause changes in the immune system (Segerstrom & Miller, 2004).

Noise Effect on Auditory Systems

The auditory effects of noise incorporate hearing disability resulting from extreme noise vulnerability. The human auditory system is designed to process frequencies and intensities, at best, a range of 20 to 20000 Hz applicable to contain the sound environment of nature (Blauert, 1983). Indeed, individuals find themselves exposed to environments that dominate the human auditory system. Inordinate sound levels above 75 dB(A) could trigger off temporary threshold shift (TTS) (Melnick, 1991). Similarly, sounds of 115 dB(A) may result in permanent threshold shift (PTS) (Clark, 1991). However, hearing loss incurred is dependent on sound quality, duration of exposure, and individual susceptibility, as well as protection, age and genetic factors (Sareen & Singh, 2014). It has been shown that excessive sound levels may activate alterations in cochlear blood flow (CBF), which can contribute to increased levels of reactive oxygen species (ROS) in the cochlea (Miller et al., 2003).

Research has revealed that cancer survivors who have undergone platinum-based chemotherapy and radiotherapy to the head and neck are at higher risk of developing hearing loss or tinnitus when exposed to excessive noise (Peleva et al., 2014). Sound levels generated by high-powered tools in orthopaedic theatres have been found to exceed safety guidelines, and have the potential to lead to hearing impairment among staff and patients (Siverdeen et al., 2008). Similarly, a study has shown that the sound generated by orthopaedic surgical instruments such as saws, drills, and hammers exceeding sounds of 100dB(A) during knee replacement may cause hearing impairment among orthopaedic surgical staff (Pearlman & Sandidge, 2009). Several other investigations have shown that occupational noise among other sources of noise is associated with hearing loss problems. Moreover, research evidence has established that noise-induced hearing impairment is more vulnerable in children than in mature persons (Belojevic et al., 2003).

Noise Effect on Mental Health

Mental performance can be characterised into various sorts of reaction that includes, control activity, rapidity of reaction, learning, memorizing, or intelligence. The stages of mental performance can be categorized as sensory processes, perceptual and attentional, short-term memory, central and specific processors, and long-term memory. In all stages, there are individually determined capacity limitations, which may lead to disturbance by some intrusive factors for processing (Gamberale et al. 1990; Belojevic et al., 2003). Research evidence has demonstrated that people with existing depression and anxiety are more likely to be sensitive to the effects of environmental noise interference. Moreover, environmental noise is a menace that has been associated with physiological arousal, which sets off psychiatric disorder. Hardoy et al. (2005) concluded that high degrees of aircraft noise could heighten the danger of prolonged syndrome anxiety states such as Generalized Anxiety Disorder and Anxiety Disorder NOS, corresponding with the assumption exposure to chronic noise sustained central autonomic arousal. Similarly, one recently conducted study in Iran University of Medical Sciences concluded that neuroticism does not influence mental functioning, but reported that low-frequency noise (LFN) was associated with the heightened arousal level of participants. Moreover, extraversion has a significant influence on mental functioning (Alimohammadi et al., 2013).

Noise and Task Performance

Increased medical errors and speech interference are two potentially dangerous effects of hospital noise that has clear implications for patient safety. A research investigation has linked noise with the capability of masking pharmaceutical name recognition in the health care environment (Busch-Vishniac et al., 2005). One experimental study revealed that noise is a likely contributor to increased medical errors and poor staff retention, including poor task performance and job frustration in the healthcare environment (Morrison et al., 2003). Similarly, studies of patient safety in the hospital operating room have found that background noise may not only affect public health, but might negatively have an influence on human performance, which includes tasks such as comprehension, attention, and vigilance (Christian et al., 2006). Similarly, several controlled laboratory studies have associated noise with poor task performance, poor concentration, job dissatisfaction, irritability, fatigue, illnesses, and injuries (Kracht et al., 2007). A research conducted to determine the sound levels, staff perceptions, and patient outcomes during a year period of a hospital renovation project on the floor above a neonatal intensive care unit (NICU), indicated 89% of staff members perceived louder noise during the renovation period, and 83% reported interruptions of their work (Trickey et al., 2012).

A substantial research has shown that noise negatively affects hospital staff performance, quality of work, ability to concentrate and communicate, as well as increased rates of burnout, and reduced occupational health. Moreover, distractions resulting from noise can potentially deteriorate mental efficiency and short-term memory, including increased error rates, and fatigue generated by alarms can significantly have an effect on healthcare providers (Messingher et al., 2012). Consequently, it has been demonstrated that unwanted sound disturbs, modifies concentration, and increases exhaustion amongst patients' care providers in the intensive care unit – ICUs (Xie & Kang, 2010).

Noise and Annoyance

Noise annoyance is a phenomenon of mind and mood that is strongly associated with stress. Indeed, much of the previous studies have linked annoyance reactions with individual characteristics, such as personality, attitudes, noise sensitivity, or individual preference for sound, indicating that both individual noise sensitivity and transient moods are substantive for human auditory perception evaluation (Vastfjall, 2002). Buttressing on this, an experimental study on community noise disclosed that noise level above thresholds of 50 to 55 dB can cause noise annoyance and stress, and elevated above 80 dB can induce psychologically related stress, leading to aggressive behaviour (Berglund et al., 1999). Similar findings in a paediatric intensive care unit at Johns Hopkins Hospital reported noise to be the major contributor to higher heart rate and tachycardia among nurses, as well as to nurses' stress and annoyance

(Morrison et al., 2003). A laboratory study of annoyance from low-frequency noise (LFN) discovered that there were no differences in annoyance assessments between females and males, however, concluded that more than half of the subjects predicted LFN at the low-frequency A-weighted SPL above 62 and 83 dB as being highly annoying (Pawlaczyk-Łuszczyńska et al., 2010). Similar findings attributed mechanical noise as the major source of low-frequency noise (LFN) in patients' rooms, resulting in annoyance, elevated blood pressure, and sleep disruption (Berglund et al., 1996).

Noise and Sleep Disturbances

As early as in 1977, the survey on Urban Noise confirms that 28% of the sampled population experienced sleep disruption, which indicates annoyance as the major detrimental effect of noise on individuals (Westman & Walters, 1981). Sleep disturbance is the most common complaint among patients in the hospital facilities. The indices have been connected to environmental and medical issues, such as intensive care units (ICUs) environment, medical disease, psychological stress, medicaments, and armamentarium used on critically ill patients (Salas & Charlene, 2008). Similar reported findings on health care noise studies have shown that unpleasant sound in the hospital environment have a damaging effect on health and healing process, and have hurtful effects on the patient's periodic state of rest, which can alter memory, increase agitation, aggressive behaviour, depression or anxiety (Ryherd et al., 2008; Short et al., 2011).

A well-documented body of evidence has shown that unpredictable noise is a significant barrier to sleep for hospital patients, and sleep has been shown to be therapeutic for health, including healing and recovery (Monsén, & Edéll-Gustafsson, 2005; Muzet, 2007). In a similar study, ambient noise has been associated with the major cause of sleep deprivation or disturbance in patients' rooms, resulting in confusion and increased medication, including restraint among patients (Mazer, 2012). Other similar reviews concluded that environmental noise induces sleep fragmentation in the intensive care units, upsurge tiredness, increase low vigilance state and reduces daytime performance and quality of life (Drouot et al., 2008). As demonstrated in Figure 3.9, noise effect on sleep interruption can cause multiple consequences over time. A significant research by Joo et al. (2012) on the effects of 24 hours' acute sleep deprivation, cognition and stress hormones among patients depicted an increase in the levels of stress hormones (cortisol, epinephrine, and norepinephrine) and a decrease in cognitive function. Sleeping disruption has been associated with numerous events and conditions, including increased falls, elevated physiological indicators of inflammation, altered glucose metabolism, elevated blood pressure, and increased pain (Solet et al., 2010).

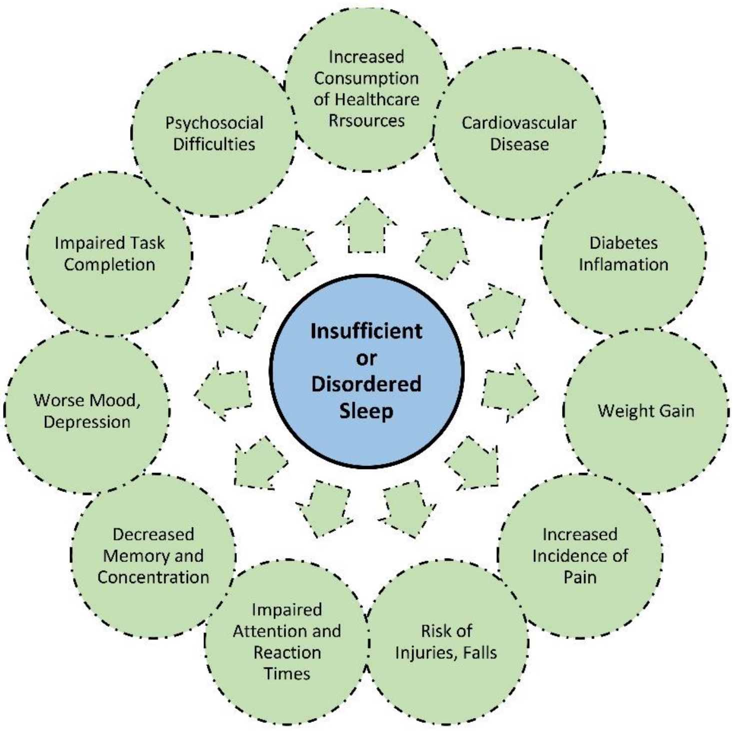


Figure 3.9. Multiple consequences of noise on sleep interruption over time (adapted from Solet et al., 2010).

A literature survey on sleep studies in the (ICUs) ascertained that almost 20% of the arousals and awakenings are associated with noise and 10% from patient care activities. Moreover, sleep fragmentation resulting from noise induce sympathetic activation and elevation of blood pressure, contributes to patient morbidity, including a decrease in immune function that may result in negative nitrogen balance (Parthasarathy & Tobin, 2004). Previous investigators have attributed noise and environmental noise within the intensive care units (ICUs) as a detrimental factor that activates psychological reactions among patients, resulting in sleeping disruption and fragmentation, abnormally rapid heartbeat, and weariness (Stanchina et al., 2005; Freedman et al., 2001).

Noise and Cognitive Impairment

Neurological and psychoacoustic studies have shown that elevated noise does not only arouse stress response but also have an impact on all aspects of the neuronal networks, involving brain function and negative behaviour. It is important to note that even a soft intensity suprathreshold background noise might have an effect on brain function. Investigators in this field of study have shown that background noise can positively have an effect on speech intensity production in Parkinson disease (PD) (Dykstra et al., 2012). Prolonged exposure to intense sounds has a persistent effect on the brain organization of speech processing, perception, and attention control, affecting the individual's behaviour (Kujala & Brattico, 2009). Similar investigation concluded that prolonged exposure to continuous occupational noise alters the cortical sound and sound-change processing, thereby affecting the speed, strength, and topography of the neural auditory responses (Brattico et al., 2005). A high noise level of 85 dB(A) decreases the extent of information processing and consequently impairs creative cognition (Mehta et al., 2012).

Psychoacoustic investigations have shown that under adverse listening conditions, children's speech recognition threshold is more impaired than in adults, implying that children's capacity to recognise speech or consonant sounds under combined noise conditions involving reverberation and noise improves until about 14 years or teenage age (Johnson, 2000). For example, one qualitative study attributed noise to be the major contributing factor to nursing performance or obstacles in the intensive care units – ICUs (Gurses & Carayon, 2007). Similarly, loud noise and nursing intervention procedures or routine have been found to significantly alter or change behavioural and physiological responses of premature infants in the neonatal intensive care unit – NICU (Zahr & Balian, 1995).

Noise and Cardiovascular Diseases

Several epidemiological studies have demonstrated that environmental noise exposure induces endocrine and cardiovascular diseases, which are associated with an increased risk of high blood pressure or hypertension, coronary heart diseases and stroke (Floud et al., 2013). McAndrews and Wu (2013) vividly described the endocrine system as an aggregation of glands and organs located within the entire body, which is responsible for storing, and secreting chemical hormones that maintain and control a wide range of body functions, such as coordination of the body's responses to stress. Indeed, chronic noise is a major determinant factor of stress hormone reactions, which induces changes in the endocrine system that stimulate aging of the myocardium, with an increase in the risk of cardiovascular diseases, including hypertension and circulatory and heart diseases that are associated to myocardial infarction (Ising et al., 1999). A recent study supported the importance of environmental noise as a risk factor that induces changes or transient effects on adult vascular properties. These changes heighten [1.25 (1.10, 1.42) % mL/mmHg] arterial compliance and decreases [2.12 (−2.

51, −1. 80) kdynes·s/cm^5] arterial resistance over 24-h (Chang et al., 2012). However, the related mechanism of vascular structural changes is still ill-defined. Babisch (2003) suggested that a qualitative procedure should be applied in the noise study for risk assessment and interpretation of endocrine noise effects to understand the mechanisms of physiological reactions to noise and to identify the vulnerable groups.

Occupational and environmental noise studies have shown a higher prevalence of cardiovascular diseases, including high blood pressure and ischaemic heart diseases in individuals exposed to chronic noise at their workplace or dwellings. A clinical survey of post-cardiac surgery patients in an intensive care unit (ICU) in Taiwan recorded an average noise level ranging between 59.0 and 60.8 dBA in the unit within 42hours. Noise annoyance and sleep fragmentation were partially associated with the major psychological and physiological complaint among 40 patients after a cardiac operation. However, the noise level measurement observed have no correlation with self-assessed psychological and physiological reactions, but there was a strong link on noise-induced heart rate and blood pressure among patients (Hsu et al., 2010b).

Noise, Pain and Wound Healing

Thus, far, how noise affects pain and patients' recovering from anaesthesia is still unidentified. Only limited but indefinite investigators have postulated pain to be associated with noise. In one study, exposure to highly variable noise was associated with fear, sympathetic arousal, and lessened pain responsiveness in women. In the same study noise, did not correlate with fear or physiologic arousal in men, but reacted with surprise and increased pain responsiveness. They concluded that fear and physiologic arousal is associated with hypoalgesia. However, the relationships between noise and pain management are also uncertain in this investigation (Rhud & Meagher, 2001). A survey conducted on a post anaesthesia care unit in France argued that noise has no correlation with pain in patients' recovery from surgery. Only six of twenty-six patients in the study group complained that noise is a stressor. However, the regression analysis confirms pain to be the major cause of uncomfortableness in the anaesthetic recovery room (Allaouchiche et al., 2002). Until now, only one study in a 10-bedded recovery room hypothesises noise to induce pain in postoperative patients already suffering from surgical pain. Although, this postulation revealed an equal proportionate increase and decrease in noise and pain medication, though associated with the number of patients receiving pain medication (Minckley, 1968). There is also an assumption that noise can cause Cephalalgia (head pain). In the contrary, Martin et al. (2005) concluded that noise does not potentially activate Cephalalgia but have a substantial link with elevated temporal pulse amplitude (TPA) in the subjects.

Investigators have also shown that sound can suppress or distract pain in some cases. An experimental study on the effect of white noise and newborn's perception of pain in a state hospital in Turkey concluded that white noise is an efficient nonpharmacological method to cut down pain, shorten crying time, and enhance vital signs in newborns. They further indicated higher pain in the neonatal infant pain scale (NIPS) score and crying time for the holding group compared with the white noise-only group (Karakoç & Türker, 2014). Similarly, another experimental study on the effect of magnetic resonance imaging (MRI) scanner noise and white noise on pain unpleasantness ratings of 24 healthy volunteers confirmed that acoustic noise from a non-compressed (MRI) scanner as well as white noise significantly reduced pain unpleasantness and localisation (sensory-discriminative) ability (Boyle et al., 2006).

The aetiologies of how noise affects wound healing in hospitalised patients are still not attested. However, short – term and long – term studies of animal have provided a biological mechanism for the detrimental effect of noise on wound healing, which substantiates that noise delays wound healing. A laboratory study of 124 albino rats imposed with wounds on their back and exposed to combine environmental stressors, such as scraping of metal wheels, flashes of light and ringing of bells indicated a wound healing delay in male rats over female rats with no significant reactivity (Toivanen et al., 1960). Similar findings from an experiment on wounded rats intermittently exposed to noise for a quarter-hour for 19.5 days discovered a delay in wound healing of the group of rats exposed to periodic white noise at 85 dB(A). Results apparently show a decrement in the average weight of the exposed group of rats than the control groups, despite that there was no variation in the food intake between the exposed and unexposed group of rats (Wysocki, 1996). In another study of 119 mice imposed with wound and exposed to temperature and noise stressors consisting of 99dBC white noise demonstrated that noise decelerated rate of wound healing. However, results show that Temperature stressors significantly have a higher effect on healing than the noise stressors (Cohen, 1979).

Noise and Cancer

Investigators have documented that elevated noise exposure can have a detrimental effect on cancer (tumour growth), though elaborated mechanisms are still unclear. Edwards et al. (2005) concluded that exposure to loud noise from machines, power tools, and/or construction are the major contributing factors to higher risk for acoustic neuroma (odds ratio (OR) ¼ 1.79, 95% CI: 1.11, 2.89), including exposure to loud music (OR ¼ 2.25, 95% CI: 1.20, 4.23). The result of the study demonstrated that loud noise exposure could actuate acoustic neuroma, although suggested further investigation to validate the obtained results including the effect of possible detection prejudice. In addition, Fisher et al. (2014) demonstrated that occupational exposure to loud noise has no correlation with acoustic neuroma. In contrast, statistical results show a strong link between acoustic neuroma and those exposes to loud noise from leisure activity such as attending concerts, clubs, and sporting events without hearing protective devices. Moreover, acoustic neuroma initiated by noise from loud leisure activity, mostly have an effect among women. Investigators did not report any prejudice or bias regarding age, marital status, and radiotherapy treatment in regression models. Table 3.5. Selected summary of the studies linking noise, stress, and health.

Table 3.5. Selected studies that highlight sound, stress, and health outcomes

Health symptoms	Selected references	Main measured outcome(s)	Result on health-related outcome(s)
Noise, Stress, and Annoyance	Morrison et al. (2003)	Noise and nurse's stress outcomes (salivary, heart rate, and amylase) in a paediatric intensive care unit.	Reported increased stress associated with annoyance, and heart rate (tachycardia).
	Topf (2000)	Environmental stress model that attempts to respond to hospital noise, providing guidance to nurses seeking support.	Reported noise to be the major sources of environmental stressor and health correlated outcomes in patients and nurse's in hospital context.
	Short et al. (2011)	Noise level impact on patients in multiple clinical care areas of an Australian emergency department.	Measured sound levels exceeded world health organization standard. Increased communication problems, annoyance/stress levels, negative behavioural change and sleep disruption.
	Blomkvist et al. (2005)	Effects of acoustics on the psychosocial work environment of healthcare and the staff as it relates to distress, pressure and strain in a coronary critical care unit.	Sound-absorbing ceiling tiles intervention improved reverberation time, and speech intelligibility, including reduced demands, and pressure or strain among staff.
	Slevin et al. (2000)	Quiet period intervention on a NICU environment and its impact on infants' physiological and movement responses.	Results showed reduced median diastolic blood pressure and mean arterial pressure including decreased movement responses in infants.
	Griefahn & Robens (2010); Spreng (2000)	Effects of noise on cortisol increase/awakening response.	Nocturnal noise activates cortisol increase and cortisol awakening response during sleep.
	Wang et al. (2013)	The significance of a dedicated service corridor in a new intensive care unit (ICU) on staff perceived noise environment, staff stress, and satisfaction	Nursing staff perceived quieter work environments and reported being less stressed and more energetic during work in the new ICU when compared with previous ICU.
	Mahmood et al. (2011)	Nurses' perception of how the physical environment in hospitals affects medication errors.	Among other factors reported by nurses, high levels of noise frequently contributed to medication, documentation, and other types of nursing errors.
	Wysocki (1996)	Noise impacts on wound recuperation.	Noise exposure decreased average weight (weight loss) in the treatment group's average weight when matched with control group.
	Cohen (1979)	Noise, stress and wound healing.	Slower healing area rate was reported

	Bailey & Timmons (2005) ; Fife and Rappaport (1976)	Noise and hospital stay length.	Hospital stay length increased due to noise exposure.
	Pawlaczyk-Luszczynska et al. (2010)	Annoyance and low-frequency sound	Study results demonstrated increased annoyance in both groups.
Noise and Sleep disturbances	Stanchina et al. (2005)	Noise on sleep arousal	Patients reported outcomes showed noise triggered off 1178 arousals
	Drouot et al. (2008)	Noise on sleep fragmentation	Noise increased immune disturbances and caused neuropsychological damages
	Pisani et al. (2015)	Noise on sleep disturbances in patients with critical illness	Noise-induced brain dysfunction (e.g., delirium)
	Muzet (2007)	Ambient noise on sleep	Noise increased tiredness, reduced performance and quality of life in patients
	Joo et al. (2012)	Noise effect on 24 hrs. acute sleep deprivation, cognitive function, and stress hormones levels	Reported increased stress hormones levels and reduced cognitive function
	Freedman et al. (2001)	Noise effect on sleep–wake/disruption	Sound Levels of above 80dBA triggers off sleep–wake
	Monsén & Edéll-Gustafsson (2005)	Noise levels effect on sleep deprivation factors	Implementation of noise intervention reduced no. of sleep deprivation and noise levels
Noise and mental Heath	Murthy et al. (1995)	Noise effect on speech reception threshold and speech discrimination	Worsen mental efficiency, short – term memory was reported by patients
	Zahr & Balian (1995)	Nursing routine and noise effect on behavioral, physiological reactions	Noise alters behavioral, physiological responses in self-reported outcomes

3.7 Chapter Summary

In order to support the theoretical framework presented in chapter 2 of this study, this chapter presents a vast research on the hospital physical environments with a focus on the role that sound perception evoke in healthcare space design. This highlights design to foster the reduction of environmental stressors such as the sense of control over physical-social surroundings, access to social support, connection to nature, and access to positive distractions. This chapter also highlighted studies taking up the subject of sound from various disciplines, including music psychology, noise in healthcare environments and evaluation of best design practice to mitigate or enhance the excessive sound in the hospital facilities. This chapter emphasized on the auditory and non-auditory effect of noise on health as it correlates with psychological and physiological health outcomes. This includes the nature of hospital sound environment, noise level, noise sources and their impact on hospital patients and health care providers. It also discusses the use of music in the hospital setting covering music medicine and the use of music in operating rooms in terms of stress management, psychological and physiological responses. This chapter also covers the aspect of music as a complementary medicine for improving health care, contradicting arguments concerning the use of music in the health care and implications for clinical practice.

Chapter 4

DESIGN INTERVENTIONS FOR IMPROVED SOUND EXPERIENCE IN HOSPITAL ENVIRONMENTS

Over the last few decades, a greater emphasis has been placed on the impact of patients' physical and psychological comfort, healing and satisfaction. Studies have attempted using environmental design interventions to improve patients' experiences within the healthcare context, such as providing single-patient rooms and rooms, enclosed with walls in examination and treatment areas, private discussion areas in admitting areas as well as on the unit for private conferences with families and staff, including installing high-performance sound absorbing acoustical ceiling tiles to prevent sound from bouncing off from the ceiling to adjoining spaces (Frampton et al., 2003; Joseph & Ulrich, 2007; van de Glind et al., 2007). However, only few sound investigations have explored the effects of single patient rooms thoroughly (Kol et al., 2015; Xie & Kang, 2012).

As set out in Figure 4.1, considerable researches have suggested several interventions for sound reduction in the healthcare facilities, and have postulated that environmental design interventions may be effective in reducing the sound levels and improving the hospital environment sound experience. Some of these interventions include selecting the proper materials and furniture, installing high-performance sound-absorbing ceiling tiles, eliminating or reducing noise sources and providing single-bed or private rooms for patients rather than multi-bed rooms. Additionally, it is important to note that the architectural features are the comparatively permanent aspects of the physical healthcare environment. In terms of evidence-based design practice, these architectural features comprise the physical spatial layout of hospital ward/units, size and shape of rooms, including the placement of openings/windows and access to nature views (Dijkstra et al., 2006), as well as provision of single patient rooms, and acuity-adaptable spaces.

Furthermore, among the nursing unit features considered by the Agency for Healthcare Research and Quality (AHRQ) to influence patient and staff outcomes include providing staff with workstations that are not long distances from patients' bedsides, visibility of patients from nurse workstations, regular staff hand-hygiene stations, and noise reduction through ceiling tiles and carpeting, as well as single rooms for patients' satisfaction (AHRQ, 2007). Therefore, this study chapter explores how different features of the environmental design approaches that can be used to improve the acoustical environment of hospital settings, as such, ameliorating sound experience for hospital occupants

4.1 Hospital Environmental Noise Interventions

Investigators have advocated that environmental modifications can effectively extenuate chronic noise level in the hospital premises, as such suppressing the acoustical environment. Indeed, it has been supported by investigators that high-performance sound-absorbing ceiling tiles (Taylor-Ford et al., 2008), adopting a noiseless paging system, and encouraging single-bed rooms rather than shared rooms or bays can reduce hospital noise to an extent (Xie & Kang, 2012).

For instance, an investigation in Johns Hopkins Hospitals to enhance the acoustic conditions through the installation of sound absorbing materials, revealed that after the application of absorbing materials, the level of sounds decreased by 5 dB (A) and the reverberation time mitigated by a factor over 2 (MacLeod et al., 2006).

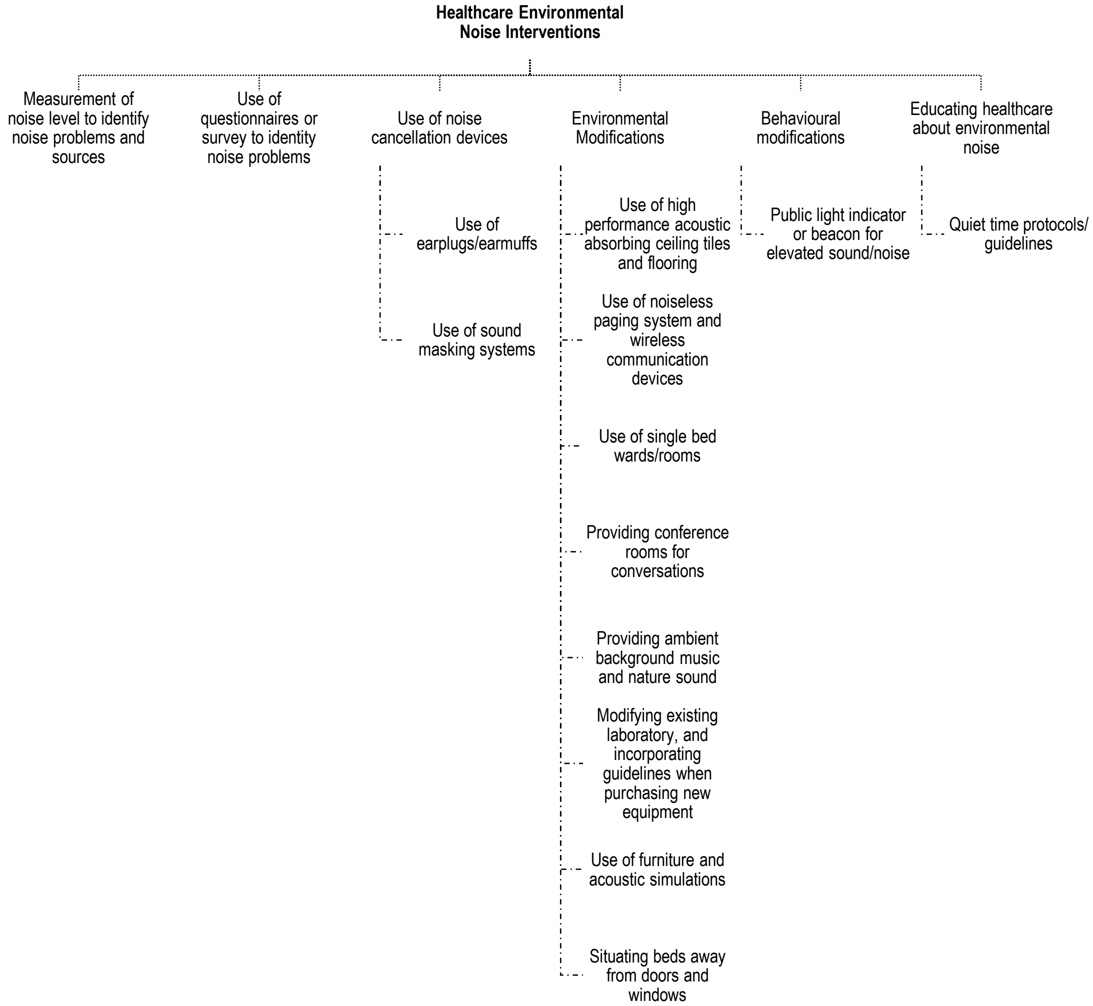


Figure 4.1. Environmental design strategies for noise mitigation in hospitals (Compiled by the author).

Studies assessing the hospital (ICUs) noise have indicated that behavioural modification and improvement of major noise sources can effectively minimise noise within the hospital acoustical environments (Xie et al., 2009; Kahn et al., 1998). Well-documented investigations have shown that the quiet time protocol through the allocation of quiet time in the hospital environment can mitigate noise level conditions in the hospital (Crawley & Emery, 2006). Similar studies on hospital noise setting have suggested educating the hospital care providers by implementing educational programs about the awareness of environmental noise sources and Caregiving behaviours that contribute to noise (Johnson, 2003). More than dozens of researchers have suggested that provision of earplugs or earmuffs to patients can lessen peak ICU noise levels, as well as reduce arousals from sleep (Wallace et al., 1999).

A review of the literature on the correlation between noise pollution and music intervention recommended department of sound in the hospital settings to subdue noise and to improve the quality of hospital environment for ill patients (Cabrera, & Lee, 2000). A similar study in the healthcare setting proposed that bed in the hospital wards/rooms should be located away from the corridor (Verderber, 2010). In a nutshell, many evidence have demonstrated that enhancing the acoustical environment in hospital facilities through substantial design or strategies can lessen hospital environmental noise pollution, as well as enhancing patient confidentiality and outcomes. It is a common rule of thumb that the adverse effects of noise pollution can be improved through blocking the production of noise or the entry of noise into the ear (Katz, 2014). After recognizing the essential sources of noise pollution, the accompanying change procedures can be executed. In order to understand the noise mitigation methods in the hospitals, (see Appendix A: Table 4.1 in supplementary materials) for a detailed summary of previous environmental interventions/methods for noise reduction in the healthcare facilities.

4.1.1 Behavioural Modification and Staff Education

Behavioural modification is the branch of psychology, which is associated with analysing and modifying human behaviour. It broadly means identifying the interrelation between environmental events and a peculiar behaviour in order to understand the reasons for behaviour, as well as to develop and implement procedures to help people change their behaviour through alteration of the environmental events to have an influence on their behaviour (Miltenberger, 2012). Furthermore, the results of Kahn et al's. (1998) study demonstrated that most of the peak sound above 80dBA is amenable to behaviour modification and that noise levels in the ICU environment significantly decreased by (1.9 dBA) through educational programs of behaviour modification of staff in the ICUs. Moreover, they noted that implementing a program of behaviour modification could be effective in reducing noise levels in the hospital ICUs wards. A controlled clinical trial in a neonatal ICU explored the impact of noise on sleep disturbance and recorded sound levels before and after a behavioural modification program for all staff. Moreover, the study also implemented a non-disturbance period during the day (afternoon) and night, as well as changed nursing and medical routines. Results of the investigation showed a reduction of 1.9 dB(A) in noisy activities, as well as a significant reduction in sleep disturbance factors in the neonatal intensive unit (Monsén & Edéll-Gustafsson, 2005). A prospective longitudinal study that evaluated the cost effectiveness of applying a noise reduction protocol that combines behavioural modification that requires staff education about the harmful effects of loud noises on the neonate, and low-cost environmental modifications (LEM) reduced the sound levels of the noisiest (ventilator) room by 9.58 dBA. The behavioural modification includes talking in low tones, avoidance of elevated noises across a distance, having discussions in separate rooms, careful handling of trays and metallic object, as well as turning off FM radio systems. Whereas, the (LEM) include fixing of rubber shoes on furniture legs, replacing of metallic files with plastic files, tuning alarms not to exceed 55dB, keeping the doors of where metallic trays were cleaned always closed, pasting of poster to remind staff the need of being quiet, and trimming down of phone ringers to required audible volume. The noise reduction protocol substantially decreased noise in all the rooms of the NICU (Ramesh et al., 2009).

For example, Macedo et al. (2009) suggested continued educational programs for intensive care unit (ICU) staff and informing them about noise to avoid behavioural alteration. They believe that clinical treatment such as controlling bells, turning down alarms, cell telephones, pagers, TV and radios, use of posters in clinical areas, defining quiet time for sleep periods wound diminish noise in the ICU. Additionally, the authors recommended mitigating noise through the application of absorbing floors, ceiling, walls, as well as physical partitions between beds in larger units. Furthermore, the authors remarked that rubber seals be introduced on doors and windows to evade noise intrusion, as well as clinical equipment, be tested for noise before acquiring it them for use in the ICU. On the other hand, research has recommended the closing of doors in a systematic way to avoid noise, reduction of the volume of sound from hemodynamic monitoring alarms, lowering of the voice during talking as well as switching off the phone, television, and radio. Moreover, the investigators also suggested synchronising, and limiting of nursing interventions within 11 pm - 5 am, and avoidance of direct light or electric torch in the room surveyed within 11 pm - 5am significantly reduced noise levels in the hospital surgical ICU (Walder et al., 2000). Similarly, Kam et al's. (1994) study suggests that educating the staff about the detrimental effects of noise on patient's wellness, and modification of nursing care routine or activities, including adequate hospitals equipment design, could be effective mitigate noise in hospital wards. In addition, educational intervention for reduction of noise level in the (NICU) using pre-test/post-test design with an interventional staff education program demonstrated that noise levels could be decreased (i.e. minimum average noise intensity from 52 to 38 dB(A) and the maximum average intensity from 70 to 60 dBA) through enhancing staff awareness of the noise issue (Elander & Hellstrüm, 1995). Philbin and Gray (2002) introduced education program to reduce noise as well as environmental modification such as switching off the overhead fluorescent lights when not in use, replacement or changing of the heavy - lidded, all - metal trash and linen bins with lightweight plastic receptacles to reduce the major sources of impact noise in the ICN. They furthered applied physical space renovation which includes expanding of the central workstation to preserve the short dimensions and overall shape of the room, reconfiguring of the air-handling ducts with noise – reducing registers, covering the old sheet vinyl floor with a high- quality, bacteriostatic, monolithic carpet with chemically welded seams. In addition, the investigators also suggested plastering of new ceiling and application of sound- absorbing, provision of separate lighting controls or dimmer switches in the central desk area and for each two- bed area to minimise noise in the intensive care nursery (ICN). Additionally, the investigation discovered that operational noise was decreased through the application of staff behaviour change, while facility noise was attenuated through the renovation of the hospital intensive care nursery. The study found that changes in staff behaviour only have no substantial effects on the control of sound pollution in the ICN and suggested that joined method or combination of staff behaviour and the physical change of the facility were more effective in promoting a quieter environment than just implementing staff training or education only. A research attempts to reduce the noise level to attain satisfactory response in patients, applying performance improvement model (PDCA) of Plan, Do, Check, Act, showed that the loudest noise present within the hospital environment originates from the nurses' station, which in turn was the highest activity noise level as well as the central area for call bell and telemetry monitoring. The authors discovered that before the application of staff education program, noise level averaged 65dB decreased to 61.3 dB after staff educational program. The noise level further decreased to 56.1 dB after 6 months' educational program implementation. However, results obtained still go beyond 45dBA, WHO recommendation standard for maximum noise level in the healthcare premises (Connor & Ortiz, 2008).

4.1.2 Environmental Modifications

A controlled trial study conducted in an existing Level III Neonatal Intensive Care Unit (NICU) at Rainbow Babies and Children's Hospital in the University Hospitals of Cleveland, found lower sound levels and a perceived change to a quieter environment in the experimental patients' room compared with the control patients' room following the execution of environmental sound modifications. Besides nursing staff education about noise impact on newborn infants, placement of weather stripping on all doors and drawer fronts, substituting all metal trash cans with rubber types, placing of covers over incubators, installing of carpet along the centre of the nursery, and sound-absorbing acoustic material in all monitor bays and soffits were applied to reduce unnecessary noise. The investigators argued that light and sound could be altered in an existing NICU at low cost, without influencing or compromising patient safety (Walsh-Sukys et al., 2001). An investigation that measured the noise level in a noisy NICU as well as compared the levels of noise produced by other sources inside or outside of the isolette (incubator) reported that after sound absorbing panel (SAP) application, median SPL of background noise inside the NICU reduced from 56 dB(A) to 47 dB(A) inside the isolette. The investigators result also demonstrated that median SPL of temperature alarm inside the isolette significantly reduced from 82 to 72 dB(A), as well as monitor alarm from 64 to 56 dB(A), porthole closing from 81 to 74 dB(A), and isolette door closing from 80 to 68 dB(A). After applying SAP, there was a significant noise reduction from 79 dB(A) to 69 dB(A) in noise generated by baby crying. Findings of the study also demonstrated that there was a significant attenuation effect of panel on the environmental noise. However, this study did not consider strategies to reduce the chronic noise during lengthy hospital stays and this may affect some morbidity in preterm babies (Altuncu et al., 2009).

Environmental modifications application in the healthcare has been supported by investigators who suggested that detailing environmental considerations for modifying existing laboratory settings, building new settings, and incorporating sound level criteria when making new equipment purchases would be beneficial to control noise levels in the healthcare environment (Mortland & Mortland, 2002). A systematic survey of the literature on environmental interventions in the healthcare by Ulrich et al. (2004) showed that, for example, noiseless paging system, single-patient rooms, sound-absorbing ceiling tiles, and flooring effectively reduced noise in the hospital setting and improved patients' sleeping. Similarly, another investigation demonstrated that continuous quality improvement (CQI) was essential for controlling noise pollution in the hospital ICUs. As such, they suggested identification, monitoring, and controlling of noise sources in the ICUs. In addition, the authors suggested that it is apparent to reduce the frequency and duration of sound peaks that exceeds 80dBA, decrease the background noise, and improve the ICU environmental quality (Parente & Loureiro, 2001).

Another case study that applied PDSA (Plan, Do, Study, Act) process model indicated reduced decibel levels following staff education and implementation of various environmental noise control interventions that includes reducing alarm and voice volume, decrease traffic, close doors, dim lights. Plan; define the purpose of the quality improvement project. Do; collect noise dosimeter readings and patients' comments on what disturbs their sleep. Study; analyse the dosimeter readings and patients' comments. Act; Implement changes based on the dosimeter findings and patients' comments. The results demonstrated a significant peak noise levels reduction from 113 to 86 dB(A) and found a reduction in average night shift noise levels (Cmiel et al., 2004). Similarly, Anand et al. (2009) remarked that diminishing noise from ventilator, monitor alarms, phones ringing, doorbells, and lubrication of doors to avoid noise from door hinge as an effective strategy to reduce noise in the hospital ICUs. A quantitative and descriptive qualitative study was conducted in patient care unit (PCU) by Dube et al (2008) to identify levels of noise perception by patients and staff and noise sources, as well as implementing methods for noise reduction. The survey identifies the noisiest time of the day to be Morning (7 am to noon) and found the most annoying noise source to emanate from people talking. The study demonstrated that noise was significantly reduced by the implementation of intervention such as closing of patient room doors, dimming of lights at night, limiting the usage of overhead page, reducing talking voices, turning down ringers on phones, posting of quiet signs to keep voices soft, and turning down of alarms as far as safely possible.

4.1.3 Quiet Time Protocol to Improve Sleep

A study investigation has developed a quiet time program in the Neuro-ICU to reduce noise and light levels, as such to enhance sleep among patients. The investigation incorporated 50 Neuro-ICU patients in total that includes 35 observed during daytime hours and 15 at night hours. During the Quiet Time (QT) protocol, everybody inside the Neuro-ICU was to stay noiseless and lights turned off or diminished. Consequences of the study uncovered an essentially lower noise and light levels during day shift quiet time, and patients were fundamentally more prone to be watched dozing during day shift quiet time hours. The study found a cut down in noise levels during a quiet time when contrasted with before and after quiet time intervention, even though noise levels was found to surpass recommended levels of 45 dB (Dennis et al., 2010).

A multi-centred non-randomised, parallel group trial study implemented a quiet time intervention to test the therapeutic outcome of 299 participants in acute orthopaedic wards of two major urban public hospitals in Brisbane, Australia. This study adopted a quiet time intervention that includes, quiet time between 14:00 and 15:30h, restriction of visitors to patients, restriction of staff movement and treatment activities during the quiet time intervention. The study likewise included ‘promotion of patient rest and comfort through positioning and pain relief prior to quiet time as well as reduction of environmental stressors through reduced lighting and ward noise, for example, diminished phone volume, corridor discussions, TV, and radio’ during quiet time intervention. The finding of the study demonstrated that a quiet time intervention on an acute care hospital ward could affect noise level and patient sleep/wake patterns during the intervention period, as well as improving a satisfactory therapeutic benefit. Furthermore, the result of this investigation advocated that quiet time intervention has the ability to mitigate the noise level by an average more than 10 decibels (dB) on an acute care hospital ward (Gardner et al., 2009).

4.1.4 Music and Nature Sounds

It has been generally accepted that nature sounds are the sounds generated by natural phenomena. These sounds are generated from wind, rain, ocean, streams, and living organism such as birds. Frumkin and Louv (2007) argued that people are closely attached to the natural world, which suggests that contact with nature is beneficial to health and wellbeing. Indeed, sound may also be included in the environment as a positive distraction, and positive distraction, on the other hand, have been extensively studied and have been shown to have a significant influence on patients' clinical and behavioural outcomes (Shepley, 2006; Pati & Nanda, 2011). For example, an investigation has shown that patients listening to ocean sounds during the night on postoperative coronary artery bypass graft surgery after transfer from an ICU scored statistically significantly higher on a scale measuring self-reported sleep, demonstrating an indicative of improved sleep (Williamson, 1992). Additionally, a survey conducted to investigate stress recovery during exposure to nature sound and noisy urban environments indicated that the application of pleasant nature sounds of fountains and tweeting birds in healthcare reduced psychological stress and facilitated fast physiological recovery of sympathetic nervous system when matched with disagreeable city noises of road traffic (Alvarsson et al., 2010). Similarly, an investigation has demonstrated that participants who either listened to river sounds or saw a nature movie with river sounds during a post-task restoration period reported having more vigour and better motivation after the restoration period when matched with participants that only listened to office noise or silence. However, furthermore, this same study also suggests that the combination of viewing nature movie and river sounds during the restoration period had a more positive effect than only listening to the river sounds alone (Jahncke et al., 2011).

There is evidence that the combination of both music and sounds can be used very successfully in health care applications. For example, in the absence of windows, a study has revealed that the sounds and sights of nature displayed on a bedside curtain showed reduced discomfort and pain in patients undergoing flexible bronchoscopy procedure (Diette et al., 2003). Similarly, it was also discovered by Cutshall et al.,

(2011) that listening to comforting music and nature sounds during post-operative cardiac surgery significantly increased patient's experience, thereby significantly reducing levels of pain and anxiety including increased relaxation and overall satisfaction. A randomized controlled trial of patients undergoing colonoscopies in an Indian hospital reported that patients who listen to a soothing mixture of soft instrumental music with nature sounds received less sedative drugs and had reduced uncomfortable medical procedures than those who did not (Harikumar et al., 2006). In addition, it could be indicated that music frequently can be highly subjective, however, Harikumar and Kumar (2007) advocated that the combination of nature sounds with music may be more acceptable as it spans across languages, social and cultural roadblocks. In fact, music and nature sounds may reduce pain and anxiety through distraction, thereby focusing the mind of individual away from the pain and anxiety toward a more pleasurable stimulus (McCaffrey & Good, 2000) that can offer a peaceful sense of healing power for increasing coping strategies associated to fear, sorrow, burden and negative emotional outcomes in dying patient (Schrodeder-Sheker, 1994).

4.2 Hospital Layouts as Space Organisation

Space layout design is viewed as one of the primordial activities in architectural design for new construction and in most cases of building adaptation. However, study has shown that the conception of space layouts in healthcare buildings could be very challenging because of its strict and complicated relationships among component spaces and operational units (Zhao et al., 2009). It could be observed that only limited detailed research has been investigated on features of space layout plans in healthcare buildings. There is a need to investigate this aspect as the physical design of hospital care units can influence safety and care delivery costs when well-planned and designed. It has been demonstrated that a well-planned hospital layout possesses a positive effect on patient wellness and well-being (Schweitzer et al., 2004), as well as affect nurses' walking behavior and distance (Seo et al., 2011; Yi & Seo, 2012), although most reported effects of this spatial layout appear to be inconsistent, and are merely based on perceptions of privacy. An example of such a study is that of Pattison and Robertson (1996) which found that patients reported higher on disturbance due to noise and increased levels of anxiety and depression on the Nightingale ward (long, single, open-plan room) when compared with the bay ward (bays of four or more beds parallel with the corridor and the external wall).

Lately, architects and their collaborators have attempted using various types of unit layout in order to improve circulation problems, reduce noise, errors, stress, pain, improve lighting, promote better ventilation, better ergonomic designs, supportive workplaces, improve sleep and other associated outcomes (see Marberry, 2006). Trzpuc and Martin (2010) classified the four basic nursing units as 'centralized' (include one main nursing station serves a nursing unit), 'decentralized' (includes small nursing stations or pods are distributed throughout a unit), 'hybrid' (includes a larger, central nursing unit and several "touchdown" areas located throughout the unit), and 'the 'multi-hub' design (includes several essentially identical larger nursing stations are distributed across a nursing unit). Similarly, as set out in Figure 4.2, a study that intensively investigated the different kinds of hospital layout revealed 7 fundamental types, which includes open or Nightingale type, corridor or continental type, duplex or Nuffield type, racetrack or double corridor type, courtyard type, cruciform or cluster type, and radial type (James & Tatton-Brown, 1986).

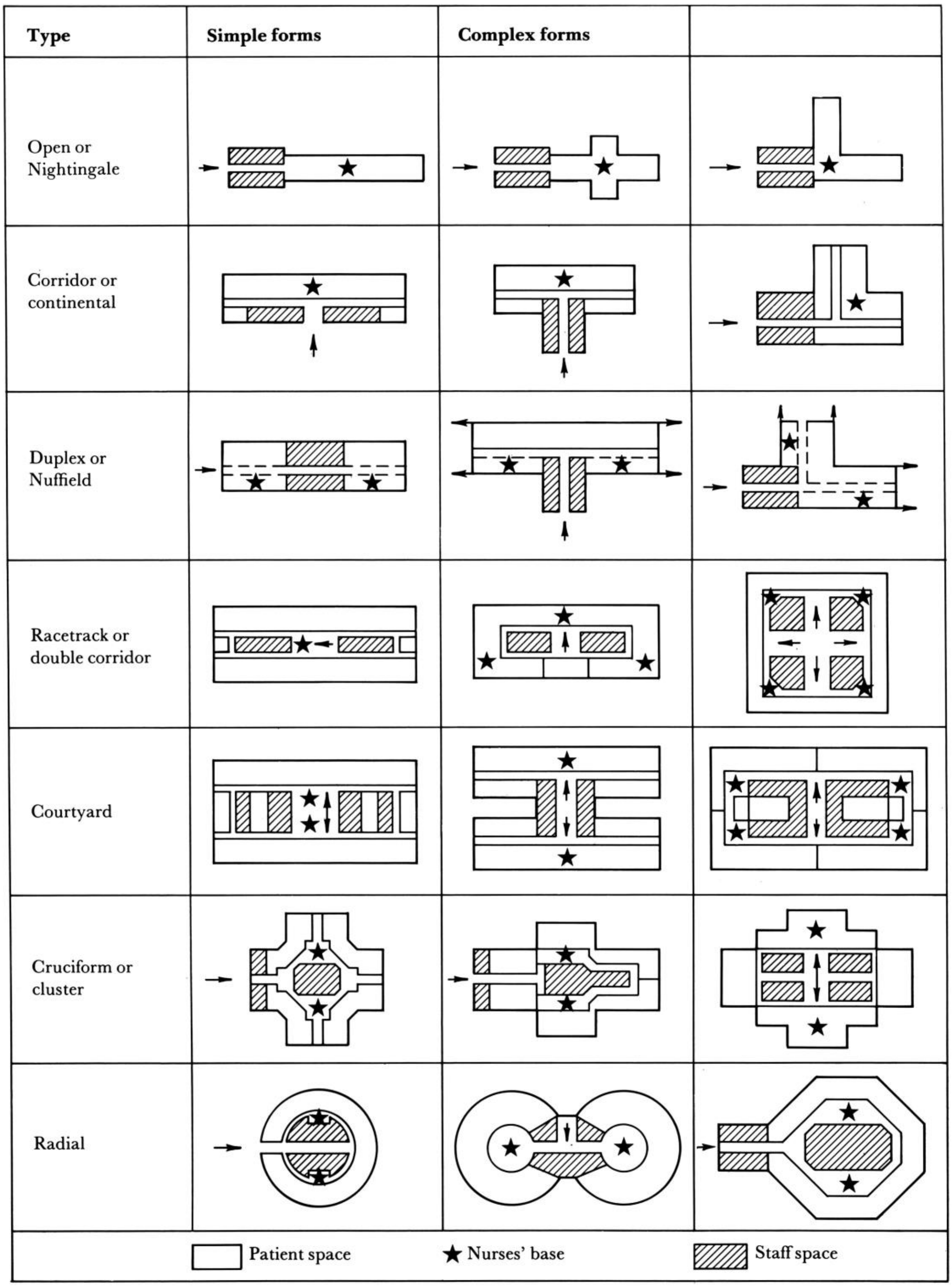


Figure 4.2. Layout types of hospital units (James & Tatton-Brown, 1986).

It was as well observed that studies at the global scale have looked at the properties of the building layout in terms of lighting, orientation and healthcare staff effectiveness, with only a few studies investigating units designed for the patient- and family entered care. Similarly, hospital layout has been demonstrated to be an important architectural feature to enhance workplace performance for care providers. A well-designed layout, is one where the nurse's station is the hub for a unit, with the patient rooms being not too far from it (Ulrich et al., 2005) has been shown to reduce noise, improve workflow and reduce waiting times, as well as increase patient satisfaction with the service (Gurses & Carayon, 2007). Moreover, decentralized nursing stations can prevent large groups from talking near patient rooms, and this could control the noisy, chaotic, and crowded space associated with centralized nursing stations (Hendrich, 2003; Hua et al., 2012). For example, according to Zborowsky et al. (2010) decentralized unit model is a patient care unit with more than one nursing station of any size or configuration. Research works have reported that radial unit designs might provide flexibility in managing patient loads as well reduced walking distance for nursing staff when compared with nursing staff in the rectangular unit (Shepley & Davies 2003; Yi & Seo, 2012). The radial design is a circle that permits a "fishbowl" view of each room from the nurses' station, which is not the case for all of the patient rooms in the corridor/continental or racetrack/double corridor layout design (Catrambone et al., 2009; Seo et al., 2011). As set out in Figure 4.3 studies often compared the “radial” unit layout design with other types, such as the “corridor” or “racetrack” layouts.

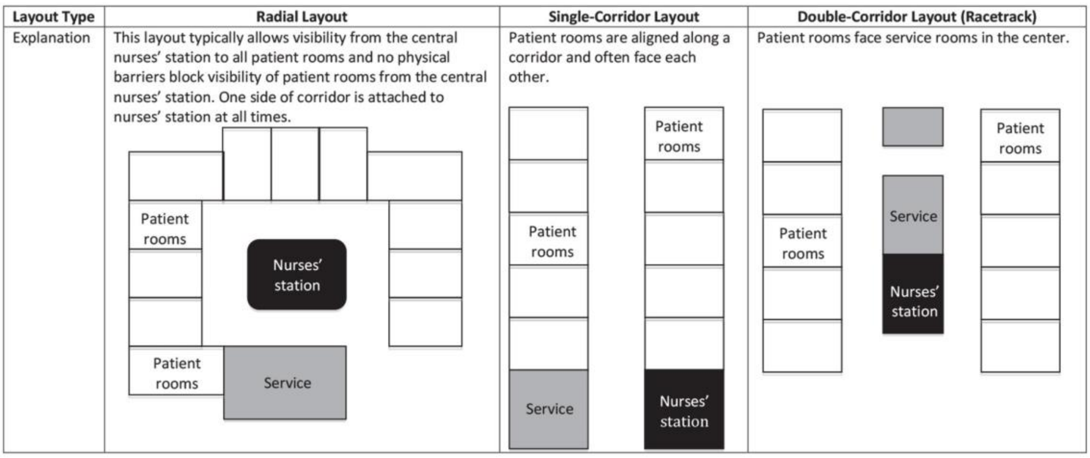


Figure 4.3. The three common hospital different unit layouts (Yi & Seo, 2012).

In recent years, private room layouts have gain popularity and are the most common method of reducing noise in hospital settings. Though, if a hospital layout is well-designed or planned have the potentials of diminishing noise transmission in healthcare interiors. For instance, an area where there is high activity should be situated in areas that are well detached from patient rooms, and opposite doors in the hallways should offset each other (Cole et al., 2005). It is likewise helpful to rethink traditional aspects of the hospital layout, as the standardized patient room has a material effect on noise, for example, the bed in each single room in St. Joseph's is in the same location as the next room. The traditional patient room style (also known as back-to-back) allows patient beds to be placed on the same wall, however, could create a major transfer of noise between rooms (Reiling et al., 2008).

Hospital unit sizes have also been demonstrated to have impact noise, including traffic flow, staffing, and functional needs within a unit. For example, between 8 to 12 beds per unit have been conceptualised to be the best from a functional perception (Rashid, 2006). Additionally, it has been observed that in most best-praxis intensive care units (ICUs), architects or designers utilises multiple pods in an attempt to improve patient-staff visibility and to take services closer to patients. However, it has been advocated that pods may do very little to reduce congestion, crowding, and noise at the critical locations in a unit. This is because most intensive care units (ICUs) with this type of layout do not have separate entrances to these pods for reasons of privacy, control, and safety. Consequently, like any other large units, the units with multiple pods are unable to distribute movement evenly (Rashid, 2006). Additionally, another type of unit layout that has gained recognition and has been awarded design prizes and is preferred is the racetrack type or double corridor configuration with patient beds on the perimeter of the unit, service rooms and areas in the centre, and corridors in between.

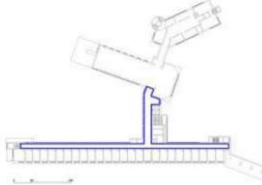
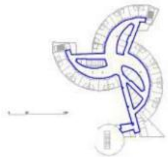
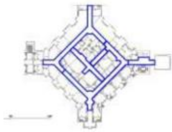
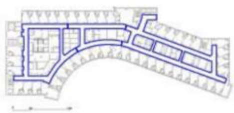
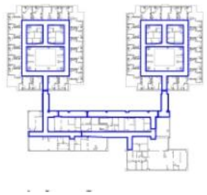
One of the reasons why this type of layout is beneficial is because perimeter wall is maximised, thereby permitting for more patient rooms to have natural light and out-of-doors views that could invite soothing sounds of nature, thus bring about facilitating patient recovery and wellbeing (Ampt et al., 2008).

Surprisingly, it was observed that only very limited research has been performed to look into the function of a corridor design strategies and their impacts on the sound levels in patient care settings and staff performance. A study conducted by Wang et al. (2013) observed that nursing staff perceived quieter work environments, had reduced stress and were more energetic during work in a new ICU with dedicated service corridor when compared with the previous ICU without a service corridor. Detailed information about these layouts can be obtained from the following sources (James & Tatton-Brown, 1986; Rashid, 2006). Indeed, hospital care providers spend a considerable amount of their time in the corridors while navigating between spaces, as well as conduct critical sound tasks in the corridors including conducting critical medical conversations such as patient care management, medication dosage and medical procedure including localization and assessment of critical sounds (Okcu et al., 2011). Table 4.2, presents different hospital nursing layout, which consists of diverse numbers of connected hallways forming complex floor-plate shapes. In addition, when the corridors within this layout are poorly designed can possibly worsen the difficulty that health care provider experience while conducting critical sound tasks. Okcu et al.'s (2011) study on acoustics of interconnected corridors with complex floor-plate shapes, found that as the shape of a long enclosures gets more complicated, the sound behaviour also become highly complicated.

4.2.1 Single-Patient Rooms Versus Multi-Bed Rooms

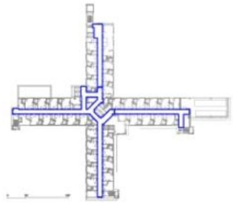
Studies have consistently shown that private rooms help reduce noise. The private rooms approach to enhance the acoustic environment have been supported by evidence-based design (EBD) research strategies. These strategies include the specification of noise-reducing materials and the provision of single-occupancy patient rooms (Maschke et al., 2000; Mazer, 2002). For example, concerning staff efficiency and patient safety, as well as comfort and satisfaction, the multi-patient room cannot be compared with a single patient room in terms of features such as patient visual and auditory privacy. This supports the notion that patients who are already ill and suffering from their existing infection, should not be placed in a noisy, crowded and impersonal hospital spaces, as this may increase their rate of illness. Additionally, it could be argued that private rooms are the norms of hospital planning and design in recent years (Mader, 2002), as experimental, comparative, correlation and case–control studies on single-patient rooms and safety have demonstrated that hospital spaces should meet the patients' privacy, safety, and dignity needs (Jolley, 2005; Lawson & Phiri, 2000).

Table 4.2. Floor plans of nursing units located in different hospitals

Hospital	Nursing units	Hospital	Nursing units
1 Paimio		2 Indiana Heart	
3 Bellevue		4 UCLA Medical Center	
5 Hasbro		6 Emory (5E)	
7 Clarian West		8 Johns Hopkins	
9 St. Joseph (MN)		10 Dublin	

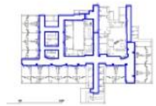
11

St. Joseph (WI)



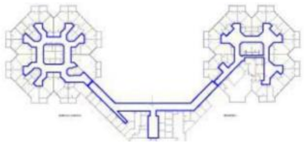
12

Emory (2D)



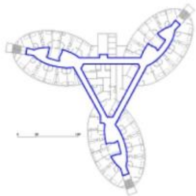
13

Dartmouth



14

Memorial North

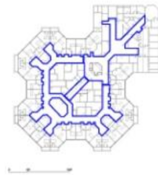


15

St. Thomas

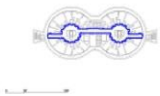
16

Yale New Haven



17

Kaiser



(Adopted from Okcu et al., 2011)

As it may be expected, single-patient rooms are better in creating an isolated environment by reducing the ambient noise level. Indeed, sound levels are much lower in single-bed rooms than in shared rooms or alcoves. Walsh et al. (2006) remarked that elevated sound levels and catheter-related infections have been demonstrated to be reduced for critically ill infants in single-bed rooms when compared to multiple occupancy rooms. Several research works have consistently established that most of the noise in a shared room is connected to the presence of another patient in the room. Relatively, the major environmental risk factors for patients in multiple occupancies comprises of lack of privacy, excess noise levels that can be detrimental to patient's comfort and recovery (Bayo et al., 1995). Buttressing this, a study has revealed that patient satisfaction with hospital sound levels was over 11 percent higher in double rooms when compared to single rooms (Ulrich, et al., 2004). It is interesting to recognize that several new hospital constructions today are already assuming a trend toward standardizing single-bed private rooms. Be that as it may, patients in multi-bed wards are subjected to more noise than those in single-patient rooms, which indicates that their tolerance levels may be higher. However, it should be noted that research has found links with higher noise levels in wards and poor sleep quality in daytime, affecting patients' health outcomes (Freedman et al., 1999). Similarly, Meyer et al. (1994) propounded that environmental noise and light, including patient interruptions can lead to sleep disturbance, particularly in the intensive care unit. Indeed, it could be supported that that patient will sleep better due to less noise in single rooms.

It could be argued that patients and family members tend to be more satisfied with single-bed rooms when compared to multiple bedrooms (Chaudhury et al., 2004). Similarly, several studies on patient satisfaction in single rooms has reported that patients experienced a higher level of privacy, more comfortable environment and more caregiver support and education (Swan et al., 2003), as well improved clinician satisfaction (Gallant & Lanning, 2001). Additionally, similar studies found that clinicians opt single rooms for maternity patients and neonatal intensive care patients (Harris et al., 2004). Likewise, single-patient rooms and the promotion of hand hygiene practice have shown to be effective in controlling the spread of infection from patients infected with air borne disease such as methicillin-resistant Staphylococcus aureus (Bracco et al., 2007; Ulrich & Wilson, 2006) gram-negative bacteraemia in burn patients (McManus et al., 1994) and respiratory and enteric infections requiring contact isolation in paediatric units (Langley et al., 1994). An intensive study conducted by Dramowski et al. (2015) confirmed that the combination of single-bed spaces and good air quality have the potential to reduce infection incidence and mortality among burn patients, and is safer for controlling contagious airborne diseases such as influenza, measles, and tuberculosis.

A study has demonstrated that single-bed isolation rooms intended to prevent the spread of infectious agents by means of pressure differentials to contain them and tend to be effective only if the room is tightly sealed (Saravia et al., 2007). Additionally, in order to effectively control infection in isolation rooms and other patient rooms, nurses must ensure that evidence-based practices concerning hand washing and aseptic technique to prevent infections are implemented (Ellingson et al., 2014). Studies have confirmed that the design of a patient room that foster flexible space, and fit with the changing acuity, as well as care needs of patients leads to decreased medication errors and falls (Bobrow & Thomas, 1994; Gallant & Lanning, 2001). Indeed, a comfortably-designed private patient room has also been found to be a factor for improving care delivery processes for clinicians, decreasing hospital length of stay, and enabling continuity of care during a hospital stay (Brown &Gallant 2006).

4.2.2 Speech Privacy and Patient Confidentiality

Several researchers on sound insulation have mentioned about the significance of speech privacy concern in hospital spaces. The findings of these investigations clearly revealed that many hospitals and outpatient physicians' offices suffer from speech privacy problems and as result compared to an open environment. This conforms to Barlas et al's (2001) who argued that patients are often exposed to a situation where private conversations are being overheard by an unintended individuals or listener. Furthermore, privacy is an obvious outcome of isolation, and isolation has been conceived as the most extreme form of privacy (Mazer, 2005a). Conversely, speech privacy has been conceptualised as to how well a private conversation can be overheard by an unintended listener, and the level of speech privacy achieved in a space is indicated by a privacy index (PI). Speech privacy and patients' confidentiality is one of the concerns of hospitals in recent years. For instance, in several outpatient physicians' offices within the hospital spaces, patients are often exposed to situations whereby their conversations are being overheard by an unintended person or their private health information conveyed in an open environment where it can be heard by other people. Specifically, this could pose a serious breach of patient confidentiality.

The U.S. Health Insurance Portability and Accountability Act of 1996 (HIPAA) laid an emphasis in 2004, that speech privacy in healthcare facilities must be secured, as this would promote patient's protection (Evans & Himmel, 2009). It is worthwhile to mention that until lately; no standards had been accepted for enforcement of the speech privacy provision. However, with the recommendation made by (HIPAA) in 1996, speech privacy gained interest and has been adopted greater importance. The standard set out by (HIPAA) was mandate applies to any organization that handles patient's private healthcare information, including, for example, medical records and insurance

(Nass et al., 2009). The law mandated that all patient confidential health information communicated orally should be kept private. As set out in Figure 4.4 describes the range limit for speech privacy in healthcare and hospitals premises. The commonly recognized levels of speech privacy are presented in the footnote below. Moreover, the rules of thumb of the American Institute of Architects (AIA) recommended that normal speech privacy should be provided between enclosed rooms and confidential speech privacy in admitting areas, such as where patients speak about their personal health problems, as well as, psychiatric and psychological testing rooms, haematology labs, test rooms (Tocci et al., 2007).

Barlas et al. (2001) compared the effects of privacy on curtained areas in an emergency department rooms with solid walls and ascertained that patients perceived a lower sense of privacy because their private health information is being overheard and body parts exposed to unintended individuals. The results of the same study found that 5% of the patients examined in curtained spaces in an emergency department withhold part of their private medical history and refused to disclose their physical examination as a result poor privacy. Supporting this finding a very recent study by Pope and Miller-Klein (2016) reported that privacy curtains improved sound absorption from 20% to 30%, thereby enhancing auditory protection for the patients. The authors further propose that in order to cut down reverberation time, additional absorption, and compact and more fragmented nursing unit floor plate shapes should be encouraged. In addition, Ryherd et al. (2013) identified that on the overall speech privacy and intelligibility is a major problem in most hospitals. In their study of speech intelligibility in hospitals, results demonstrated no unit had good intelligibility based on the speech intelligibility index (SII>0.75) and several locations in the hospital environments were found to have “poor” intelligibility (SII<0.45). Moreover, results showed that a unit treated with sound absorption had higher SII ratings overall and for a larger percentage of time as compared to the identical untreated unit. Indeed, one architectural design intervention that has gained recognition in reducing speech privacy include rooms enclosed with walls in examination and treatment areas where patients would be required to reveal personal health information (Barlas et al. 2001; Ulrich et al., 2004).

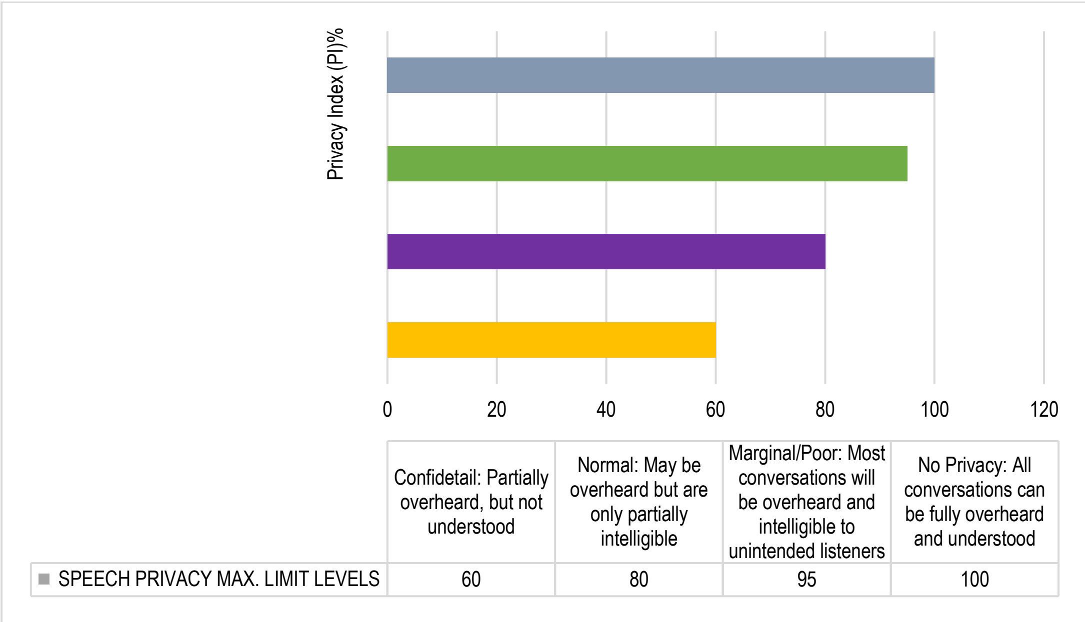


Figure 4.4. Shows level of maximum speech perception in hospitals and healthcare premises.[1][2][3][4]

Likewise, it has been indicated that patients in single-bed rooms consistently demonstrated more satisfied with concern for privacy when compared with those with a roommate. Additionally, a study that investigated staff perception as it concerns speech privacy in acute care environments reported that nurses acknowledged single

[1]Confidential: PI rating of 95 percent to 100 percent, conversations conducted within the space may be partially overheard but not understood outside the confines of the space.
[2]Normal: PI rating of 80 percent to 95 percent, conversations may be overheard but are only partially intelligible.
[3]Marginal/poor: PI rating of 60 percent to 80 percent, most conversations will be overheard and intelligible to unintended listeners.
[4]No privacy: PI rating less than 60 percent, all conversations can be fully overheard and understood.

rooms to be superior to double rooms for examining a patient and for collecting a patient's history (Chaudhury et al., 2006).

Architectural and engineering surveys have backed up the concept that installing high-performance sound-absorbing ceiling tiles could effectively mitigate reverberation times, in this way enhancing speech privacy problems within hospital environments for patients and staff satisfaction. For example, Blomkvist et al. (2005) noted that installing sound-reflecting ceiling tiles in an intensive coronary care unit shorten longer reverberation time and improved speech intelligibility. A similar study by Hagerman et al. (2005) remarked that installing sound-absorbing ceiling tiles and other finishes in an intensive coronary decreased reverberation time and enhanced speech intelligibility, as well as the quality of care for patients. In this same study, the researchers recommended that individual rooms should have walls that extend upward to the ceiling, particularly in areas such as inpatient, examination, and discussion rooms where private health data between patients and staff is intended to be harboured, as this would effectively reduce intrusive sound from outside the room, thereby enhancing speech privacy.

Another method for improving speech privacy in hospitals involves adding sound to the environment. In line with this, the FGI/ASHE provided guidelines for the design and construction of health care facilities, recommending that sound masking systems should be encouraged in healthcare applications to reduce reverberation time and improve speech privacy quality in hospitals. This technology incorporates a series of speakers, usually set up in a grid-like pattern in or above the ceiling, which distributes a comfortable sound evenly that most people compare to softly blowing air. However, sound masking systems are not very effective in reducing background sound level, as it increases it. In addition, occupants perceive treated spaces sound masking systems as quieter since it dominates noises that are lower in volume and reduces the impact of those that are excessive by mitigating the magnitude of change between baseline and sound peak levels. Supporting this technology application in the healthcare system, Xie et al. (2009) suggests that sound masking system can be very effective method for improving sleep in the intensive care settings. Similarly, Stanchina et al's. (2005) investigation in an intensive care unit (ICU) found that patients sleep quality improved by 42.7 % when sound masking was installed in the unit. In addition, similar to sound masking systems, adding soft or soothing music or sounds of nature such as that of falling water to the healthcare environment has been suggested to render unpleasant sound unnoticeable or help in masking less pleasant sounds, which may lead to health benefit such as reducing patient pain medication and facilitating recovery (Mazer, 2005b).

4.3 Components of Hospital spaces

Besides unit layouts and single-patient rooms, other design features in terms of evidence-based design practice for enhancing hospital space sound experience, include wall openings/windows and access to nature, as well as materials and finishes.

4.3.1 Wall Openings and Access to Natural Views

Hospital beds should be set up to give everyone a direct window view. This conforms with Ulrich's (1984) findings that hospitalised patients that had a view from their window into nature received fewer analgesic medications, fewer negative comments in nursing notes, and had a shorter length of stay when compared to those who looked at a brick wall. Research has also shown that larger windows increase provision of natural daylight and enlarge views offering opportunities for enhanced calming effect essential for patients' recovery and improved outcomes including a benefit for hospital care providers (Phiri & Chen, 2014). Similarly, study evidence has shown that healthcare design that meets the users' needs can positively influence patients' outcomes (Cesario, 2009; Ulrich, 1984; Verderber & Reuman, 1987), in that way improving recovery and reducing the length of hospitalisation for patients.

Many aspects of the hospital physical environment have received particular interest, such as the presence of a naturalistic view from the windows, and green spaces, including lighting and sound (Devlin & Arneill, 2003; Monti et al., 2012). A number of studies have shown that visual exposure to nature through the window have the potential of decreasing stress by eliciting positive emotions such as pleasantness and calmness in patients and healthcare providers (Parsons & Hartig, 2000; Van den Berg et al., 2003). Likewise, research findings on hospital ward soundscape suggest that positive feeling was clearly revealed in hearing songs of birds through the windows of the ward oriented toward a green space (Mackrill et al., 2013b). Indeed, the combination of views and sounds of nature have the potentials of evoking positive feeling in patients and healthcare providers. This concept is closely related to the biophilia theory which suggests human attraction towards nature (Wilson, 1984). In support of the human's positive association with natural sounds, studies have shown that certain natural sounds in a given space may enhance positive feelings and can have a substantial positive effect on the perceived tranquillity of a view (Guastavino, 2006). Further evidence of natural sound in a general anaesthesia context demonstrated that sounds of birds, and that of soft wind, and rippling stream dull physiological changes after anaesthesia, as well as enhanced patients' experience and perceived acceptability to anaesthesia (Tsuchiya et al., 2003).

Evidence from studies has shown that bedridden patients had a high preference for a hospital window view of nature (Douglas & Douglas, 2005). Similarly, a study has hypothesised that patients recovering from abdominal surgery had shorter stays if they had a bedside window view of nature rather than if their windows looked out onto a brick wall (Ulrich, 1984). Another study remarked that even when building sites have limited views of nature, designers are using interior spaces to create healing gardens and walls of windows to connect indoor and outdoor (Berry et al., 2004).

Exposure to natural scenes could be enhanced by means of using nature inspired curtains that exhibits scenes of nature and elements that incorporates nature sound. Study evidence has shown that the combination of nature simulations, including visual and auditory distraction may be more diverting and engrossing and hence more effective for relieving severe pain. This suggests that patients should not be put in rooms or treated in spaces that lack nature distraction or encourage environmental stressors such as excessive sound as this may exacerbate pain (Malenbaum et al., 2008). Similar findings by Kozarek et al (1997) investigated the effects of seeing and listening to a nature travelogue on patients undergoing painful gastric procedures and demonstrated that patient reports and nurse observations converged in suggesting that the combination of visual and auditory distraction improved comfort and tolerance for the procedures, when matched to a control condition without distraction. On the other hand, Tse et al (2002) discovered that healthy volunteers in a hospital setting had a higher pain threshold and greater tolerance when they view at a videotape (waterfall. Mountains, landscapes) of nature scenery on an eyeglass display when matched to those that looked at a blank display. A similar study by Miller et al. (1992) ascertained that distracting patients during burn dressings with a bedside television screen displaying nature scenes of forest, flowers, waterfalls, ocean and wildlife, in combination with music decreased both pain and anxiety/stress in burn patients suffering from intense pain.

Similarly, patients with pain might be encouraged to place their bed or chair near a window and take advantage of nature views and sounds by spending time outside (Malenbaum et al., 2008). In the same way, a research conducted on patients who had been treated in an intensive care unit (ICU) with windows that have natural attributes showed that they recalled their admission and discharge more accurately, had better orientation of the day and time, as well as experienced fewer sleep disruption, less visual disturbance, and less susceptible to hallucinations (Dijkstra et al. 2006; Keep et al., 1980). In addition, Wilson (1972) investigated the effects of windows on surgical patients retrospectively and divulged that patients placed in a windowless unit had statistically significantly fewer delirium reactions after surgery.

4.3.2 Materials and Finishes

Research suggests that several environmental interventions may be effective in reducing the hospital sound levels and improving the acoustical experience. The major means applied over the years to mitigate sound and to enhance patients and staff satisfaction includes installing high-performance sound-absorbing ceiling tiles and reducing noise from its sources (Taylor-Ford et al., 2008; MacLeod et al., 2006). There are evidence from existing literature that installing high-performance sound-absorbing ceiling tiles and panels results in reducing sound sources such as overhead paging sound levels. As such, reducing sound impacts on staff by improving speech intelligibility and reducing perceived stations work pressure among staff (Blomkvist et al. 2005; Hagerman et al. 2005. Moreover, it was noted in these studies that decibel levels were not significantly reduced (reduction of 3 to 6 dB(A), after implementing ceiling-tile, however, there was a significant reduction in reverberation times and sound propagation. Additionally, Hagerman et al. (2005) remarked that patients cared for in an intensive coronary care unit that integrates sound-absorbing ceiling tiles had healthier attitudes than patients in a unit that incorporates sound-reflecting ceiling tiles. It was deduced from the same study, that in terms of sound mitigation in hospital spaces, sound-absorbing ceiling tiles could be more effective than sound-reflecting ceiling tiles.

Furthermore, Chaudhury et al.'s (2009) recommended that sound-attenuating surfaces, such as ceiling tiles, may help mitigate excessive sound levels in hospital settings. Supporting this approach, Blomkvist et al., (2005) suggested that when traditional lightweight ceiling tiles (such as suspended ceiling made up of wood or mineral fibres) are replaced with sound-absorbing tiles in patient rooms, enhances patients sleep, reduces patients stress outcomes, and improve nursing staff-patients care giving. Although research suggested that carpet should be installed in hospital hallways and patient's rooms to minimize noise (Harris, 2000; Neumann & Ruga, 1995). Conversely, McCunn and Gifford (2013) remarked that carpeting is not a design feature used anywhere in the Acute Care Settings, most especially in Neurological Rehabilitation Unit (NRU). MacLeod et al. (2006) remarked that when sound absorbing materials were applied in an oncology unit corridors, results demonstrated reduced reverberation times and sound pressure levels in the unit diminished by 5 decibels. Moreover, it was observed that patients and patients care provider perceived a better-quality acoustic environment when compared with the initial unit without absorbing materials. The nurses reported improved concentration, communication, and sleep for patients in the unit. The study concluded that sound absorbing materials should only be applied in the hospital hallways. Specifically, carpeting of hospital floor has been highly discouraged due to microbiology associated contaminants (Anderson et al., 1982) that could comfortably breed in damped carpets. For a carpet to be used it must meet the highest performance standards. Be that as it may, it should be noted that choosing carpet system with antimicrobial properties can further inhibit the growth of harmful bacteria and fungi within the hospital space. For instance, in hospital spaces hard surfaces are often highly encouraged for cleanability, however, these surfaces extremely reflect sound that generates excessive reverberation in these spaces. In addition, high-efficiency filtration systems are of paramount, as they greatly reduce the airborne particles in healthcare systems, however, these surfaces require more fan horsepower, but generates greater noise within the hospital space when compared with other systems (Davenny, 2010, 2007).

According to Armstrong Ceiling Systems (2003) documented report, it has been broadly admitted by various researchers that when individual component's acoustical performance and installation details are combined will significantly change the overall performance of a hospital space. Additionally, to sum this section, the acoustical design properties of some usual materials and finishes in hospital settings are addressed briefly below, as it is not within the scope of this thesis to go into details on this aspect.

Acoustical Ceiling Tile (ACT)

Acoustical ceiling tile (ACT) has the ability to mitigate reverberation times and enhancing speech intelligibility, as well as improving the psychosocial work environment for patient care team (Blomkvist et al., 2005). Therefore, choosing the right ceiling for hospital spaces is significant in generating the fitting speech privacy level. However, it should be noted that in some circumstances different ceilings are needed in different areas, as the case may be. Hence, in choosing a ceiling tile for a hospital space, the designer should consider to what degree noises need to be absorbed, blocked, and/or covered (MacLeod et al., 2007). For instance, in the event that a hospital space allows incorporating a suspended acoustical ceiling system (i.e., sound-absorbing ceiling tiles), the sound designer should set up the sound absorbing panels directly onto the ceiling and upper walls, as this may be efficient in mitigation noise, thereby promoting a satisfactory acoustic environment for hospital residents. In addition, the Green Guide for Health Care (GGHC) in 2007, recommended that hospital spaces with noisy equipment above the ceiling plenum with walls that do not extend above the plenum level, should consider using specified ceiling tiles that have a Ceiling Attenuation Class (CAC) of 35 or more to effectively minimise noise in the space for the user's health and wellbeing (Davenny, 2007).

Similarly, Glass fibre Acoustical ceiling tile comprises of high sound absorption qualities and usually have a Noise Reduction Coefficient (NRC) ratings of 0.90 or higher. If the Glass fibre is covered with a thin, anti-microbial film, using a particle-free assembly can make them acceptable for clean room applications, as well as not compromising their sound absorption qualities. Glass fibre is deemed appropriate for corridors and open offices use as they do not have very high sound isolation qualities and the background noise will often mask the noises coming from the ceiling plenum. Additionally, mineral fibre acoustical ceiling tile incorporates sound absorption properties (maximum 0.80 Noise Reduction Coefficient), which is lower than glass fibre acoustical ceiling tile, however, characteristically have a higher Ceiling Attenuation Class (CAC) that falls between 30 and 40, demonstrating that they have the ability to mitigate sound transmission. Moreover, they may be suitable for healthcare spaces that call for both sound absorption and isolation and it has been shown to be effective in diminishing noise from equipment in the ceiling plenum. On the other hand, composite ceiling panels which comprises a combination of a glass fibre facing and a mineral fibre or gypsum board backing have high sound isolation and sound absorption, that is, high Ceiling Attenuation Class (CAC) and Noise Reduction Coefficient (NRC), making them a good option for hospital noise reduction, particularly neonatal intensive care units (NICUs) (Davenny, 2010; 2007).

Wall Surfaces

Wall surface materials is a fundamental factor to be considered for getting an appropriate acoustic environment for users. One major consideration is to prevent flanking noise from negating the intended functioning of any wall assembly, as this would result in a significant drop of acoustical performance (Waropay & Roller, 1986). For instance, healthcare designer and their collaborators should be cognizant that both doors positioning and HVAC duct layout can influence the privacy performance of walls. It should as well be noticed that direct duct running through rooms should be avoided, as this would improve privacy and decrease distractions in a healthcare environment. Moreover, in the case of wall surfaces, designers should recommend surface-mounted, one-inch thick wall panels or other sound-absorbing wall materials which incorporate Noise Reduction Coefficient (NRC) of 0.70 or higher to effectually absorb noise from common activities in hospital spaces, specifically in large areas where noise tends to be excessive (Green Guide for Health Care, 2007). In the same way, cover glass- or natural- fibre wall panels with a thin, impermeable film (e.g., taffeta vinyl, polyvinyl fluoride) could be applied to walls in hospital spaces to mitigate noise, as permits easy cleaning. Another wall surfaces material is Fabric-wrapped wall panels which could be applied in non-clinical areas of a hospital to reduce noise, especially where regular cleaning is not necessary, as they are more effective and inexpensive than panels that are encapsulated in the film (Davenny, 2007).

Flooring Materials

It is likely to decrease impact noise produced by footfalls and rolling carts through recommending suitable flooring materials and finishes. As it may be expected, most common floor surfaces applied in hospitals such as rubber flooring tiles can create less impact noise than other kinds of flooring, for example, vinyl composition tile installed directly on concrete or terrazzo. Similarly, building floor discontinuities such as expansion joints and transitions between floor finish types should be minimized to avoid impacts when engaged by rolling equipment (e.g., rolling carts) in hospital spaces (Sykes et al., 2010). Another design consideration for flooring materials is recommending appropriate carpet to effectively reduce impact noise, such as footfalls, rolling carts in hospital spaces. Carpets to be applied in hospital environments should integrate Noise Reduction Coefficient (NRC) of around 0.20 to 0.30 and should be considered as substantial element mitigating absorbing sound (Sykes et al., 2010). Therefore, not understanding the right carpeting to be used in hospital corridors may potentially create problems related to efficient movement of computer carts and cleanability. Consider placing computers in each patient room to eliminate the need for carts. Certain carpet tiles that can be easily removed and cleaned, when needed, should be recommended for hospitals (Montague et al., 2009).

4.4 Summary of Lessons from Best-Practice Designs

Several studies have recommended other conventional way for reducing sound levels in healthcare spaces which include substituting overhead paging with cell phones or wireless communication devices and turning off equipment when not in use (Glind et al., 2007; Chaudhury et al., 2009; Baevsky et al., 2004; Bailey & Timmons 2005; Buelow, 2001), behavioural change and eliminating excessive sound sources such as ice machines from the unit (Xie et al., 2009), conducting group conversations in an enclosed space, and educating staff about the importance of talking quietly (Nagorski, 2003; Kahn et al., 1998) and maintaining a quiet environment (Crawley & Emery, 2006; Gardner et al., 2009; Dennis et al., 2010; Cranmer & Davenport, 2013). However, most these methods are inconsistent, and specifically, it is not clear whether these interventions are successful in trimming down the sound levels in hospital environments, as none of these sound level reduction methods comply with the World Health Organization (WHO) recommended sound level guidelines of 40 decibels for night-time noise (Blomkvist et al., 2005; Persson Waye, 2013).

Conversely, Philbin and Gray's (2002) investigation showed that change in hospital care provider's behaviour has no notable effect on the control of sound pollution in hospital wards. Even so, the same study found physical changes of the acoustical features and behavioural change of staff in wards to be efficacious in cutting down noise. Additionally, low-cost or affordable environmental alterations such as fixing the noisy doors and wheelchairs can have a small but noticeable effect on the sound levels within the Intensive Care Unit (ICU). Moreover, educational noise reduction programs to the ICU staff commonly appeared to be the most helpful and inexpensive mechanism for reducing sound. Public indicators that provide a light or beacon when sounds exceed specified levels are also helpful reminders for ICU staff and visitors about sound levels. A quiet time protocol may be helpful to institute a culture change for the staff. In addition, even if it only runs for an hour during the afternoon, such a protocol serves as a useful reminder for everyone of the importance of quiet, however, could be discomforting to hospital occupants.

On the other hand, many of the studies applied administrative control methods such as behaviour modification and staff education, which reduced noise in the intensive care units (ICU), but the reduction, was nevertheless not enough for sound levels to achieve recommended levels for ICUs. It should also be noted that the finding of the sound reduction program or intervention established that no investigation has measured sound levels in the hospital settings, particularly, in the intensive care units (ICUs) that comply with the World Health Organization (WHO) and other international recommended sound level guidelines for healthcare noise. However, as a hint for future implantation, an effectual combination of administrative and architectural controls may reduce the excess sound levels slightly close to the recommended level while simultaneously ensuring occupant safety within hospital environments.

Adding to the aforementioned, traditionally associated with healthcare architecture, evidence-based practice is making inroads into being part of the process for designing hospital spaces. This focuses on approaches demonstrated to be effective through empirical research rather than through anecdote or professional experience only. Architects and their collaborators have always intuitively known the value of design decisions on the quality of human experiences. Social and behavioural scientists as well have added to this body of knowledge that increases our understanding of how design impacts these experiences. From evidence-based practice connotations, it is now possible to use research to answer critical questions about why this happens and how designers can improve the human experience. The key concept of evidence-based practice includes defining evidence-based goals and objectives, finding sources for relevant evidence, critically interpreting relevant evidence obtained, creating and innovating evidence-based design concepts, developing a hypothesis, collecting baseline performance measures, monitoring implementation of design and construction, and measuring post-occupancy performance outcomes.

Drawn from different knowledge sources, this present research attempts to develop an improvement potentials for hospital experience, a conceptual model for understanding sound and the possibilities for improving hospital spaces in view of patients, their family members/visitors and patients care team's positive experience. This model includes knowledge sources, aspects of design and strategies for improving and developing potentials for hospital positive experience. The theoretical and empirical support for the proposed model, including the practical strategies for its implementation in other industries or settings are outlined in chapter 5.

4.5 Chapter Summary

This chapter presents the design interventions for improved sound experience in hospital environments. Most of the previous hospital environmental noise interventions for mitigating noise in the health care facilities were also highlighted. This chapter also highlights the aspect of hospital layouts with a focus on patients and caregivers' safety and satisfaction. This includes the provision of single-patient rooms, speech privacy, and patient confidentiality concerns. In addition, components of hospital spaces were also highlighted considering wall openings and access to natural views as it relates to inviting positive sounds into the hospital design space for evoking positive feelings in patients and staff, materials and finishes as it relates to reducing sound impacts on staff by improving speech intelligibility and reducing perceived stations work pressure among staff. This chapter concludes by discussing the lessons from best-practice designs as it relates to the proposed model presented in this research.

Chapter 5

A MODEL FOR UNDERSTANDING AND IMPROVING HOSPITAL SOUND EXPERIENCE

The conceptual model presented in this study contributes to the rising body of evidence, often termed 'evidence-based practice' which advocated that the physical health care environment can produce a difference in how quickly patients recover or adjust to specific health conditions. This means that understanding the specific environmental stimuli (e.g., sound/noise) and their effects on wellness and health outcomes may facilitate atmospheric changes in hospital space and in turn may act upon positive experience of patients, staff, and patients' family members. In order to efficiently implement such design concept on a larger scale for other industries or sectors, a clearer understanding of the exact mechanisms involved is desirable. To enable the implementation of an effective intervention in health care practice and design, the presented integrated model emphasizes the importance of focusing on evidence-based practices, improvement strategies and development possibilities to achieve successful and lasting reform (see Figure 5.1). This recognizes the fact that scientific evidence alone is not sufficient to sustain the evolution of evidence-based practice. The presented model incorporates best practices drawn from several fields, including environmental psychology, music psychology, soundscape ecology, hospital management, engineering, industrial design and multisensory architecture to offer a framework for sustaining effective interventions for improving hospital experiences.

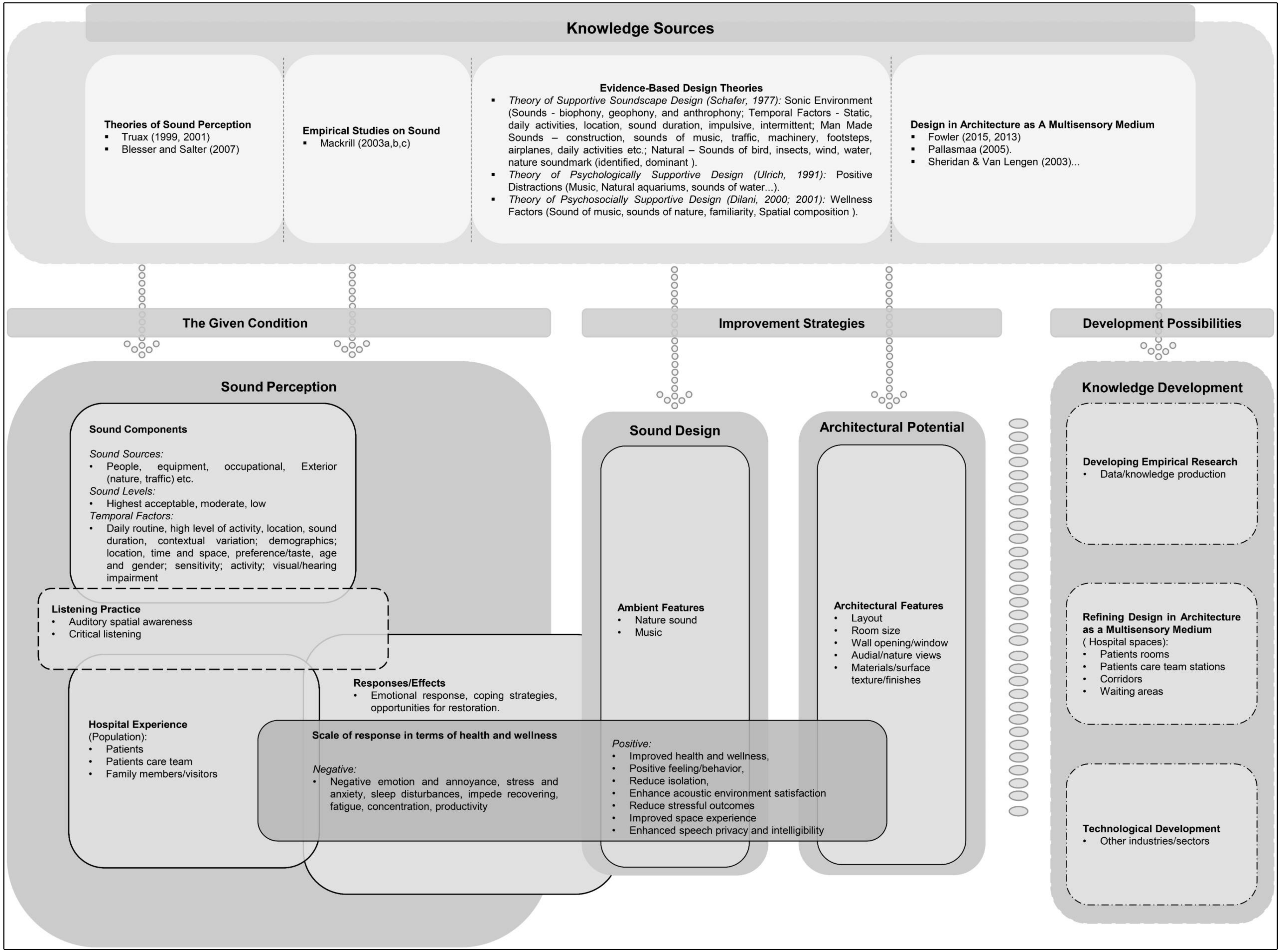


Figure 5.1. A conceptual model connecting the aspects of knowledge and design strategies for understanding and improving hospital sound experience.

The model comprises of 4 main important components and each role is essential and overlap each other, one cannot thrive with the other. This includes knowledge sources (theories of sound perception, empirical studies on sound/noise, evidence-based design theories, and design in architecture as a multisensory medium); the given condition of the research (sound perception); improving strategies (designing with sound and architectural potentials) and; development possibilities/potentials (knowledge development). The researcher believes that investment in the integrated model offers many benefits. The model is clearly evidence-based, having been developed from empirically tried and proven practices, including theories of evidence-based practices. Ultimately, the implementation of the model should result in improved functioning of the hospital ecosystems. Each part of the conceptual model is discussed from sound sources to development possibilities. These explain the logic and theoretical interpretation of the model. The model main components are discussed as below, which include the knowledge sources, the given condition, improvement strategies and development possibilities.

5.1 Knowledge Sources

This informs the theories and sources of knowledge/materials derived from the vast literature that developed and help in shaping the understanding of the inquiry describing the perception of sound. A variety of information sources were used which include literature from different disciplines as aforementioned. The knowledge sources were critically reviewed through selecting significant findings to determine what information is credible, and what practices would be most effective in giving the best available evidence. This also contributes to determining the evidence's meaning in relationship to this study. The themes derived from the huge knowledge sources were categorised to develop a conceptual model.

5.2 The Given Condition (sound perception)

This aspect of the model provides a rich data information for understanding the perception of sound and the experiences its evoke on patients, staff and family members/visitors. It also portrays subjective responses to sound within a hospital environment, incorporating both physical and social context as well. This facilitated a variety of different aspects to emerge from the data revealing 5 key themes for understanding the perception of sound in hospital spaces. This includes sound components (i.e., sound sources, sound levels, and temporal factors), listening practice, hospital experience, response/effects and scale of response in view of health and wellness. The model highlights the causation factors that generate the sounds within a hospital soundscape, as well as associated factors that could affect sound perception including time and space. The sound sources are central features of perceptual experience as they activate the communication between the surroundings and the populates of the space.

In order for sound to be understood in a given environment, listening practice is required (i.e. attentive or critical listening and auditory awareness). Supporting this claim, Topf's stress model postulated that when patients have access to information from within their environment they perceive it less stressful. In line with this model, it is posited that when users understand the hospital sounds, this enables them to habituate and accept sound. However, the manner in which space is experienced by the hospital inhabitant (patients, their family members/visitors) could have a twofold effect. This gives rise to responses or effects, a scale of response in terms of health and wellness that could either be perceived as positive or negative, depending on the physical and temporal variation in which the sound is heard. If individuals are informed about a specific sound within the hospital environment this can alleviate the negative feelings, they have. In addition, sound can provide a positive effect as long as they are accepted and understood within the context by individuals. The fact that patients and staff cannot escape unwanted sound in the hospital and it is not controllable from their point of view adds to the experience of stress, termed as a negative experience. This is linked with elements of control they may have towards the sound. However, a transition from physical sound into the emotional response of the individual could bring about coping strategies, giving an opportunity for restoration that offers a means to 'enable, optimize, and facilitate health and wellness, promoting thoughts and behaviour.

In this view, the effect of sound in the healing environment is not necessarily negative. If the sounds are intelligible, controllable and make sense in the overall environment of the hospital, they may not have a deleterious effect and might bring about the satisfaction that promotes hospital experience. This moves sound from what is considered a negative environmental component to a feature that is understood. This understanding contributes to an improvement strategy, which requires that the hospital experiences could be further improved by incorporating sound design and architectural potentials.

5.3 Improvement Strategies (sound design and architectural potentials)

The model depicts the understanding of sound perception and the possible improvement strategies through sound design and architectural potentials to improve the emotional experience. The cluster of sounds within the hospital environment and the experience they evoke can be mediated through sound (e.g., nature sound and music) and architectural potentials (layout, room size, wall openings etc.). This approach may have a profound impact on the hospital experience, thereby improving health and wellbeing. The model demonstrates that hospital spaces designed with meaningful sound of nature and music have the ability to transform the space, thereby promoting positive hospital experience for users.

Regardless of negative notions about adding sound into the hospital environment, sounds have the potentials to elicit more positive feelings, which may promote health, safety, and well-being. Sound creates an emotional connection with audiences. This is consistent with hospital space that incorporates openings (windows/view out) that invites the perception of birdsong through the windows of rooms that overlooked a green space brings about a positive response. It would be more evident when visual and hearing are combined to bind our senses. The combination of visual elements and hearing nature sound contributes to the positive emotional feeling that promotes hospital experiences. The model suggests that aural understanding has the potentials of creating pockets of conversation which in turn may increase intelligibility within a hospital space. It is believed that these same ideas can be adapted to a larger scale, within the context of other architectural spaces, to tackle the problem of noise or render other unwanted sounds unnoticeable. Expanding on this, in terms of music, sound designers with the knowledge of parametric modelling and digital fabrication can create an integrated acoustic system where meaningful sounds are all part of a single ceiling surface. We can imagine facades, and hospital interior spaces in the same manner. Making hospital space resonates by incorporating sound into its design have a profound influence on the hospital experience which promotes positive health outcomes.

Therefore, the combination of sound design and architectural potentials give rise to improved hospital experience. This experience includes improved health and wellness, positive feeling/behaviour, space experience acoustic environment satisfaction, speech privacy and intelligibility, reduce isolation and stressful healthcare outcomes. Despite this claim, the challenge for design research is to understand how to design meaningful sound within the healthcare setting for a more positive experience. In order to achieve this, further development possibilities are required.

5.4 Development Possibilities (knowledge development)

Developing empirical research (data/knowledge production): The model highlighted theories of cognitive appraisal and multisensory design as it refers to an emotional reaction to sound perception, sensitivity to the hospital sounds as well as acknowledging diverse physical and social environments. This provides a rationale for developing empirical research on how sounds can manipulate perception through physical and cognitive means to improve hospital experience. It is obvious that further empirical research should be developed or conducted to corroborate the model. This may lead to feasible possibilities to improve the hospital experience for users. It will also move the knowledge of sound to what is considered a negative environmental component to a feature that is understood. Exploring the notion conveyed in this model in an in-depth manner provide a clearer picture of hospital sound and how it induces residents' response and behaviour. It is believed that this would generate a means for improving the perception of the sound based upon the interpretation of the model.

Refining Design in Architecture as a Multisensory Medium**:** The model prepared will be tested against benchmarks based on the users' experience to verify the various aspects of the development. This should be refined to achieve multisensory architectural design spaces in hospitals. The model will be scientifically tested through laboratory/control trials or field experiments involving repeatable listening evaluations. This may provide a robust way to evaluate the model components and further develop the idea of what sounds evoke. The model will be implemented in hospital spaces such as patients' rooms, patients care team stations, corridors/hallways, and waiting areas. The refinements and rectifications of the model will be undertaken until target users' satisfaction is reached.

Technological Development (other industries/sectors): The model presented that sound perception in space for experience should go beyond listening evaluation to balance the academic knowledge with practical production work. In this case, other industries/sectors such as audio-visual industries, including sound designers and engineers are also involved in manipulating the space experience through the production of new technologies, equipment, and techniques, design and materials to enhance the process and art of sound perception. For example, they might design, acoustical simulations of rooms and materials, shape algorithms for audio signal processing, and specify the requirements for public address systems. The typical sound designer would be interested in furthering their experience and knowledge, applying skills across a broad range of sound genres to which sound design applies, such as film, media production, special effects, computer games or related multimedia and sound art applications. Therefore, this suggests that the combination of theoretical knowledge of sound and the technological know-how on sound production/design will provide a more feasible way on how to manipulate and improve space experience through sound sources.

5.5 Limitations and Future Work

The suggested model is by no means conclusive, it could be further expanded for clearer elucidation. It could be argued that many of the factors affecting sound perception do not relate to the sound itself. Other factors such as variations in the context, demographics, activity, time and space, preference, sensitivity, visual and hearing impairment might affect the perception of sound (see Figure 5.1). It is hoped that by creating a basic sound and materials through new technological means that produce better sound quality, may help make sound positive within the context of the hospital space for user's experience. Empirical research should further explore the conceptual model notions expressed in this research in a rigorous manner to determine the role of hospital sound and how it evokes patient response and behaviour.

5.6 Chapter Summary

This chapter presents a proposed model for understanding and improving hospital sound experience. The model/framework highlights the aspects of knowledge sources, design practices and strategies for understanding and improving hospital sound experience. The model development is an effective research method which provides a logical guideline to the architects and other researchers in proposing any new system of research in hospital noise and user experience. This chapter concludes by discussing the limitations and future work as it relates to the proposed model presented in this research.

Chapter 6

CONCLUSION

The present chapter gives a summary of the study findings and provides suggestions for further research. This study developed a theoretical framework, a novel paradigm for noise research and design practice for hospital environments. Indeed, hospital sound research will continue to be an important topic as researchers are finding out more about how to better sound perception in these spaces and its relationship to physiological and psychological outcomes of patient and patient's care teams. This study re-articulates findings of investigations worldwide about hospital sound level and sources. These are far too high, with decibel intensities greatly exceeding guideline values such as those issued by world health organization (WHO), United Kingdom (UK), and the United States Environmental Protection Agency (EPA). For example, much of the sound in the hospital spaces emanate from bed rails being moved, overhead paging, trolleys, medical equipment, and staff shift changes, including conversation etc. and are unnecessarily loud. The problem is exacerbated by the prevalence of hard, sound-reflecting floors and ceilings that cause sounds reverberate, linger, and propagate over large areas into patients' rooms and staff areas.

Massive research has been conducted in hospital environments based on sound levels analysis and sound level reduction of these spaces. However, previous research often overlooks the social aspect of sounds and the meaning they evoke within the hospital physical spaces. In order to understand the hospital sound, subjective response to sound is also essential, that is, the emotional aspect of sound perception. This dissertation attempted to tackle some of these potential holes in the previous research. It highlights that design concerns with sound can improve the physical environment, and foster positive mental, emotional, and social characteristics essential for reducing stress, anxiety and promoting profound outcomes for hospital occupants.

The main research question posed in this study is *'how can sound be better incorporated into hospital space so as to evoke a positive influence on the occupants' experience?'* This question has been addressed, as the orientation and scope of the research was to develop a theoretical framework for understanding the meaning and the role of sound in hospital environments, and how the acquired understanding can be used for improved hospital experience for occupants' health and well-being. The present study sheds light on the physical, environmental factor design in terms of sound sources and music and their impact in facilitating better user health and wellbeing, including satisfaction, efficiency, and organisational outcomes.

However, another important aspect of this inquiry is to go beyond the notion that noise is simply undesirable and look into the extent to which researchers have investigated the significance of sound in hospital environments, thereby identifying a novel opportunity for conceptualising research, and design practices with respect to hospital noise. This present study argued that there is a need to view the sound in hospital settings as if there were soundscapes and have a closer look of sound in terms of the meaning they convey within the healthcare soundscape, rather than merely containing unwanted sound or the absence of it. This dissertation dealt with the main research question raised by using an interdisciplinary approach, taking up the subject that includes theories of sound perception and ecology, empirical studies, evidence-based design theories, environmental psychology, hospital management and multisensory design in architecture, including other environmental factors and hospital experiences. It exceeds current studies and developed a conceptual framework for creating a positive sound experience and design practices for hospital environments.

The whole idea of the thesis was framed from three theoretical underpinnings that are related to evidence-based design (EBD) theories. These include the *theory of soundscape design, the theory of Psychologically Supportive Design and theory of Psychosocially Supportive Design.* The intersections of these theories (i.e., sound perception) as it relates to hospital experience were rigorously explored in this research. These theories incorporate the sonic environment (including natural and man-made sounds and music composition), positive distraction (including natural sound and music) and wellness factors (including sounds of music and nature) which gave rise to the scope of this study (the role of sound perception).

The proposed model demonstrates the links and relationship between the concepts that represent the hospital user’s sound perception. It also highlights the major features of acceptance and habituation of sounds, which give rise to a coping strategy by which occupants deal with the hospital sounds. This could be perceived either negative or positive, depending on the variations in the context, demographics, activity, time and space, preference/taste, sensitivity, visual and hearing impairment might affect the perception of sound. This creates a link between the physical and social environment, components of the sounds (sound sources, sound levels, temporal factors), hospital experience and scale of responses/effects. The model suggests that sound design and architectural potentials could have a profound impact on patients, patients care providers and family members. The model includes development potentials for improving hospital experience for occupants. The notion behind this conceptual model is to inform architects, designers, and their collaborators that there is scope for manipulating space with sound through evidence-based design for improving the quality of care for patients, their family members and patients care providers within the hospital. In addition, by evidence-based design understanding, hospitals can shift from being unsupportive settings to become places that enable interdisciplinary interaction, promote staff wellbeing, and enhance the safe and efficient delivery of patient care.

This study highlights that sounds have some beneficial aspect in terms of enhancing the experience, influencing mood, improving emotional and mental restoration capacity of an individual in a space, including improving coping strategies and reducing stress among health care users. It also establishes that sound increases awareness of a given space, which in turn promotes positive feelings, such as relaxed mind, social cohesion, and improved health and recovering. Evidently, much of the sound conveys meaningful information that is positive for both occupants, in terms of pleasant nature sounds of fountains, soft wind, rippling stream, soothing bird songs, and comforting music. In addition, it is evident that when listeners are engaged in auditory spatial awareness, there is that tendency that they can detect and interpret the audible attributes of spatial sound quality.

This study foreground that audible cues can produce emotional responses, such as an elevated sense of intimacy, and on the other hand, cues can change behaviour. However, it could be argued that sounds may add to increasing or diminishing the positive impact of an architectural space experience, which gives the impression that there are pleasant sounds and unpleasant sounds in a given space, and this might affect how individuals respond to sound in space. It was shown that using music, ocean sounds, and random sounds have the ability to improve the sound quality of hospital ward design. It was also demonstrated by research findings that sounds of chirping birds, car horns, and babies crying have the ability of alerting listeners to imminent dangers, in addition to contributing to an individual's sense of awareness and well-being. It is believed that when sounds are clearly understandable, controllable and make sense in the health care settings, they may not have a detrimental effect, and may be beneficial in the overall ecosystem of the hospital for occupants.

Furthermore, research shows that music intervention in health care can have a positive effect on patient's emotions and recuperating processes. Additionally, music intervention also has the potentials of reducing stress outcomes associated with blood pressure and post-operative trauma when matched to silence conditions. It can be deduced that sound design can effectively render unwanted sound unnoticeable in space, however, at the same time, excessive sound in healthcare settings has been conceived to have unwanted impacts on patient care provider and patients, which as a result increases stress, interfere with sleep and impede patients' recovery. Indeed, soothing sound of music is an intervention that can help distract patient's attention away from undesirable experience, thus helping them to deal with emotional stress. This study also establishes that hospital environment that incorporates musical sounds can be a positive distraction that may effectively mask other irritating sound and therefore, reduces negative emotional feelings and facilitate recovery from illness. The study also infers that hospital physical environment that incorporates orchestra playing pleasant music promotes a positive experience that stimulates the senses, calms the nerves and makes the whole healthcare experience comprehensible, manageable and meaningful.

Indeed, the physical environment in which a patient receives care plays a significant role in their outcomes and should reduce pain, anxiety, and stress for patients' comfort and safety. However, the healing environment in hospital settings commences with the healing comportment of the patient care teams. Thus, such an environment should incorporate an atmosphere that is secured, trustworthy, and permits for compassions, clearness, and trueness. Research findings help deduce that hospital physical and social environments encourage wellness if they are designed to foster the reduction of environmental stressors such as the sense of control over physical-social surroundings, access to social support, connection to nature, and access to positive distractions. Additionally, such a space could also foster social, psychological, physical, spiritual, and behavioural components of healthcare support and stimulate the body's innate capacity to heal itself. Specifically, the main concept behind the healing environments is to provide a safety, and comfortable environment to reduce stress and confusion for hospital occupants. These stress reduction elements through evidence-based design concepts integrate soothing sound of music, bird songs, and water sounds, as well as single bedrooms, privacy, and speech intelligibility concerns. Other physical factors contributing to healing in the healthcare environment include views of natural landscape and implementation of environmental changes to enhance patient safety that may intensify medical error and increase infection rates. Therefore, a well-designed physical setting plays an important role in improving patients care team's efficiency and reducing the patient's hospital length of stay, thereby promoting less stressful conditions in the health care facilities. Interestingly, this current study suggests that nature exposures may tend to be more diverting and can reduce emotional distress and pain if they involve sound and visual stimulation.

However, while evidence-based design in hospitals and health care facilities has become an accepted principle in health architecture circle, it is still embryonic in practice and most architects have not yet embraced this practice. It was noted, that Architects and designers of health care facilities were failing to apply evidence to produce spaces that promoted healing. Evidence-based interventions in hospital spaces play an important role in making hospitals safer and more healing for patients and better places for staff to work. Moreover, it could be suggested that psychosocially and psychologically supportive hospital design can be achieved through the impression of a positive soundscape with the support of evidence-based research on sound sources and music in hospitals. This is also evident when architectural features are included in the hospital context to promote user experience. This current investigation identified quite a few evidence-based interventions for improving patients and patients care teams' outcomes, which consist of creation of single-bed rooms rather than multi-bed rooms, an environment that incorporates window that allows sounds of nature and views of nature, better ergonomics, acuity-adaptable rooms, as well as improved floor layouts and patients care providers work settings that mitigate noise. Furthermore, the findings of this study show that architectural design solutions can improve patient and staff sound experience, as well as improve their satisfaction within the hospital spaces. Application of architectural design interventions can have a profound effect on health and well-being of patients and patients care, teams, as well as improving patient's recovery, and reducing isolation. Similarly, architectural design solutions can reduce stressful outcomes, improve space experience, enhance speech privacy and intelligibility.

6.1 Proposals for Clinical Design Practice

- There is a need for implementing soothing sounds of music in hospitals to calm the mind and enhance healing, especially in waiting areas and isolated hallways within the hospital.
- Architects and their collaborators should design hospital courtyards and landscaped gardens close to patient areas to include plants that encourage the sounds of nature such as that of bird songs.
- Attractive curtains with good sight lines towards views of nature and nature sounds would add appeal to patients' rooms.
- Architects and their collaborators should work towards manipulating hospital spaces through positive sound/soundscape design, as this would reduce stressful outcome and strengthens coping strategies for occupants. Architects and designers should purposely introduce sounds such as those of birds, background music, ocean waves, rain showers in the design of the clinical environment for both patients and patients care team to elicit their emotional feelings, reduce stress correlated outcomes and strengthen coping strategies.
- However, not all types of music or sound can produce a desired calming effect, due to life experience, different musical tastes, and preferences. As such, it is essential to give patients and staff a sense of control over their music preferences. A greater sense of control can be achieved when patients are offered access control that supports patients to select their choice of music and control over televisions.
- Through the impression of evidence-based design, single bedroom should be highly encouraged in hospital environments, as this is beneficial for greater privacy, reduced noise, and crowding, improved quality of sleep, the

opportunity for family members to stay, and avoidance of upsetting the other patients. In addition, single patient room reduces the risk of development of new infections and reduce falls for patients who require constant supervision. Furthermore, falls may be reduced due to assistance from family. In the case of social isolation, single-patient rooms should be designed to incorporate nature scenes and sounds of nature that have the ability to distract thereby taking away stressful conditions of patients.

6.2 Suggestions for Future Research and Development

Creating a healing environment through thoughtful design by applying evidence-based design practice has the potentials of alleviating stress and even promoting eccentricity and imaginative thinking within the healthcare context. Designing positive sound spaces with the help of evidence-based research on sound sources and music in hospitals is a very important issue for health care worldwide. Moreover, the collection and overall description of sound, music and health literature surely is adding helpful knowledge to this issue. Conceptualising the essential qualities of sound in the hospital environment as a soundscape, rather than simply noise can permit a subtler and socially practical interpretation of the signification and the use of sound in hospital spaces. Thus, sound should be viewed from a social aspect as a positive addition to clinical settings to promote health in hospitals, rather than just emphasizing on noise reduction.

Winston Churchill once said that “We shape our buildings and afterwards our buildings shape us” (Stamp, 2000), by this, he meant that the buildings we design as architects have a significant impact on our social, physical and mental behaviour. In other words, architects and their collaborators need to base their focus on the social-physical meaning and role of sound in the environment of health care, and how these may be transformed into a soundscape to provide a richer physical space within hospitals. Furthermore, as this study proposes a novel dimension for understanding sounds in the built environments, this may help to change the notion of sound being regarded as a negative addition to the hospital space that requires mitigating. The findings of this investigation through evidence-based design may bring the concept of sound psychology and soundscape understanding to the architectural attention and design profession, which may be incorporated into holistic environmental evaluations of health care facilities. This would yield a way forward for promoting health and wellbeing of patients and patient care teams through evidence-based design practices.

The future approaches could advance the discipline, and influence better understanding of its contemporary manifestations. In addition to enriching theoretical foundations, such new approaches will help architects and their collaborators, including students to acquire skills in using the advancements of different disciplines in architecture and urban planning. The inference of this research will also provide new directions, unique propositions for broadening existing learning programs in architectural practices by adding to their knowledge about sound psychology and soundscape as well as new technologies and scientific research. Rather than emphasizing on noise and its deleterious effect in hospital space, there is a need to start conceiving the social aspect of sound as this may improve the perception and emotional experience of users within the hospital ecological system. As such, creating a positive soundscape hospital environment with the support of evidence-based research on sound sources and music in hospitals is a pertinent issue for health care worldwide and this area should be further explored to create a greater understanding of this new paradigm in the field of hospital noise.

Furthermore, this study recommends that architects and their collaborators should investigate different aspects of these supportive design approaches in hospital design. This would give room for conducting more empirical studies to investigate and verify the proposed conceptual model and identify other health factors in psychosocially supportive design, supportive soundscape design, and psychologically supportive design. The model suggests that the combination of theoretical knowledge of sound and the technological knowhow on sound production/design will provide a more feasible way on how to manipulate and improve space experience through sound sources. Future research should explore the proposed model concepts expressed in this research in a rigorous manner to establish the possible role of hospital sound and how it evokes a patient behavioural response.

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APPENDIX

Appendix A: Studies on Sound Reduction Practices in Hospital Facilities

Table 4.1. Summary of previous studies on methods for sound reduction in the healthcare facilities

Author (s)/ Pub year, Specialties and Study Design	Purpose & Objectives	Participant Size	Instruments/research tools for Noise Level Measurement	Duration of ICU Measurement	Identified Noise Sources	Suggested Method for Noise Level Reduction	Results/Conclusion	Study Pitfalls
Macedo et al. (2009); ICU; Observational study approach	To measure the sound pressure levels in three ICUs at a hospital in Jundiai, State of São Paulo, Brazil	Staff was recounted every 5min during the study, but the no. of staff involved was not specified	A Minipa model MSL1532C (USA) sound meter was used, corresponding with the Brazilian Technical Standards (NBR 10151), to measure sound levels in the ICUs at different periods including morning, afternoon and night at peak times of activity. Afterwards, the data were statistically analysed using Microsoft Excel 2000 software	Measurement was done during 2hrs per session (including morning, afternoon and evening)	No noise sources were mentioned nor specified in this investigation	Continued educational programs for ICU care providers and Informing them about noise to avoid behavioural change. Behavioural modifications, including provision of a particular environment for clinical treatment, controlling bells, turning down alarms, cell telephones, pagers, TV and radios, use of posters in clinical areas, defining quite time for sleep hrs., nursing. Environmental measures to reduce noise includes, noise absorbing floors, ceiling, walls, as well as physical partitions between beds in larger units, rubber seals should be introduced in doors and windows to avoid noise, and equipment should be tested for noise before acquiring it for ICUs	The sound pressure levels in the first ICU were found to be 64.1dB (A), in the Coronary Unit was 58.9 dB (A) and 64dB (A) in the second ICU. Elevated sound pressure levels in ICU are still associated with health-related problem for patients in these units. However, none of the three ICU pad levels were above 85dB, indicating no occupational risk for the health care providers in the studied environment	The significant effect of noise reduction by these methods was lacking in this study (i.e. Minimum and maximum noise reduction level). Measurement duration is not sufficient to justify result outcome. Longer duration is preferred and could be the best way for accurate results. Peak times of activity measurement were mentioned, but results were presented in dB (A) instead of DBC. Indicating that peaks (L_{peak}) were jumbled for maximum pressure level (L_{max})
Xie et al. (2013); CCU; Observational study approach	To investigate the behavioural patterns of typical noise sources in critical care wards and to associate their patterns to the health care environment in which the sources adapt themselves in several different forms	Staff and patients were mentioned, 3 nurses work together to turn over 3 patients in the multiple ward during the observation period, but total no. of participants involved in the investigation were not properly defined	Observational survey combined with statistical distribution analysis. Data were analysed with the aid of Matlab statistics Toolbox to fit and plot distributions, as well as to evaluate distributions at assorted points	Measurement was done for 3 inconsecutive nights, starting from 11:30 PM and ending 7:00 AM (7hrs 30min), the following morning	Sources of noise were observed from hospital personnel, static medical equipment, staff wearing protective clothing such as plastic apron, ventilators, monitors, syringe drivers/pumps, including humidifiers. Other sources of noise noted include hand washing and patients coughing, but were not included in the analyses	Investigators suggested behaviour observation that involves identification of typical noise sources. Five descriptors were used to identify the noise behaviour, which include interval, Frequency, duration, perceived loudness, and location. Clearly understanding the behaviours of typical noise sources. A behavioural modification was adopted in this study. The frequently inform the	The results of the study demonstrated the lognormal distribution to be most effective or appropriate statistical distribution for noise behaviour in relation to an interval and duration patterns. The turning of patients by healthcare providers was among different occurrences of noises. Talking was reported as the highest frequency noise, with the shortest intervals, as well as the longest durations, accompanied by monitor	The extent to which this method mitigates noise was not clearly defined, which might be difficult to apply as an effective noise reduction programme. The study includes reliance on self-reported measures and analysis, which implies that only observation and statistical distribution analysis might not be

						nurses to keep their voices down in order to promote patient sleep in the multiple – bed ward.	alarms. The main conversational sources of noise in single-bed wards took place around the entrance zone. Conversation in the multiple-bed wards was reported to emanate from the staff work zone. More occurrences of noises that are accompanied with longer duration were observed in multiple-bed wards compared to that of single-bed wards. Monitor and ventilator alarms were the least reported combination noises observed	sufficient for effective characterisation of major noise sources. However, the combination of this method with longer duration of nocturnal noise measurement could yield better outcomes.
Kendrick et al. (2012); Multiple occupant wards, single rooms and nurse stations; Experimental study approach	To investigate the blind Reverberation Time (RT) estimation in an occupied classrooms and hospital wards	The sound created by 2 individuals in the wards triggers noise that correspond to the sound ascertained in real hospital wards.	A Norsonic 140 Class 1 Sound Level Metre (SLM) was utilised in an occupied hospital wards to estimate and record discrete sound files at every period that the A-weighted noise level (L_{Afmax}) goes beyond 70 dB(A)	Ambient sound recordings were taken in a number of wards in two hospitals for 7 days.	Triggered noise sources (speech and impulsive sounds) comprises of conversation, moving of furniture and bed rails, use of rubbish bins and sinks, dropping objects as considerably as opening and closing of doors (door banking)	Maximum Likelihood Estimation (MLE) method	Results demonstrated measuring the hospital conditions using MLE could be quite challenging, since the occurrence of free reverberant decay is erratic and the acoustics may not be static. Although, results within a period of week shows that blind estimates of reverberation time can have a significant effect or accurate within ±0. 07s. Moreover, when curtains are drawn around the beds, results show a RT_{20} reduction between 0.1 and 0.3 s.	MLE method is limited in their ability to estimate or accurately control the quality of data or parameters. MLE can be highly biased for small samples (i.e. have a less significant in determining low frequency sounds). The authors suggested continuous recording (at least window lengths of 36 periods) in order to achieve accuracy, yet the acoustic conditions can be altered due to privacy curtains in use, confidentiality concerns, occupancy level, window openings and doors etc. and in turn can lead to irregularity conditions that can thwart accurate results
Morrison et al. (2003); PICU; Cohort observation study.	This study measured and described hospital noise as well as determined if noise is associated with nursing stress measured through a questionnaire, salivary amylase, and heart rate	Eleven (11) registered nurse were recruited as volunteers for the study	Audiogram, questionnaire data, salivary amylase, and heart rate were collected in a quiet room for the study analysis. A calibrated Quest Advanced 1900 precision integrating logging sound level measure (i.e. Quest Technologies,	After every 3-hours during the study period, each nurse was observed in routine patient care, considering and observing, the shift periods, the number of patients in the room, statistics of the whole unit, as considerably as recording the Paediatric Risk of Mortality Score (PRISM) of the nurse's patients. Heart rate and sound level were recorded	Typical sound pressure levels of noise sources were found to be (i) trauma phone 73 dB (A), (ii) overhead pages 59–84 dB (A), (iii) monitor alarms 62–74 dB (A), (iv) ventilator alarms up to 79 dB (A), (v) medication pump alarms 55–56 dB (A), (vi) conversations up to 73 dB (A), (vii) infants crying 78 dB (A), and (viii) cleaning crew/equipment which was up to 96 dB (A)	There was no substantial noise mitigating intervention that was recorded in the study, however, the authors mentioned an ongoing research on the need of reducing and replacing overhead pages and noises associated with trauma phone calls, as well as concentrating on	The average daytime sound level was found to be 61 dB (A), and 59 dB (A) at nighttime. Elevated average sound levels significantly triggered higher heart rates (p =. 014). Results demonstrated that higher average sound levels were also predictive of greater subjective stress (p =. 021) and annoyance (p =. 016).	A time interval of noise level measurement was not taking into account in this study. Another barrier that could pose limitation to this study is the small study size that was used in the survey. Another pitfall is that the nurses

			Oconomowoc, WI), was used for the measurement SPL in dB	continuously throughout the study period as well as saliva samples and stress/annoyance ratings were collected every 30 minutes.		noises related to cleaning equipment and staff conversation that compound high noises. The authors suggested further research on sound level and changes in nursing stress after replacement of noise sources.	Conclusion: The result showed that noise is associated with several measures of stress as well as tachycardia and annoyance ratings. However, further studies of interventions were suggested to reduce noise are essential.	were aware that the researchers were present and that they were being monitored, this could affect the result outcomes as well the nurse's routines of patient care and the amount of noise generated.
Tsiou et al. (1998); ICU; Observational Study	The study evaluated noise sources and levels in a six-bed intensive care unit (ICU) in Athens, Greece	The study uses 10 patients (6 males, and 4 females) to obtain questionnaire results, as well as nine 8hr sound measurement to obtain noise levels	Observation, questionnaire survey, as well as a Bruel and Kjaer 2231 sound-meter was used to determine the LEQ in decibel-A scale	The sound Measurements session lasted for 72 consecutive hours that was subdivided into nine 8-h periods, considering the staff shifts, which includes morning, evening and night-time shifts	The sources of sound fall into two categories and were further subdivided various part such as; *(i) Constant and quasi-constant noise* which includes, Human discussions (75-81dBA), Open oxygen sources (70-77 dBA), Air conditioning (60-67 dBA), Open suctions (70-82 dBA), Respirators (49-72 dBA) and (ii) *Thrust noise* that includes, Door (85 dBA), Connections/disconnections of gas supplies (88 dBA), Opening/closing of drawer and closets (85.7 dBA), Equipment, stretchers (beds, mobile X-ray unit) (90.3 dBA), Telephones and intercom devices (70-77 dBA), Equipment alarms (84 dBA), Mishandling of chairs: stools and other equipment (78 dBA), Items falling onto the floor (mainly metallic) (88-92 dBA) and Loud voice (90 dBA)	The study suggested lowering down of alarms, particularly at night-time. Staff awareness about sensitive issued to reduce noise, such as lubricating door squeaks with oil, lowering volume of loud telephone ringing, replacement of equipment such as broken trolley wheelbase, turning or switching equipment that are not in use such as inhalers, respirators or other equipment, avoidance of raised conversation (e.g. shouting), and keeping of voices as low as possible especially at night-time	The investigators identified human activity, operating equipment and construction engineering of the hospital building as the major noise sources. Noise levels were found to be [LEQ = 60.3-67.4 dB (A) daytime] and [60.3 - 62.7 dB (A) night-time] respectively, exceeding the WHO recommended criteria of LEQ should not be more than 40 dB (A), indicating that the ICU noise levels were higher by 27 dB (A) than recommended hospitals levels. There were no significant results derived from the questionnaire survey. The author argued that staff awareness and sensitivity are essential for noise pollution reduction in ICUs	Various sound sources combined with other continues high level of noises made it difficult to distinguish the intensity at sources, due to overlapping. The small number of sample size used in this investigation could affect result outcome.
Parente et al. (2001); ICU; observational study	To monitor, as well as to identify and control noise production in the ICU environment		The study used calibrated Brüel and Kjaer precision sound level meter type 2232 for the sound measurements in a 9 beds medical and surgical ICU	Measurement were conducted within a duration of 15-days without staff consents to reduce bias outcome. Noise level estimations were arbitrary examined at the peak of activity periods in the ICU (i.e. morning) and at lower activity periods	The documented noise sources of this study were found to be from equipment, human activity and conversations among the hospital providers and visitors or family members	The study suggested CQI, that includes identification, monitoring and control noise sources (including equipment, activities that occurs from humans, staff and visitors talking or discussion), reducing the number and duration of sound peaks that exceeds 80 dB(A), reducing the level of baseline background noise, as well as improvement of the ICU patients and staff environment	Results found measured maximum sound to be 81.9 dBA and mean measured sound to be 70.9 dBA (8.0 SD). Results also demonstrated minimum measured sound to be 55.5 dBA. However, obtained results in general showed that noise levels go beyond recommend levels for hospital and ICU with 27 dB(A). The study suggested for a continues quality improvement (CQI) project to control noise pollution in the ICU	Intervention did not reduced noise to the recommended criteria by WHO and EPA. Noise go beyond by 27 dBA for hospitals (Leq-60.3-67.4 dBA)
Kahn et al. (1998); ICU (MICU) and (RICU); noise identification and	Investigates sources of noises generating sound peaks of ≥ 80 dBA and to reduce the	Noted that all ICU staff participated in the study, but fail to mention	The study used sound level meter type 700 with internal storage capabilities for sound level measurements.	Measurements of mean peak noise level were recorded for a 60s interval sequentially for 24hrs over 2days	The major noise sources identified to be television and talking (49%). Other identified noises generated from air-conditioners,	The study implemented a 3-week period behaviour modification program that was tailored towards educational program,	The authors concluded that many of the noises generating sound peaks > or =80 dBA are amenable to behaviour modification and argued that	The investigators concluded that applying behaviour modification program reduced noise level

a trial of behaviour modification	80 dBA peak sounds through a behaviour modification program	number of staff involved in the training program	The measurements were done before and after behaviour modification. Data were analysed using Microsoft Excel for Windows type 5.0.		Ventilators, alarms (IV alarm, monitor, ventilator, and Oximeter alarms), telephones, nebulizers, intercoms, and beepers	including discussions about noise pollution and its influence on patients and the hospital work environment	noise levels in the hospital ICU can be effectively mitigated through a behaviour modification program. Study results demonstrated a decrement of sound by 1.9 dBA	in an ICU setting but did not specify the effectiveness of using this program to reduce noise
Kam et al. (1994); OR, RR and ICU; a systematic review of hospital noise pollution	To identify the noise sources in hospital wards and its detrimental effects on patients' health as well as to train staff about noise to obtain reduced noise in hospital wards	The study cited 28 article related to hospital noise environments	Secondary sources/review of existing literature	The time duration of the study was not stated	The major noise sources were found to be conversation among staff and equipment	Educating the staff about the detrimental effects of noise pollution on patients' wellness, modification of nursing care routine or activities and hospitals equipment design	The found that noise in the OR, RR and ICU exceeds the internationally recommended levels. The conclude that reducing conversation among hospital personnel in the hospital OR, RR and ICU can promote quitter settings for patients and healthcare providers	Time duration of the study and selected article range was not mentioned
Walder et al. (2000); SICU; observational/ Interventional study	To evaluate environmental factors (i.e. noise and light) that could hinder sleep and to implement guidelines that will significantly reduce noise through behavioural rules on light and noise levels for SICU staff during the night shift	During P1, 9 patients were enrolled in the study (Signifying 35 patient nights and 17 patient nights of mechanical ventilation) and during P2 8 patients were enrolled (Signifying 26 patient nights and 15 patient nights of mechanical ventilation)	A sound level meter in dBA scale was used to monitor continuously the noise levels from 11 pm to 5 am, before (period P1) and after (period P2) the implementation of guidelines. Software for data analysis was not mentioned, however, Comparisons between the two periods were made with an unpaired two tailed Student's t-test for both light and noise values, while nurses' sleep evaluation was reported with descriptive statistics	The noise levels were measured for a period of 2 nights before and after implementation of guidelines. Noises were monitored continuously for 7hrs (11pm – 5am). Period 1 took 13 nights and period 2 took 11 nights	Noise sources that contribute to sleep disturbances were found to be alarms and activities around patients but was not accessed in the study, noise was equated to restaurant for peak noise level during both periods	The guidelines implemented by the study include a. Systematic closure of all doors b. Utmost reduction of the volume of the alarm sound of the hemodynamic surveillance monitor c. Coordinating and limiting of nursing interventions within 11 pm - 5 am d. Talking only with a low voice as well as switching off phone, interphone, and television, or radio e. No use of direct light or electric torch in the room surveyed within 11 pm - 5 am	The study demonstrated that noise levels in both periods were high, which results to sleep interference, and the implementation of guidelines effectively reduced noise level equivalent from (P1, 51.3 dB; P2, 48.3 dB), peak noise level form (P1, 74.9 dB; P2, 70.8 dB), and noise identified alarms from (P1, 22.1 dB; P2, 15.8 dB) during P2. however, the background noise level in both periods were found to be constant	Software for statistical analysis was not mentioned, as well as the sources of noise around patients in the surgical were not clearly identified and accessed in this study
Anand et al. (2009); ICU; observational study	To measure noise levels and evaluate their relation to the time of the day and location in ICU	Number of human participants was noted in this study	Calibrated (accuracy ± 1.5 dB) three Tecpel DSL-330 noise meters was used for noise pressure levels to recording and SPSS version 15 software was used for the statistical analysis	Noise levels were measured over five different days with a sampling interval of 30 s, and the maximum, minimum and average noise levels at each hour of a 24-h period were utilised for analysis	The major sources of noise identified in the study were from medical equipment in use and occupant's general activities	The study proposed reduction of noise from realised sources and increasing noise effect awareness among staff, decreasing noise from ventilator, monitor alarms, ringing phones, door bells and lubrication of doors to avoid noise from door hinge	Results showed that mean noise levels for beds 2, 7 and 14 found to be 54.4, 56.3, and 52.5 dBA respectively. The lowest, highest, and average noise levels during nighttime were 40.6, 76.1, and 59.19 dBA; and during daytime were 40.9, 79.1, and 59.38 dBA respectively. The lowest recorded sound levels (> 40 dBA) and background average (> 30 dBA) noise levels during any 24-h go beyond WHO rule of thumb	Number of participants in this study was not noted. This study literature review was too limited to justify results
Monsén et al. (2005); NICU; observational/	To examine factors that interfere with sleep as it associates to staff	M1 (i.e. before executing behavioural modification	The non-disturbance behavioural modification programme (BMP) periods occurred	Using a dB meter, min, max and peak mean noise levels were measured and recorded incessantly in dBA during a	Major source of noise and sleep interferes factors include general and specific nursing care that involves patients' daily care	The implemented behavioural modified programme involved educating the staff about	Results showed that min and max noise level measurements before BMP, lies between 51.25 and 73.63	Since the decibel meter was not set to, count the number of peaks over 80 dBA,

Interventional study	and recorded noise level during 2 weeks before and after execution of non-disturbance period of a behavioural change programme on a hospital NICU	programme (BMP), 9 patients and, M2 (i.e. after behavioural modification, 14 patients were included in the measurement periods. Number of included staff was not noted	between 13.00 h and 15.00 h during the day and between 24.00 h and 05.00 h during the night-time. Measurement was assessed in dBA with model Larson-Davis Laboratories 700, a decibel meter that comprises of a storage capability, and the data were transferred every 17-h period for Excel-97 and SPSS software for data analysis.	fourteen, 24-h periods for each intervention (M1 and M2) and a total of 71 and 68 record forms were completed for M1 and M2 respectively	activities, such as medical treatment inhalation, drug administration and CPAP (Continuous positive airway pressure) treatment, tube feeding, positional changes and bed bath, change of parenteral nutrition bags as well as lungs and respiratory associated activities	sleep and factors that contributes to sleep and sleep interference, changing nursing and medical procedures as well as the inclusion of afternoon and night non-disturbance periods in the NICU	dBA, respectively, and lowest and highest peak values measured fall 61.0 and 111.5 dBA, respectively. After BMP, results showed lowest and highest maximum noise levels that lies within 41.5 and 95.0 dBA, respectively, and lowest and highest peak values that fall between 54.5 and 114.0 dBA respectively during this period. It appears that after execution of a BMP and non-disturbance periods co-ordinated nursing procedures that ensued decreased in sleep disruption factors and partially cut down noise levels by 1.9 dBA in the NICU	as well as default placement of the decibel meter's in the room could have affected the registration of minimum noise level. Bias reporting might have occurred in the second phase that could be connected to stress related problems at work and acute critical situation
Philbin et al. (2002); ICN; a quasi – experimental, longitudinal study	To describe the extent of sound levels in a busy ICN, and to document the impacts of changes in staff behaviour and the physical space of the hospital ICN	Number of participants in this study was not noted	A dosimeter, model 700 and 712 were used in this study for sound levels measurements in dBA and autocorrelation and Fourier analysis was used to obtain periodicity	The dosimeter measurements comprise of one set of data for each hour of the week spanning across 139 consecutive hours of Friday evening until Thursday morning. Measurement was done before nursery noise became a major concern. After 4 years, staff education about the noise effect on infants and behavioural change was implemented. Multiples of measurements called staff change were made 18 months after the program started. 2 years later staff change measurement that was accompanied with renovation of physical space	Identified noise sources during the renovation were HVAC, plumbing lines and fixtures, door mechanisms, surface materials on floors, walls and ceilings, as well as the locations of desks, storage areas, and travel paths	Staff education and behaviour change that includes switching off the overhead fluorescent lights when not in use, replacement of the heavy - lidded, all - metal trash and linen bins with lightweight plastic receptacles to reduce the major sources of impact noise in the ICN	The study results found the lowest levels (L_{min}) to fall between 60 and 65 dB(A). After the implementation of staff behaviour change, (L_{min}) dropped to about 56 dB(A), yet the highest noise levels (L_{max}) remained at 78 to 100 dB(A). Renovation of the (ICN) dropped noise levels (L_{mins}) from 47 to 51 dBA and (L_{maxs}) from 68 to 84 dBA. The study advocated that a joined method was more effective in promoting a quieter environment than just implementing staff training or education only	The study points out that data collection was limited by the memory capacity of the dosimeter or the larger computer which it is attached, however, this could equally affect result outcomes
Dube et al. (2008); patient care unit (PCU); quantitative and descriptive qualitative study	To identify levels of noise perception by patients and staff and noise sources, as well as implementing methods for noise reduction	30 patients from each of the 55 PCUs (n = 1650) was initially selected for the pre- and post-noise appraisals, but only 47% (n = 775) and 43% (n = 704), respectively participated from the 2 hospital PCUs	Patients and personnel perception of noise level were assessed / collected by survey. Noise level measurement was collected through a noise dosimeter and sound level meter. Data were analysed using SPSS, Inc. (Cary, North Carolina) statistical software	Sound level measurements for 24-hour period uninterrupted data recording	The most burdensome sources of noises identified includes Voices, carts travelling in the hall, foot traffic in the hall, cardiac monitor alarms, overhead pages, and pulse oximeter alarms	Noise was significantly reduced by intervention such as closing of patient room doors, dimming of lights at night, limiting the usage of overhead page, reducing talking voices, turning down ringers on phones, posting of quiet signs to keep voices soft, and turning down of alarms as far as safely possible	Results identified noisiest time of the day to be morning period, which may be due to staff and visitors arriving the PCU, and Night-time to be quieter. Implemented noise reduction method significantly reduced noise as perceived by patients and staff	The intervention type was not noted. The level or degree at which this method reduces noise was not taken into account. Noise level measurement by the survey, which was recorded by patients and staff, might not be sufficient to validate results
Ramesh et al. (2009); level III of an NICU; a prospective longitudinal study	To examine the effectiveness and cost of applying a noise reduction protocol in a (NICU)	An average of 25 (range 20-30) neonates was noted in the NICU. 3 staff members were	An hourly noise level measurement was conducted for 15 days (consisting of 13 working days and 2 holidays) period before and after	A portable digital sound pressure level meter was used for the sound intensity level measurements. The SPSS version 15 software was used for the statistical data analysis	Noise sources not observed	a. Behavioural change that requires staff education about the harmful effects of loud noises on the neonate (i.e. talking in low tones, avoidance of	The noise reduction protocol substantially decreased noise in the noisiest room and other rooms of the NICU. The intervention reduced noise by 9.58dB in the	Duration of each recording period was not included in study. Behavioural modification and low-cost environmental

		selected as persons who would remind the others to lower their voices when it goes louder	implementation of the protocol	and Power analysis, statistical system (PASS) was used to accomplish power analysis		elevated noises across a distance, having discussions in separate rooms, careful handling of trays and metallic object, as well as turning off FM radio systems. b. Low-cost environmental modifications that include fixing of rubber shoes on furniture legs, replacing of metallic files with plastic files, tuning alarms not to exceed 55dB, keeping the doors of where metallic trays were cleaned always closed, pasting of poster to remind staff the need of being quiet, and trimming down of phone ringers to required audible volume	ventilator room, 6.54 dB in stable room, 2.26 dB in isolation room, 2.37 dB in pre-term room, and 2.09 dB extreme preterm room.	modifications were only capable to reduce noise within 60dB, exceeding the WHO and EPA rule of thumb of 45dBA
Walsh-Sukys et al. (2001); Level III of a NICU; a prospective control trial study of light and sound levels	To change an existing Level III NICU, as well as comparing light and sound levels in a renovated nursery that incorporates an adjacent traditionally configured nursery		Sound level measurements include two phases: continuous sound monitoring for 24-hour period (7AM to 7 AM) with (Larson- Davis Model 705 meter), and 12- hour period (7 AM to 7 PM) with (Quest Model 2900 sound meter).		Noise sources not observed	The study applied environmental modification that include nursing staff education about the impacts of light and sound on neonates in the NICU. A series of cost effective sound modifications that include placement of weather stripping on all doors and drawer fronts, substituting of all metal trash cans with rubber types, placing of covers over incubators, installation of carpet along the centre of the nursery, and sound-absorbing acoustic material in all monitor bays and soffits	The study revealed that both light and sound could be modified in an existing NICU at modest cost, without compromising patient safety. Results demonstrated a significant sound reduction in the modified nursery	
Taylor-Ford et al. (2008); medical surgical unit; a quasi-experimental study	To quantify noise level and evaluate impact of the noise reduction program		Topf Adapted Sound Disturbance Scales, and Quest 2900 Sound Level Meter was for the environmental sound levels recording.		The major noise sources were found to be opening and closing of doors, falling objects, paging system, phones, television and people’s conversation	The study used educational noise reduction program that includes one 15-minutes presentation daily for 2 weeks. Also, behavioural modification that involve sound-detection equipment, as well as low-cost environmental alterations	Educational noise reduction or behavioural modification program did not significant reduce noise level. Hence, the investigators encouraged the use of sound-absorbing tiles to reduce noise levels in medical surgical unit.	The recording duration interval was not reported in the study. The staff manipulated sound-detection equipment, this might have ensued data loss. The nursing staff may have demonstrated nonchalant manner towards warning sign indicated by the sound detector.