Soundscape Approach in Designing Dementia Care Units

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SOUNDSCAPE APPROACH IN DESIGNING DEMENTIA CARE UNITS

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SOUNDSCAPE AND DEMENTIA

SOUNDSCAPE APPROACH IN DESIGNING DEMENTIA CARE UNITS:

A Case Study at Toronto Rehabilitation Institute, Geriatric Psychiatry Unit

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Noises are the sound we have learned to ignore.

—R. Murray Schafer, 1993

ABSTRACT

Noise is an important sensory stimulus in any environment, especially in unfamiliar settings. Noise is impossible to ignore, and any disturbing noise or constant sound can be agitating, disturbing, and confusing for people who cannot escape the environment. People with dementia may already feel strange, isolated, and confined inside care facilities; uncontrolled sound can add to their anxiety and agitation. Review of existing research shows an interest in sound mapping and soundscaping of care facilities, however there is a lack of research specific to dementia care units. Soundscape refers to the human perception of the sonic environment in context: it is not only relying on the subjective quality of sound by measuring the sound level, but also the objective quality of the auditory environment based on people's perception. This study aims to develop a soundscape of the dementia care unit at Toronto Rehabilitation Institute, through data collection and observation, and to evaluate the quality of soundscape in the units. Further, the study introduces a systemic design for improving the quality of soundscape in dementia care units. The proposed system; through real-time interaction with the environment, active monitoring of sound, and a feedback mechanism; adapts and controls the sonic environments and is designed to improve the auditory situation of dementia care units.

KEYWORDS

Soundscape

Dementia care

Sensory

Perception

Environment

Noise/Sound

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1. INTRODUCTION

Noise is an important sensory trigger in any environment, especially in an enclosed and unfamiliar setting. People with dementia may already feel strange and isolated inside care facilities. Any distracting noise or constant sound can be agitating, disturbing, and confusing for people living with dementia. Recently, there has been interest in sound mapping and soundscaping of care facilities, Busch-Vishniac et al looked at noise level in John Hopkins hospital (2005) and Mackrill & Jennings, introduced a model to experience the hospital ward soundscape (2013). These are good examples of interest in soundscaping of care facilities, however there is a lack of research specific to dementia care units. The majority of studies on this topic look at the impact of noise by focusing on hospitals, operating rooms, but not specific to dementia care units. There is good documentation on the relationship between noise, stress levels, and how noise can facilitate “change in autonomic nervous system, impairing mental faculties and producing masking that could affect the staff and conscious patient alike, leading to decreased work performance and increased anxiety respectively” (Luzzi & Falchi, 2002). Also, there have been studies on monitoring sound levels in nursing homes (Aletta et al, 2017) that focus on the relationship between sound and quality of life for people living in nursing homes and for the staff.

However, none of these studies looked at the relationship between sound, environment, and dementia, in a way that people with dementia perceive their space through noise and sound. Sound is very important in making people aware of their environment (Brungart et al, 2014) also, as van den Bosch et al mention “sound plays an important role in informing people about their environment, and as such sounds influence mood, cognition, and behaviour” (2016). The word perception here is used as the way we perceive the environment, as Cassidy explains: “how the person comes to understand and deal with the environment can be understood in terms of perception” (2013). In cognitive psychology perception explains as the way we become aware of our environment: “how we become aware of information in our environment, how we process that information, and how we give meaning to that information” (2013). Vulnerable populations are usually affected by their environment and removing or reducing the disturbance improves their Quality of Life. As van den Bosch et al argue “the auditory information normally contributes to forming a sense of place which provides clarity about the current location and situation” (2016). When sound and noise are unfamiliar, they add to the anxiety of those who receive the sound, making the situation annoying and unpleasant.

1.1 BACKGROUND

Integration between people and the built environment, and the individual’s perception of space has been my area of interest since architecture school. The fact that understanding of space depends on one’s experience, culture, age, and cognitive ability fascinates me. As an architect, I look at built environments not as individual objects, but as a holistic combination of space, time, and design. A physical environment affects and is affected by those using it.

As architects, we usually design a space based on the idea that users will have the same perception of the space as we intended. Perception is how the brain makes sense of sensory stimuli. Not everyone, however has the same capability to perceive, identify, and connect to the space. This perception becomes more distracted and vague when a person has a mental dysfunction or brain injury. People with dementia have difficulties identifying and interpreting their sensory stimuli, and perception of space can become confusing and disturbing for them (Hayne & Fleming, 2014). As perception of space has been my interest for many years, looking at this from the point of view of those with cognitive difficulties made me interested in this subject. Also, as sound and noise are less examined in designing space, I decided to focus my research on this specific sensory experience.

1.2 SOUNDSCAPE

Soundscape refers to the human perception of sonic environment in context (Brown et al, 2016). Although the word soundscape not coined by him, it was reintroduced and reused by Canadian composer R. Murray Schafer. He suggested that “only a total appreciation of the acoustic environment can give us the resources for improving the orchestration of the world soundscape” (Schafer, 1993). Experience of space relies on not only visual experience, but also sonic experience of space. Soundscape relates to sonic perception of those who perceive sound in the specific environment. This phenomenon depends on the listening habits of individuals and their relation to the environment: different people in the same space may have a contrasting relationship to the soundscape (Truax, 2001) and therefore completely different emotional responses to the soundscape (Cain et al, 2013). This interaction between human and space through sounds depends on previous experiences of space, the familiarity of sounds and the mood of person at that time. We also need to remember that there is no organic way to close off the hearing, no “earlid” as Schafer calls it; even when we sleep our hearing works in our unconsciousness. However, our brain has an ability to filter out undesirable sound: “The eye points outward; the ear draws inward” (1993).

In soundscape, noise is not necessarily a negative factor: it relies on the subjective quality of sound through measurement of sound levels, and the objective quality based on people’s perception, as well as measuring quality based on people’s needs (Botteldooren et al, 2015). We need to remember that Soundscape is not the same as acoustic environment or sonic environment. As Kang et al mention, soundscape refers to “perceptual construct” and others to “physical phenomenon” (2016). The perceptual construct has a direct connection to the cognitive ability to receive and process the sound, and this ability is reduced in people with cognitive difficulties like people with dementia.

1.3 DEMENTIA

The Alzheimer Society of Canada defines dementia as “an overall term for a set of symptoms that are caused by disorders affecting the brain. Symptoms may include memory loss and difficulties with thinking, problem-solving or language, severe enough to reduce a person’s ability to perform everyday activities. A person with dementia may also experience changes in mood or behaviour” (2010).

According to World Health Organization (WHO) the number of people with dementia is increasing. In 2010 WHO estimated that 35.6 million people were living with dementia worldwide. This number was expected to double every 20 years, to 65.7 million in 2030 and 115.4 million in 2050 (Prince et al., 2013). At the same time, there are other predictions about the increase of dementia. In 2017 the WHO estimated the number of people living with dementia at 50 million with 10 million new cases every year, which is larger than previous estimate. Dementia is known to be more common in older adults. As a result, people with dementia either live in long-term care (LTC) facilities or have to relocate to LTC to reduce the responsibilities of care from their families and loved ones. LTC facilities feel unfamiliar and usually are not customized for individual needs, which make these places more agitating and disturbing, especially for people with brain and mental illnesses. Sensory perception in these spaces is also unfamiliar for residents: light, sound, temperature, and even smells may be very different from the familiar setting of one’s home.

Noise levels in hospital can become a form of environmental pollution. Sudden noises, such as when equipment is dropped or when doors are slammed, cause a startle reflex, which causes not only physiological responses in the person with dementia, but can also increase the sense of disorientation and insecurity (Dewing, 2009). Exposure of individuals with severe dementia to high noise levels may increase confusion and trigger fear or other negative feelings, which results in a reduced amount of social interaction (Garre-Olmo et al, 2012). It is also hard to measure the Quality of Life (QoL) for people with dementia. As Cahill & Diaz- Ponce studied, “there is still no universal definition of QoL, nor has a gold standard been developed for its measurement” (2011). The point of view of caregivers and researchers about QoL may be different from people with dementia and “growing international evidence has accumulated demonstrating that most people with dementia can respond well to questions asked about their QoL” (2011). Because dementia reduces the effects of sensory stimuli, it changes how a person perceives the external stimuli, which can also lead to greater risk of falls through loss of balance and sense of orientation (Hayne & Fleming, 2014). As van den Bosch et al mention, when person is unable to ignore or escape a sound; for example, people with mobility restriction in LTC, what started as an annoyance would become a source of stress and agitation (2016). Also, people with dementia may have a limited capacity to understand their environment (Hayne & Fleming, 2014).

1.4 THIS STUDY

As my interest has grown on this subject and because there is not enough research on dementia and noise, I decided to focus on soundscape and dementia. The Specialized Dementia Unit at Toronto Rehabilitation Institute is used as the grounds to obtain quantitative and qualitative data. Quantitative data is based on sound level data and qualitative is based on perception of sound. The aim of this research is to first understand the level of sound that exists in dementia care units, both positive and negative sound and noise, then, based on the data and literature review, propose a design for the unit to improve the soundscape and hopefully improve the quality of life for both patients and staff of the unit.

2. METHODS

2.1 RESEARCH ETHICS APPROVAL PROCESS

Research Ethics Board (REB) Approval was applied through Toronto Rehabilitation Institute (TRI) and OCAD (Ontario College of Art and Design) University. The Protocol was submitted to TRI on January 4, 2018, and the process of approval took about three months to complete (Appendix A). The Toronto Rehabilitation Institute and staff were concerned about voice privacy, I therefore chose specific equipment (refer to 2.5.1) to control the data collection, and not collect human voices. After receiving approval from TRI, I submitted to OCAD REB Committee and received the approval on March 5, 2018 (Appendix B).

2.2 LITERATURE REVIEW

While waiting for REB approval, I studied literature to examine research conducted in relation to healthcare and noise/sound.

2.2.1 Noise and Sound

When speaking of the sonic environment, sound pressure, and sound level are commonly expressed in decibels. Using a logarithmic rather than linear scale has a distinct advantage of allowing a smaller number to be used over an extremely large scale of numbers (Irwin & Graf, 1979). The auditory range of humans is 0 dB to 140 dB. An increase of 3dB is considered just noticeable, a 5dB noise change is considered to be clearly detectable, and a 10dB change is perceived as a doubling of loudness. The dynamic range of the auditory system is generally taken to be 0dB to 140dB. Below are a few examples of typical sound intensity levels within the decibel range of 0 to 120dB:

- Threshold of acute hearing: 0 dB
- Rustle of leaves: 10 dB
- Sleeping, studying, whispering: 30 dB
- Conversation, comfort: 50-60 dB
- Safety threshold: 85 dB
- Rock band: 120 dB
- Threshold of pain: 130 dB

Depending on what we want to measure, sound level and power at different frequencies can be weighted differently. dB is used when we want to measure general sound strength as perceived by the human ear.

2.2.2 Noise in Healthcare

The importance of noise in healthcare goes back to Florence Nightingale, when she noticed the effects of noise on patients and staff in her book “Notes on Nursing” (1859). There is some recommendation for sound level in healthcare settings. WHO recommends 30-35 dB in hospitals. WHO also suggests for a good night’s sleep in hospitals, background noise should be less than 30 dB, and individual noise events exceeding 45 dB should be avoided. Also, noise above 80 dB may increase aggressive behaviour. Noise disturbs sleep by a number of direct and indirect pathways. Even at very low levels physiological reactions (increase in heart rate, body movements and arousals) can be reliably measured. Berglund et al research shows that awakening reactions are relatively rare, occurring at a much higher level than the physiological reactions (1995). Researches show that overall sound levels are always higher than recommended. For example, Busch-Vishniac et al discovered that none of the hospitals between 1960 and 2005 complied with WHO's recommendation (2005). The noise normally occurring inside rooms is often referred to as "background noise." In hospitals, background noise can result from a variety of sources including air conditioning, medical devices such as respirators, and occupant sounds such as conversation. Impulsive noises, or very loud, short duration events, are also commonly found in hospitals (e.g., doors slamming, metal-to-metal contact, alarms) (HSu et al, 2012). The effect of equipment noise inside hospitals has been examined by different researchers. Buxton et al, for example, showed through their lab study that electronic sounds were more arousing than other sounds at the same level. The arousal effects of noise on sleep include heart rate elevations, even when the duration was short (2012). To reduce arousal by sound there are a few recommendations through evidence-based research: one study by Berg showed how installing a sound-absorbing ceiling would reduce the arousal by 40% (2001). Installing sound-absorbing tiles drops the sound level by 5-6 dB in patient rooms and 1 dB in the main areas (Hagerman et al, 2005). Other studies such as Blomkvist et al, focused on the fact that improvements in healthcare acoustics will be inadequate if they only focus on reducing sound levels (2005). They also showed how important gains in the psychosocial healthcare environment can be achieved by improving room acoustics. In the emergency wards, sounds from neighbouring patients and advanced medical treatments and equipment are perceived as disturbing. This can create a feeling of helplessness, making it difficult to find the peace and calm that are essential for recovery (Johansson et al, 2012). Overall, literature suggests that the main source of noise in healthcare facilities, as Salonen et al suggest are the operation and maintenance of the facility (2013). The main source of noise:

- Staff activities
- Elevators
- Diagnostic & Therapeutic Instruments
- Heating, Ventilation and Air Conditioning (HVAC)

2.2.3 Sound and Perception

When talking about sensory stimuli, especially sound, the perception is very important. As Irwin and Graf show “different individuals may consider the same noise to be more or less annoying” (1979). Also, the speed at which sound levels rise affects the way humans perceive the sound: “a noise with a rapid rise time is found to be noisier that the same noise with a slower rise time” (Irwin & Graf, 1979). Sound also helps in spatial perception. Spatial perception is the ability to be aware of the relation between body and environment. It is like the rest of sensory experiences in representing the world in a way that reflects the needs and interests of our own bodies (Simmons, 2003). The location and motion of sounds in space are important cues for encoding the auditory world. Spatial processing is a core component of auditory scene analysis, a cognitively demanding function that is vulnerable in Alzheimer’s disease (Golden et al, 2016). Barry Truax’s observation showed that because sound transmits slowly through air, it won’t reach the human’s ear at once. “The various differences in time of arrival at the ear provide information about the spatial relationship within the environment” (2001). We should remember that listening is the crucial interface between the individual and environment (Truax, 2001). How people think about different sound is very important, and the main point is how a listener categorizes sounds (Davis et al, 2013). Soundscape is a holistic approach, which means looking at the assessment of the acoustic environment through different disciplines. “Moreover, soundscape is a construct of human perception, which is influenced by the sociocultural background, as well as by the acoustic environment in context” (Kang et al, 2016). The literature shows how sound, as one of the sensory functions, helps humans to perceive environmental space. This perception is based on memory, cultural-social background, and individual experience. When cognitive ability decreases due to dementia, the auditory sense loses the ability to analysis and perceive the environment. By simplifying the auditory scene, introducing quiet space and adding music into the background, people with dementia can relate better to their sonic environment.

2.3 STUDY OBJECTIVES

The data collection section of this research aims to develop a soundscape of the Specialized Dementia Unit at Toronto Rehabilitation Institute. The soundscape has an objective and subjective approach. The objective approach through acoustical data gives a physical view into the quality of the sonic environment by identifying the main sources and patterns of noise. The subjective approach gives a perceptual understanding of sound quality through human perception. These steps are necessary in understanding the soundscape of dementia care units.

2.4 STUDY SETTING

The Specialized Dementia Unit was chosen as the location for data collection. This is an 18-bed tertiary dementia care unit; whose focus is the assessment and treatment of people with dementia exhibiting severe behavioural and psychological symptoms of dementia. Patients on this unit are admitted from other long-term care facilities in the region, when their behaviours are placing themselves or others at risk. Using a combination of pharmacological and non-pharmacological approaches, the goals of the multidisciplinary care team are to reduce symptoms and improve the QoL of their patients. The unit is located on 5th floor of the Toronto Rehabilitation Institute on University Avenue, in Toronto, Canada.

2.5 DATA COLLECTION

This was an observational study with both quantitative and qualitative data assessments. In quantitative assessment; sound level, audio frequency based on hertz (Hz), and loudness of sound on Decibel (dB) measured. In qualitative evaluation; six types of sound evaluated: installation sounds, operational sounds, electronic sounds, environmental noise, human sound (vocal), and human sound (non-vocal). Also, ten appraisal dimensions: pleasant, chaotic, vibrant, uneventful, calm, annoying, eventful, monotonous, safe, and intimate evaluated.

2.5.1 Quantitative Assessment

The Brüel & Kjær 2270 hand-held sound analyzer was used in the quantitative assessment. This instrument is designed for environmental noise assessment, occupational noise evaluation, and real time assessment of sound along with many other features not used in this study. There is an option to turn off the voice recording, which was necessary based on REB approval and privacy concern inside the unit. To measure sound level, audio frequency in Hertz (Hz), and loudness of sound based on Decibel dB(A) were recorded on a 10-minutes basis (LAeq- 10 min) for a total of 22 hours for three weeks. Note that A-weighted is used when measuring general sound strength as perceived by the human ear.

Measurements were taken in three different locations: the dining room, corridor, and two patient rooms (Appendix C).

2.5.2 Qualitative Assessment

Having a first-person account of sound in their environment is the preferred method of collecting and understanding both loudness and quality of sound and noise in real time. Unfortunately, in this research, based on REB, there was no access to patients directly, therefore to determine the noise sources as well as to map the quality of soundscape, the observer used a preprinted form and answered a set of prepared questions during the data collection (Appendix D). The study by Aletta et al, 2017 was used to make the form. During the data collection, the researcher sat down close to equipment and collected quantitative data on 10-minute intervals.

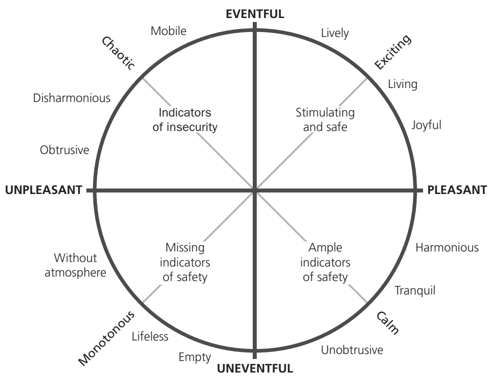
3 FINDINGS

Within the scope of this study (considering the limits of time and collected data), data analysis involved summarizing statistics of quantitative data, focusing on LA_{eq}, LAF_{max} and LAF_{min}, and qualitative data, focusing on patient and environmental characteristics in response to sound and noise.

LA_{eq}: the sound level in decibels equivalent to the total sound energy measured over a stated period of time.

LAF_{max} and LAF_{min}: correspond to a 125-millisecond time constant, usually used for measuring all the sounds in an environment, which may vary widely over time.

There are different conceptual frameworks to study quantitative data in the soundscape approach. Aletta et al (2016) looked at four different ways to collect qualitative data in soundscape studies: soundwalks, laboratory experiments, narrative interviews, and behavioural observation. Although these categories are usually used in urban design projects, we can easily use them for small scale environmental design. In the case of dementia care units, based on the scope and limitations of this study, I chose behavioural observation. “The advantage of this method is that the participant may be unaware of the study and might not be able to influence the results” (Aletta et al, 2016). Once the data collection method was chosen, the next step was to find a model to organize the data. In cognitive science and psychology, there is a universal agreement on the relation between cognition and emotion (Kuppens et al, 2012). While studying the different methods of organizing qualitative data I came across the “core affect and appraisal” model (Andringa & Lanser, 2013; Andringa et al, 2013; van den Bosch et al, 2018). Andringa & Lanser mentioned the effect of the sonic environment on behaviour and looked at direct relation between “the way we appraise the situation and the selection of overt behaviour” (2013). Based on their study, people’s appraisal in regard to the sonic environment is divided into two dimensions: either pleasure and eventfulness or vibrancy and calmness, shown in Figure 1.



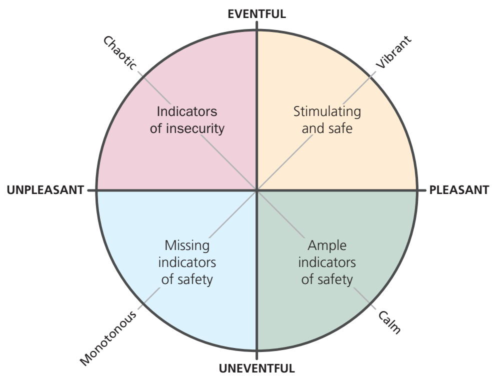


Figure 1: Appraisal of auditory environments

Figure 2

Based on this model and the qualitative data gathered during the observation, we can refer to Figure 2 as a basic model for this study. I should mention that this part of the study, the connection between human emotion and feeling, and the surrounding environment, requires more study and discussion, which is beyond the scope of this research.

Since this was a pilot study and I had no previous experience in collecting behavioural data, especially in a dementia care unit, I had to rely on my observational judgment at any given time. In the future, I would have a better understanding of the patient’s actions in regard to noise and context during this process. On the other hand, being a complete stranger to the atmosphere gave me an opportunity to collect data with no bias or influence.

3.1 RESULT

This part of the study aims to evaluate the level of sound and the effect of sound and noise on people, especially those with cognitive difficulties and dementia. The result of the small sample of data showed how, overall, TRI units exceeded WHO's recommended sound level by at least 10 dB. The recommended level is 30-35 dB.

To evaluate environmental sound and noise, LAF_{max} and LAF_{min} are compared (Figures 3,4, and 5). While both LAF_{max} and LAF_{min} show the environmental noise in the space, LAF_{min} refers to basic background noise from mechanical equipment, such as air conditioning, etc.

LAFMax shows sudden noise in an environment, such as doors slamming, table and chair movements, and so on.

To start, let's turn to consider noise levels for one day in a dementia care unit. Although the collected data are staggered between three weeks and three different locations for a total of 22 hours, I organized them based on time of day to represent a continuous 7 a.m. to 11 p.m. time cycle.

This model makes it easier to understand and visualize the loudness and sound levels of the unit during a day. Figures 3,4, and 5 show quantitative data for three different locations.

In the corridor (Figure 3), LAF_{min} noted around 40-45 dB, with LAF_{max} from 70-90 dB.

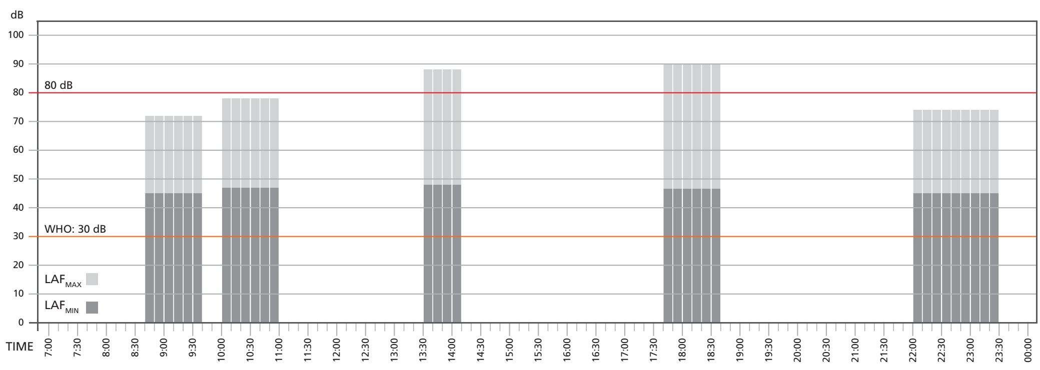


Figure 3. Corridor

Comparing these numbers with WHO's recommendation of 30-35 dB means the corridor is 10-15 decibels over the recommendation. As mentioned in section 2.2.1, a 10 dB change in sound level is perceived as double loudness by the human ear, which can be agitating and disturbing.

In the dining room (Figure 4), LAF_{min} noted at 40-50 dB and LAF_{max} at 80-90 dB during the day and 70 dB at night when the room was empty. These numbers again show 10-20 dB more than recommended.

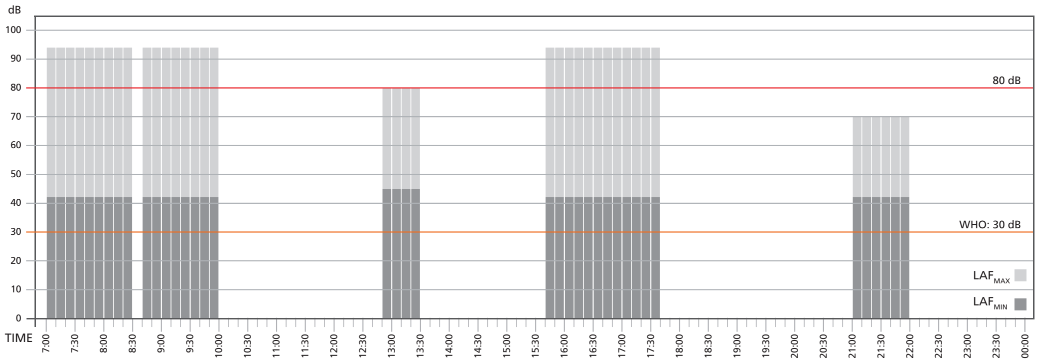


Figure 4. Dining Room

Unfortunately, due to the lack of empty patient rooms during the three weeks of data collection, access to rooms was limited to three observation times, as shown in Figure 5. LAF_{min} noted at 35 and 45 dB, and LAF_{max} noted at 65-80 dB. Comparing to WHO's recommendation for sleeping background noise of 30 dB, these numbers are very high. The morning data (8-9 a.m.) collected from a patient's room at the north-west

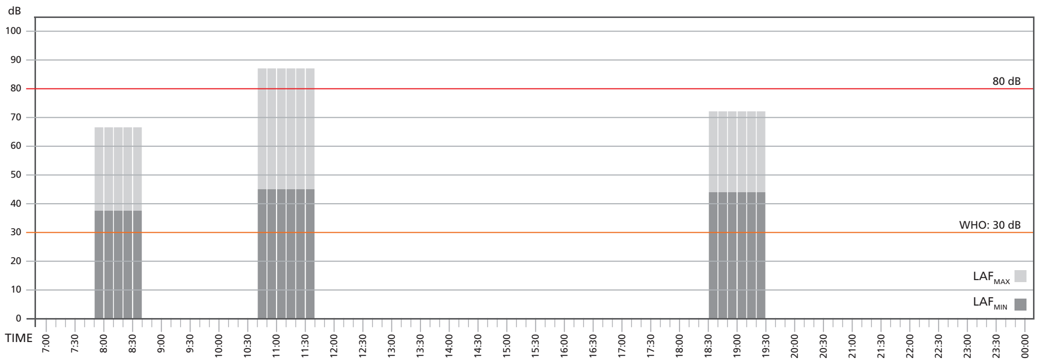


Figure 5. Bedroom

corner of TRI and the other two from a room at the south-east corner of TRI. The LAF_{min} shows the basic difference in the sonic environment of these two rooms (one is closer to the main street). Further investigation of this issue is recommended.

Qualitative evaluation is subjective and requires more in-depth knowledge of human behaviour. However, to the extent of this study, a review and evaluation of data are necessary. In a qualitative observation, as mentioned before, six types of sound were evaluated: installation sounds, operational sounds, electronic sounds, environmental noise, human sounds (vocal), and human sounds (non-vocal). These data give us an understanding of background noise in the sonic environment to shape the base of evaluation. Next, 10 appraisal dimensions were observed and evaluated on a scale of 0-10: pleasant, chaotic, vibrant, uneventful, calm, annoying, eventful, monotonous, safe, and intimate. These dimensions show the effect of the sonic environment on patients at a certain time and location.

To summarize the data, Figures 6,7, and 8 show the evaluation of four types of appraisal data from quantitative observation: calm, chaotic, monotonous, and vibrant.

In the corridor (Figure 6), overall the area is calm at night and early morning, but chaotic in the middle of the day, especially between 1-2 p.m. on a music day, when staff play piano and residents sing along (as shown). In the dining room (Figure 7), during meal times: breakfast, lunch, and dinner, there is a feeling of vibrancy but also chaos, however, in the middle of the night or early morning, the room is very calm.

In the bedroom (Figure 8), there is an overall calmness; the only chaotic moment happens when the bed's alarm goes off, which proves how the loudness of alarms can suddenly change a space's mood.

The next step is to find a relation between the two sets of data: qualitative and quantitative.

Figure 6. Corridor

Figure 7. Dining Room

Figure 8. Bedroom

3.2 DATA ANALYSIS

Once I reached a better understanding of sonic environments and soundscape through a literature review, data collection, and data analysis, the next step was to thoroughly perceive the soundscape of a geriatric psychiatry unit through examples and evidence, and then find a solution to control the noise and expand the solution to adapt to any setting within the same context.

I have to mention that this analysis is based on a very small sample of data and observation; further study is needed to provide a better understanding of the relation between the loudness of noise and residents' behaviour inside the unit. Furthermore, the behavioural data is based on my point of view and, as mentioned before, the perception of caregivers, staff, and residents need to be considered.

Observing the unit and comparing the quantitative data to the qualitative data shows that the loudness of a unit may or may not influence people's behavious. For example, Figure 9 shows quantitative data gathered in the corridor in relation to calmness (based on perception). Calmness was scored from 0-10; the higher number indicating a calmer situation.

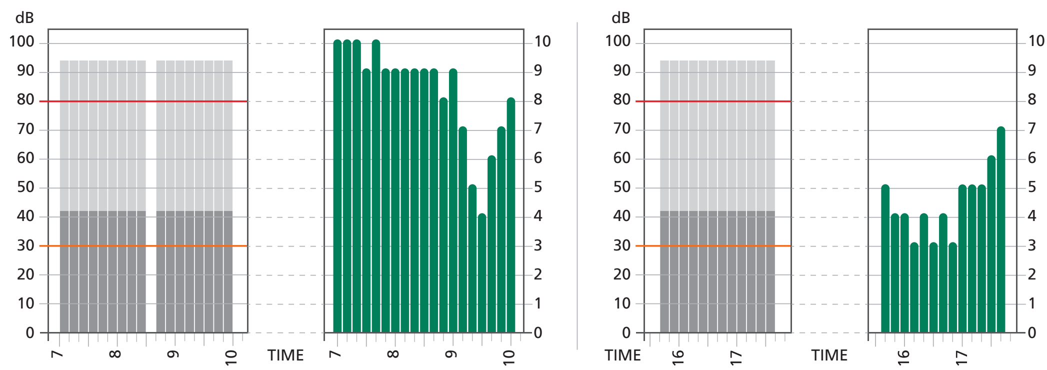


Figure. 9

The chart shows that, for example, during morning hours when the sound level was high, the corridor stayed almost calm. However, in the afternoon when the sound level was high, the corridor was not perceived as calm.

Sound level doesn't have a direct relation to the perception of sound. A low-level annoying noise, such as low-frequency mechanical noise, through time, can become very annoying and unpleasant. However, loud-level noise of falling water can be very soothing and make the space feel familiar and calm.

4. DESIGN

After analyzing data, the overall sound level of the unit is much higher than the recommended level for healthcare environments, which is in agreement with all the literature in regard to noise levels in healthcare. To reach a design solution to improve the quality of soundscape in dementia care units, I first looked at evidence-based design recommendations and then proposed a solution.

4.1 RECOMMENDATIONS

There are a few recommendations based on literature and observation that can be helpful in reducing sound levels in dementia care units. These design recommendations are not specific to TRI units but are general suggestions in designing a healthcare environment.

Three categories of recommendations are as follows:

1. Architectural Design
2. Architectural Alteration
3. Acoustical Revision

Some of these recommendations may not be possible with simple interventions, such as shortening the corridors or dividing the nursing station into smaller stations. However, some can be achieved through simple alterations. Installing sound-absorbing material or eliminating pagers, buzzers, and alarms and replacing them with vibrating and visual alarms are easy to implement.

1. Architectural Design

During the design process, a few design principles can help in reducing a noisy space:

- Building shorter corridors
- Dividing the nursing station into smaller areas rather than one large station
- Making a visual connection between rooms and corridors by installing sliding glass doors so patients do not feel isolated and annoyed

When corridors are shorter the space feels more familiar and comfortable, and noise doesn't have to travel a long distance. Smaller nursing stations with a smaller number of people in each, reduce the sound level as fewer people talk at the same time. A visual connection between rooms and corridors gives a sense of connection to patients so they won't feel left behind. This also means patients won't need to make noise or talk loudly to gain attention.

2. Architectural Alteration

These alterations are good for spaces that are already built and occupied, although they can also be implemented during the design process for new buildings:

- Installing high-performance sound-absorbing ceiling tiles and panels to absorb echoes within a room
- Installing carpeted surfaces where possible to soften up the surface within a room and reduce the echo in the space and eliminate background noise, such as footsteps and trolley wheels
- Installing sound-attenuating surfaces inside drywall studs, such as lightweight, flexible fiberglass insulation batt, which is designed to deliver noise control in metal stud wall cavities of interior partitions

3. Acoustical Revision

- Reducing noise of pagers and overhead noise by eliminating sound, and using light and vibration to alert staff when necessary
- Adding music to the sonic environment, as Easteal et al mention: "in cases where poor acoustic design is pre-existing added sounds or music may be the most pragmatic soundscape design intervention" (2014)

Although these recommendations can be helpful in reducing sound levels and improving soundscape, there is a need for a more holistic, real-time and active solution.

4.2 DESIGN PROPOSAL

The proposed design is an interactive, responsive, and smart system to learn the soundscape of geriatric units, take action to control the disturbing and unwanted noise, and to adapt the sonic environment to the requirements of units at any given time. As Kang et al suggest: "nowadays, with ICT (Information and Communication Technology) support, it is possible to cope in real time with a number of functions across the physical and social structure" (2018). ICT is based on available data and a real-time algorithm; allowing it to evaluate the sonic environment and act responsively.

Machine learning has been used recently in sound evaluation and crowd noise evaluation, especially in sports. Researchers at Brigham Young University are working on a machine learning algorithm to figure out how machines can understand and predict spectators' actions during basketball games (Acoustical Society of America, 2018). Their goal is to use the system in advertising, evaluating plays, and threat prediction. At the same time, Siemens, in collaboration with the design company Signal Noise, is using acoustic camera technology inside Alliance Arena in Munich, Germany during Bayern Munich's soccer games, to create a 3D-map that will be used as a data analytics tool to evaluate games and fan responses. These examples, although in different settings, show the evolution of machine learning in acoustical science.

4.3 SYSTEM

In the next few pages, I describe my proposed system and then, through a few scenarios, define how the system responds to specific situations. The purpose is to elaborate on the system's dynamic and explain the connection between the data and the proposed solution.

The data analysis and observation show how the overall sound level is over the recommended level and how different activities and time of day change the sonic environment of the units. To act upon this specific soundscape, I propose a system, called Responsive Soundscape System. Here is how the system works:

We use the architectural plan of a unit as the base of the system (Figure 10). This plan, presented on a nursing station monitor in real-time, shows the soundscape of the unit.

By installing a sound-monitoring system across the units and conducting a staff and caregivers survey, we would be able to have a good understanding of the sound level of any space at any given time. This data has to be monitored for 24 hours and for at least one month to give us a good understanding of the sound level and at the same time, completing the questionnaire with staff and caregivers' responses. Researchers can ask the questions and fill the form themselves, or leave the forms with staff, however, the latter may add to the staff's workload.

Figure 11 shows the distribution of sound meters around the unit. These meters have a real-time connection to the control room and nursing station. Also, the data collection gives us basic information for each space. In the dining room, for example, we have the following observation: LAF_{min} 40-50 dB and LAF_{max} at 80-90 dBday and 70 dB night.

This information can be used as the base of the plan for the dining room. So, at the any given time, real-time data can be compared with the base level. By repeating the same principle for all spaces of the unit, we would have a base for the soundscape of the unit. This data analysis will be used as the background of the system (Figure 12).

Once we design the soundscape and connect it to the nursing station as the system hub, we can monitor the unit's sonic environment in real time. Any changes in the sound level will send an alarm to the hub and let the system know about an unusual activity (Figure 13).

The system can then revise the situation or improve the sonic environment either by playing music to calm the atmosphere or starting the sound masking process (Figure 14). The system acts as an active noise control system to revise the situation.

Figure. 10

Figure. 11

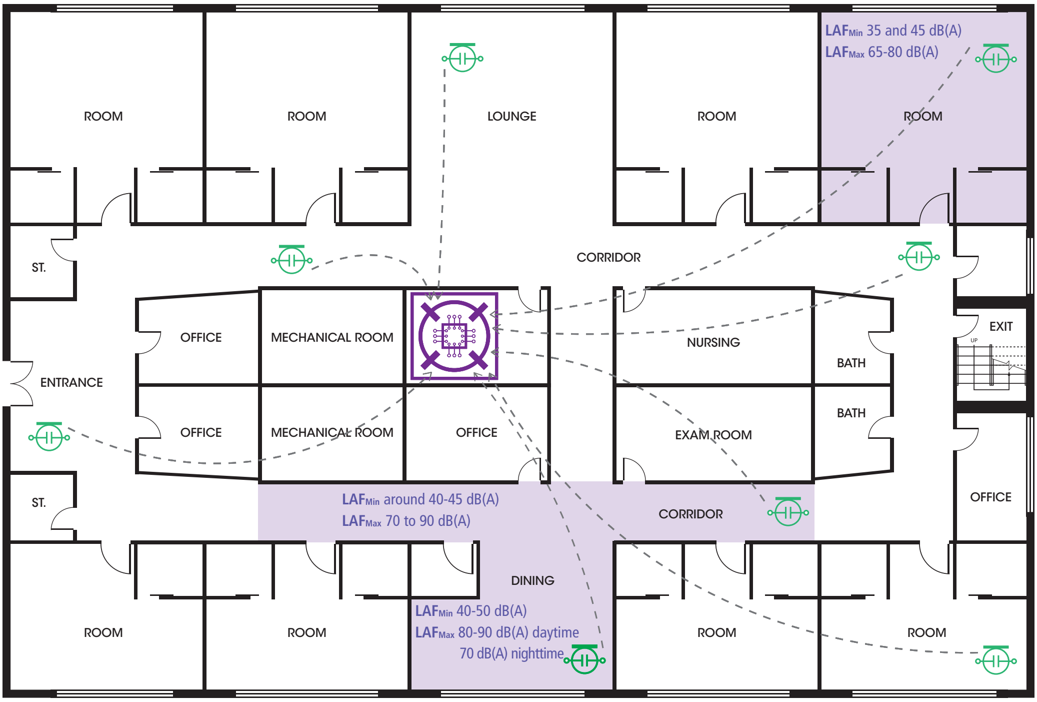


Figure. 12

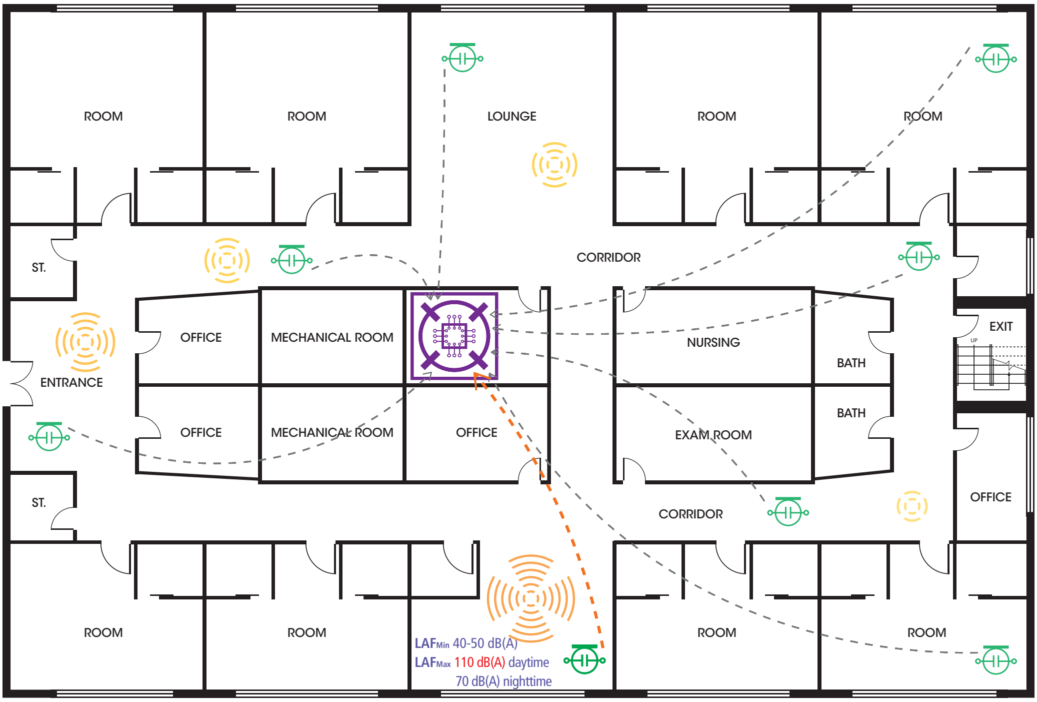


Figure. 13

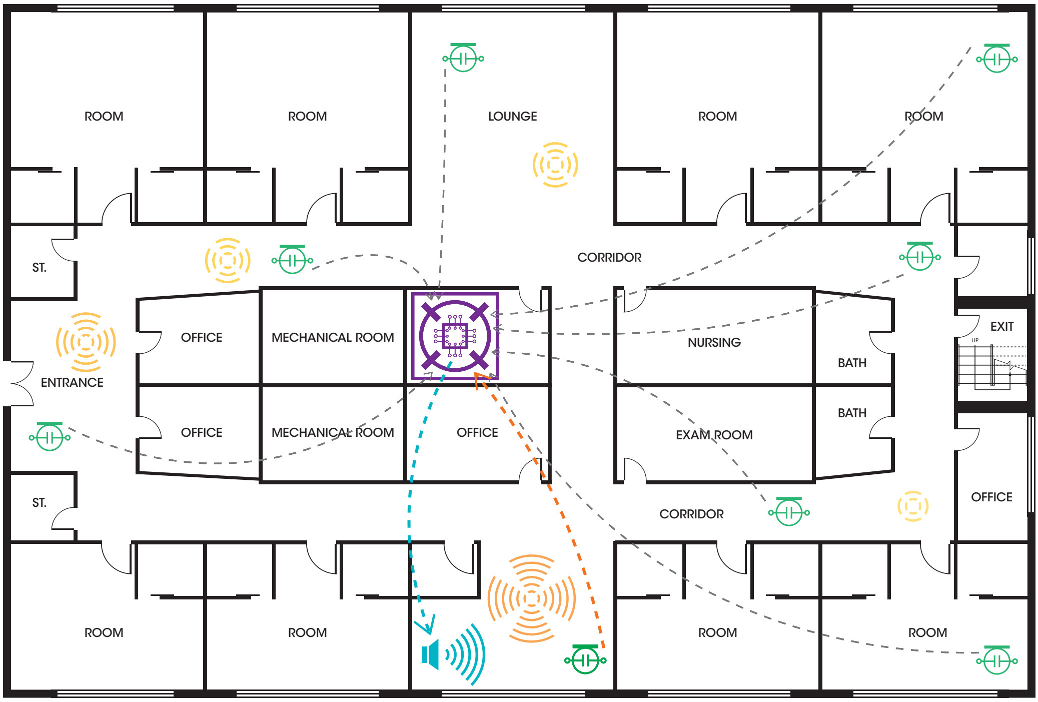


Figure. 14

To elaborate on the functionality of this system, let's talk about active noise control, sound masking, and the importance of music in the acoustical environment.

4.3.1 ACTIVE NOISE CONTROL (ANC)

ANC uses the phenomenon of wave interference. "When two waves with the same amplitude and frequency, but phase-reversed, travel in the same direction, they will neutralize each other" (Milosevic & Schaufelberger, 2005). A control system in ANC triggers a speaker to produce the exact mirror-image of a sound and neutralize the disturbing noise, using destructive interference, as Milosevic and Schaufelberger called it (2005). The result, therefore, will be null or no sound.

4.3.2 SOUND MASKING (SM)

The SM system is often used for speech privacy and to minimize distractions from other sounds. SM makes undesirable conversations and other noise distractions less audible. The principle of SM systems acts on masking, which means generating a background sound in a specific area.

“The background sound has the effect of limiting the ability to hear two sounds of similar sound pressure level and frequency simultaneously” (Moeller et al, 2013). In this way, an SM system covers the background sounds of the area, improving the general acoustic comfort level.

The SM system is used in hospitals for patient confidentiality and also for patient satisfaction. Studies show how satisfaction improves when an SM system is installed (Xie et al, 2009). As Xie et al mentioned, patients with SM intervention felt that they slept better during their hospital stay (2009).

4.3.3 MUSIC IN DEMENTIA

The effect of music in dementia care has been studied through research and implementation. The intention of this report is not to elaborate on the importance of music in improving the quality of life for people with dementia, but to use music as a reaction in soundscape systems. Researchers like Spiro (2010) looked at various positive roles of music in dementia care:

- Music as leisure can contribute to the activities of residents in long-term care facilities
- Music has positive effects on cognitive capacities such as memory
- Music positively affects state of mind and behaviours, especially those affected by dementia such as social behaviours, emotion, depression, anxiety, and agitation

4.4 RESPONSIVE SOUNDSCAPE SYSTEM

Looking back at the proposed system in Section 4.3, once the system recognizes an unusual sonic activity in any space, it alarms the hub and reacts simultaneously with noise control, playing music or soundmasking.

This responsive action can happen with or without human interference. When an alarm goes to the nursing station, a nurse can act and check on the situation. The system will continue actively until the sound level goes back to the base level (Figure 15).

In the beginning, there will be a need for human interaction with the proposed system, just as a self-driving car requires a human driver, even if only for insurance purposes.

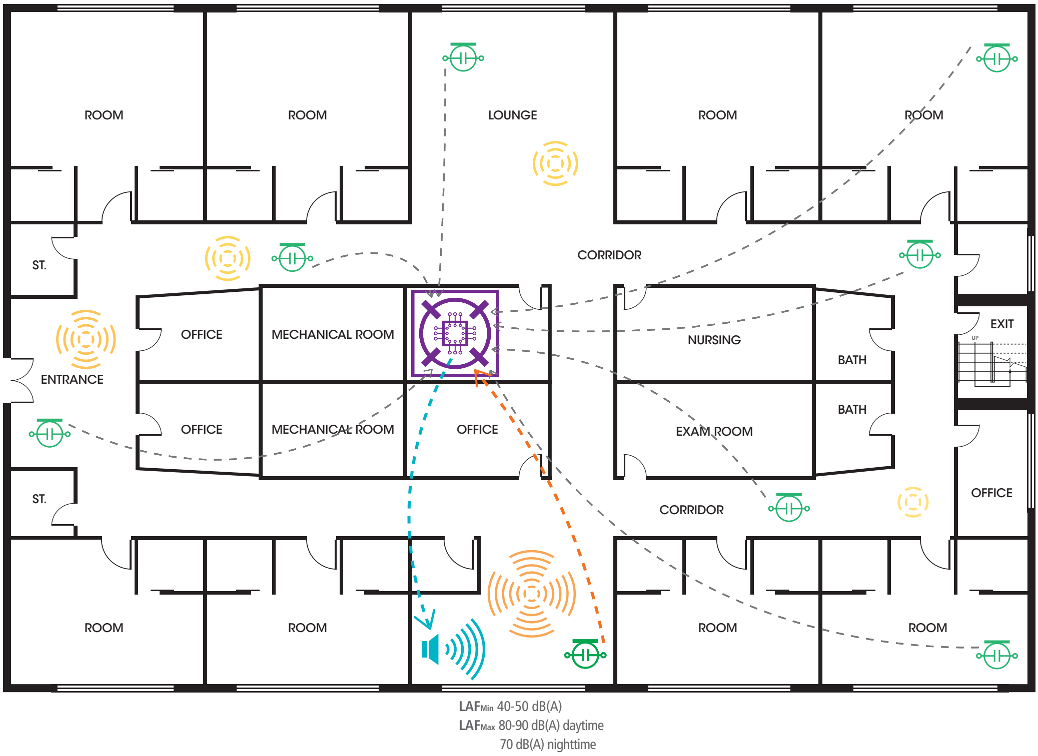


Figure. 15

Until the system reaches its full potential and safety elements are tested, human supervision seems necessary.

This system, although in need of further study and investigation, can work using existing technology. Appendix F describes a monitoring system that can be installed around the unit and through real-time cloud computing data transfers to nursing stations.

4.5 SCENARIOS

In this section, I will use three scenarios to describe what is happening within the proposed system. Scenarios are useful tools to communicate an idea or, as Katie Inglis explains, "the intended behavior within a system or environment" (2018).

4.5.1 ALARMING STAFF

It is 2 a.m. and the unit is relatively quiet. Patients are all in their rooms sleeping and night shift nurses are doing their paperwork inside the nursing station. One of the patients, Mr. D, wakes up suddenly, confused and agitated, and starts wandering around the unit, walking through the corridors slowly and entering other patients' rooms randomly. Another patient, Ms. M, sleeping in her bed, hears the sound of the intruder and wakes up scared and uncomfortable. She starts complaining and making loud noises. In a regular situation, Ms. M's noise would be heard by adjacent rooms before reaching the nursing station, causing other patients to awaken and become uncomfortable. With a responsive system in place, the system would recognize an unusual and loud activity and alarm the station. Night nurses would see the alarm on the screen with the specific room highlighted, would rush to Ms. M's room to calm her down, and would help Mr. D to his room, staying with him until he went back to sleep. I need to mention that in the existing setting, once patients leave their bed at night, an alarm goes off to alert nurses. The problem is that the alarm's sound level is almost 80 dB, so not only are nurses alarmed; the whole unit can hear the alarm, which in the middle of the night can be very agitating. The proposed system alarms the nurses with no change in the sonic environment, so other residents won't be disturbed.

This is a part of the system where human interaction plays an important role. The next two scenarios describe how the system can act responsively and independently.

4.5.2 SOUND MASKING

It is Tuesday morning and shower day. Staff has already started going through residents' rooms and taking them to the shower one-by-one. This results in a few residents resisting to taking a shower, increasing the overall sound levels of the corridors, which agitates other residents. The responsive soundscape system constantly monitors the ambient noise levels and starts the sound masking process once it recognizes the increase of sound levels. The system measures the sound level at 45 dB and sets the soundmasking to 46 dB. The system provides a continuous background sound that reduces the impact of the unwanted noises, masks conversations, and makes the resulting environment feel more private and comfortable. I need to add that sound masking, if acting continuously, makes a sonic environment unpleasant. Therefore, rather than installing a passive sound masking system, an active and responsive system will use masking only when needed.

4.5.3 MUSIC

It is 4 p.m., an hour before dinner time. The dining room is getting busier as residents start to feel hungry, walking in and out hoping for a meal to come. These movements, in addition to the residents talking loudly, asking for food or attention, increase the sound level of the dining room. The responsive system, through programming and intelligence, starts playing music to distract residents for a while before the meal arrives. I should note that this is a hypothesis and the type and genre of music needs more study and research. However, a responsive and smart system, over time, can learn about context and match the genre based on residents' interests. In addition to relaxing the atmosphere through music, the soothing music increases caloric intake during mealtime. As Ragneskog et al mentioned: "Patients spent a longer time at the table when the music was played" (1996).

4.6 SYSTEM REQUIREMENTS

Literature review and observation during the data collection showed the complexity of noise and sound as it's perceived by individuals. Sometimes loudness can illustrate a positive experience, while a lack of noise can transform a space into an unfamiliar and frightening situation. The question is, how can a smart soundscape system distinguish between positive or negative perception in relation to loud or quiet spaces?

As Booi & van den Berg discuss: "when sound is perceived as a negative factor (noise from transportation and people) there is a higher need for quietness, but as a positive factor (perceived liveliness at home/in neighbourhood) it reduces that need" (2012). This shows the importance of recognizing positive versus negative noise.

To make the system smart and capable of recognizing positive and negative noises, we need an extensive database. Data partly comes from guidelines and existing codes, such as WHO guidelines (Hurtley, 2009), and partly from observation.

4.7 DRAWINGS AND SPECIFICATIONS

Appendix G shows the drawing of a unit: its floor plan and reflected ceiling plan, with the location of a sound meter monitoring device and specifications.

5. SCOPE & LIMITATIONS

This research was designed and conducted to understand the effect of soundscape on people with dementia, based on existing literature, and subjective/ objective data. The first limitation was the scope of the project. Due to the timeframe, data collection was limited to a few locations and a few weeks. A holistic data collection will be necessary in the future.

The second limitation was the inability to gather subjective data from the patients' points of view. Due to the nature of REB, it was not possible to ask patients nor their caregivers to fill out the questionnaire. In future their points of view should be considered.

Third, I should mention that the proposed system was never tested, neither as a paper prototype or semi-functional prototype and is only a descriptive and schematic design. However, since responsive sound systems are already in use, this hypothesis with some alteration and revision will be successfully implemented.

6. DISCUSSION

This research aimed to open a conversation specific to sound, built environments, and dementia, to understand the importance of soundscape, especially when designing for people with cognitive difficulties, and to propose a solution to overcome the problem of excessive noise in care facilities.

First, there is a need to evaluate and understand both the objective and subjective characteristics of sound in dementia care units. In practice, designers and architects usually focus on a measurable quality of environments and neglect or overlook the feeling and perception of space from the user's perspective (Mackrill & Jenning, 2013). This oversight shows the importance of further research on this issue, but moreover, shows the lack of systematic proposals and solutions to overcome the absence of qualitative views. As Rosemary Bakker mentions, people who are living with dementia can lose the ability to understand what they hear accurately (2003). This confusion may lead them to auditory hallucinations, for example, the sound of a telephone may be perceived as a dog barking. "Excess noise can result in confusion, overstimulation, and difficulty communicating" (Bakker, 2003). People in LTC facilities are exposed to disturbing and loud noise from alarms, calls, pagers, and equipment during the day and night. This sonic environment results in agitation and anxiety in residents, which are frequently controlled by medication. Instead of drug use; as Bakker says, "the correct treatment would be a noise-reduction program" (2003).

Second, once the importance of soundscape is agreed upon, the need for intervention and systematic change will be necessary. The intent of any intervention should be to reduce the negative outcome of sonic environments by introducing simple changes in design. Although these interventions, either in the change of material, spatial planning, or eliminating unwanted sources of sound (as mentioned in this study), reduce the impact of noise and improve the quality of sonic environments in the short term, they may not be the best systematic proposals.

The proposed system is an active and responsive solution for controlling and enhancing the sonic environment by using real-time interventions. This system, through machine learning and data analysis, adapts to the environment and acts responsively.

7. CONCLUSION

This research aims to understand the level of sound that exists in dementia care units, both positive and negative, then, based on the data and literature review, proposes a design for the units to improve the soundscape and, hopefully, improve the quality of life for both patients and staff of the unit. The results of observation and data collection are:

- Overall sound level of dementia units is higher than the recommended standard
- LAF_{min} is usually 10-15 dB higher than the recommendation
- Although there is a relation between sound levels and perception of sound, higher sound levels are not always linked to negative acoustical environments

The proposed system is an active and responsive solution for controlling and enhancing the sonic environment by using real-time interventions.

The soundscape approach is an inclusive approach in designing a system since every location has a different personality, the system has to be designed for a specific location. The system's hardware and program can be universal, but the data, either qualitative or quantitative, should be gathered in specific locations. Each dementia care unit has its own subjective and objective characteristics, which should be determined at the beginning of the soundscape system design.

Several studies looked at the importance of noise control in care facilities through technology and how it could increase the quality of life for residents and staff. As researchers like Aletta et al mentioned: "Active soundscapes", can be a valuable approach in managing the sonic environment of nursing facilities and "should be implemented in their daily practice and organization" (2017).

8. NEXT STEPS

This proposed system should be validated first in Toronto Rehabilitation Institute, as one of the most advanced care facilities, and then, through other dementia care units. Also, there should be further research in the way this system can be implemented inside dementia care units. Once the system is implemented, another round of data collection, observation, and analysis should be conducted to evaluate the system by comparing the situation before and after its use. Here is the list of design criteria to be validated:

- Real-time interaction between the system and the sonic environment. The system will enable sound monitoring of different spaces
- Real-time evaluation of the sonic environment by comparing the sound level with the base level
- Authentication of data and the sound monitoring system. The system should authenticate the sound level
- Data security. All sensitive data should be securely used and encrypted if necessary

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11. APPENDICES

Appendix A. TRI REB Protocol and Approval

BACKGROUND

Noise is an important sensory trigger in any environment, especially in an enclosed and unfamiliar setting. People with dementia may already feel strange and isolated inside care facilities. Any distracting noise or constant sound through time and space can be disturbing, confusing and agitating for people living with dementia. Recently, there has been interest in sound mapping and soundscaping of care facilities, however there is a lack of research specific to dementia care facilities.

The majority of studies on this topic looking at the impact of noise by focusing on hospitals and operating rooms, and few specific to dementia care units. There also exist good documentation on the relation between noise, the stress levels and how noise can facilitate "change in autonomic nervous system, impairing mental faculties and producing masking that could affect the staff and conscious patient alike, leading to decreased work performance and increased anxiety respectively" (Luzzi & Falchi, 2002). Also, there have been studies on monitoring sound level in nursing homes (Aletta et al,2017) that focus on the relationship between sound and quality of life (QoL) for people living in nursing homes and for the staff. However, none of these studies looked at perception of sound and the relationship between sound and people with dementia.

Sound is very important in making people aware of their environment. As Bosch et al mention "sounds influence moods, cognition, and behavior" (2016). Vulnerable populations are usually affected by their environment and removing or reducing the disturbance environmental effect may improve their QoL. As well, environmental effects can be soothing and can help reduce behavioural change and agitation.

SCOPE OF STUDY

This project is part of my final deliverable for completing the Master of Design for Health program at OCAD University, taking place largely during winter semester. The project starts in January 2018 and continues through the end of June 2018.

For this project, I am measuring and analyzing sound level of three locations which are part of the Geriatric Psychiatry Unit in order to have a feasible research plan. These three locations will be explained later in this proposal. Sound measurement will take place over four hours at each designated location on five occasions. At the same time, a researcher will be observing and collecting data about the soundscape.

This is a pilot study designed to help guide the development of a future research protocol. The main limitations of this pilot study are that it is taking place in a single dementia care environment (the Geriatric Psychiatry Unit at TRI). The data from this phase of study is based on late winter early spring time of the study, although the soundscape may be different in other time of the year. Also, data will be collected only from three designated location and not entire unit.

STUDY OBJECTIVES

Specific Aims & Hypotheses

This research aims to develop a soundscape of the Geriatric Psychiatry unit at Toronto Rehab Institute.

Aim 1: To map sound levels in the Geriatric Psychiatry unit and identify main sources and patterns of noise

Aim 2: To measure the quality of the soundscape in the Geriatric Psychiatry unit

METHODS

Study Design:

This is an observational study with both qualitative and quantitative assessments. Loudness of sound is measured by numbers, but different sources of sound may have different characteristics. For example, the sound of air conditioning system may have different characteristic than the human voice.

Study Setting:

This study will take place on the Geriatric Psychiatry unit at Toronto Rehab Institute (TRI).

Quantitative Assessments:

We will be measuring sound levels, audio frequency based on hertz (Hz), and loudness of sound based on Decibel (dB). The sound analyzer will continuously measure all information we need during the observation periods. To do this, we will be using Brüel & Kjær 2270 hand-held Sound analyzer, sound level and frequency meter software and Vibration Analyzer (Appendix A).

The equipment will be used by either the principle investigator Arezoo Talebzadeh (AT) or the co-investigator Kaveh Ashourinia (KA). It will be mounted to the wall at head level of the investigators using double-sided mounting tape.

We will measure noise and sound in three different regions of Geriatric Psychiatry unit, dining room, corridor close to mechanical shaft, and one non-occupied bedroom (Appendix B). In each location, the timing of the observations and measurements will be divided into four time periods, which are 8 to 12, 12 to 16, 16 to 20 and 20 to 24, and we will observe during both weekdays and weekends. Each location will be measured and observed 5 times for maximum 4 hours.

For example:

- Location A
- Weekday 1 — 4 hours
- Weekday 2 — 4 hours
- Weeknight — 4 hours
- Weekend day — 4 hours
- Weekend night — 4 hours
- TOTAL Location A — 5x4=20 hours
- TOTAL 3 Locations — 20x3=60 hours (Appendix C)

Qualitative assessments:

Observing sound by a person is the preferred method due to collecting and understanding both loudness and quality of sound and noise. To determine the main noise sources, as well as to map the quality of the soundscape, the study observers will be on the unit for the maximum 60 hours. We will use this standardized form to collect observational data (Appendix D). Observers will sit in the designated location. They will mount the equipment on the wall, and sit below it, using the data collection sheet to log sources of sound on a ten-minute basis, and completing a soundscape quality questionnaire every hour.

Study participants:

This is an environmental study, and not a study of individuals, thus there are no study participants. Because the people in the environment constitute an element of the environment, we will collect some basic cross-sectional information about the people in the environment at the time of the data collection. We will do this retrospectively, using clinical data routinely collected in the DADOS database to establish the cross-sectional characteristics of the patients on the unit during the observation period. This includes the number of patients on the unit, their mean age, proportion of each sex, the mean severity of the behavioural symptoms of the patients (neuropsychiatric inventory), and the number of patients with vocalizing behaviours (number of patients with aberrant vocalization score on neuropsychiatric inventory >4). This information will be exported from DADOS in an anonymized and summative fashion, i.e. with means or counts) and there will be no identifiable PHI included in this data.

For staff information about the study, an educational hand-out will be posted on the unit and distributed to staff via email and their mailboxes before the start date of project (Appendix E).

Privacy and confidentiality

Individual patients or staff will not be identified in the sound data collection. We will not be collecting any sound recordings. Retrospective clinical data will be used, but all PHI will be removed and the data presented only in summary form (means or counts).

Data storage and safety

We will not be doing any sound recording in this study. The frequency and loudness data will be exported from the device and stored on a networked UHN research drive. The cross-sectional patient characteristics will be stored on a networked UHN research drive.

A photograph of each location will be taken before or during the measurement to be used if needed during data analysis. No patients, staff or PHI will be visible in the pictures.

Data analysis

Data analysis will involve summary statistics of patient characteristics, quantitative sound data, and the soundscape questionnaire. The final analysis of data will be presented in a report along with visual soundscape of the unit. The result of study will be used as presentation, poster and journal submission, prototype and design principles.

University Health Network
Research Ethics Board
10th Floor, Room 1056
700 University Ave.
Toronto, Ontario, M5G 1Z5
Phone: (416) 581-7849

NOTIFICATION OF REB INITIAL APPROVAL

Date: February 16, 2018

To: Andrea Iaboni
Toronto Rehabilitation Institute, University Centre, 550 University Avenue, 5th Floor, 5-105-3, Toronto, Ontario, Canada, M5G 2A2

Re: 18-5001
Sound Level Monitoring and Soundscape Approach in Designing Dementia Care Unit: A Case Study at Toronto Rehab Institute, Geriatric Psychiatry Unit

REB Review Type: Delegated
REB Initial Approval Date: February 16, 2018
REB Expiry Date: February 16, 2019

Documents Approved:

Document Name	Version Date	Version ID
Data collection form	December 29, 2017	1.0
Information sheet	February 2, 2018	1.1
Poster	February 2, 2018	1.0
Protocol	February 2, 2018	1.1

The University Health Network Research Ethics Board approves the above mentioned study as it has been found to comply with relevant research ethics guidelines, as well as the Ontario Personal Health Information Protection Act (PHIPA), 2004.

Feb/21/2018 10:13 am

Appendix B. OCAD University Reseach Ethics Approval

Student Email by Google

Arezoo Talebzadeh <3152172@student.ocadu.ca>

Application approved

cpineda@ocadu.ca <cpineda@ocadu.ca>   Mon, Mar 5, 2018 at 9:26 PM
To: "Ms. Arezoo Talebzadeh (Co-Investigator)" <3152172@student.ocadu.ca>, "Dr. Katherine Sellen (Principal Investigator)" <ksellen@faculty.ocadu.ca>
Cc: cpineda@ocadu.ca

March 05, 2018

Dr. Katherine Sellen
Faculty of Design
OCAD University

File No: 101246
Approval Date: March 05, 2018
Expiry Date: March 04, 2019

Dear Dr. Katherine Sellen, Ms. Arezoo Talebzadeh,

The Research Ethics Board has reviewed your application titled 'Sound Level Monitoring and Soundscape Approach in Designing Dementia Care Unit: A Case Study at Toronto Rehab Institute, Geriatric Psychiatry Unit'. Your application has been approved. You may begin the proposed research. This REB approval, dated March 05, 2018, is valid for one year less a day: March 04, 2019. Your REB number is: 2018-22.

Throughout the duration of this REB approval, all requests for modifications, renewals and serious adverse event reports are submitted via the Research Portal.

Any changes to the research that deviate from the approved application must be reported to the REB using the amendment form available on the Research Portal. REB approval must be issued before the changes can be implemented.

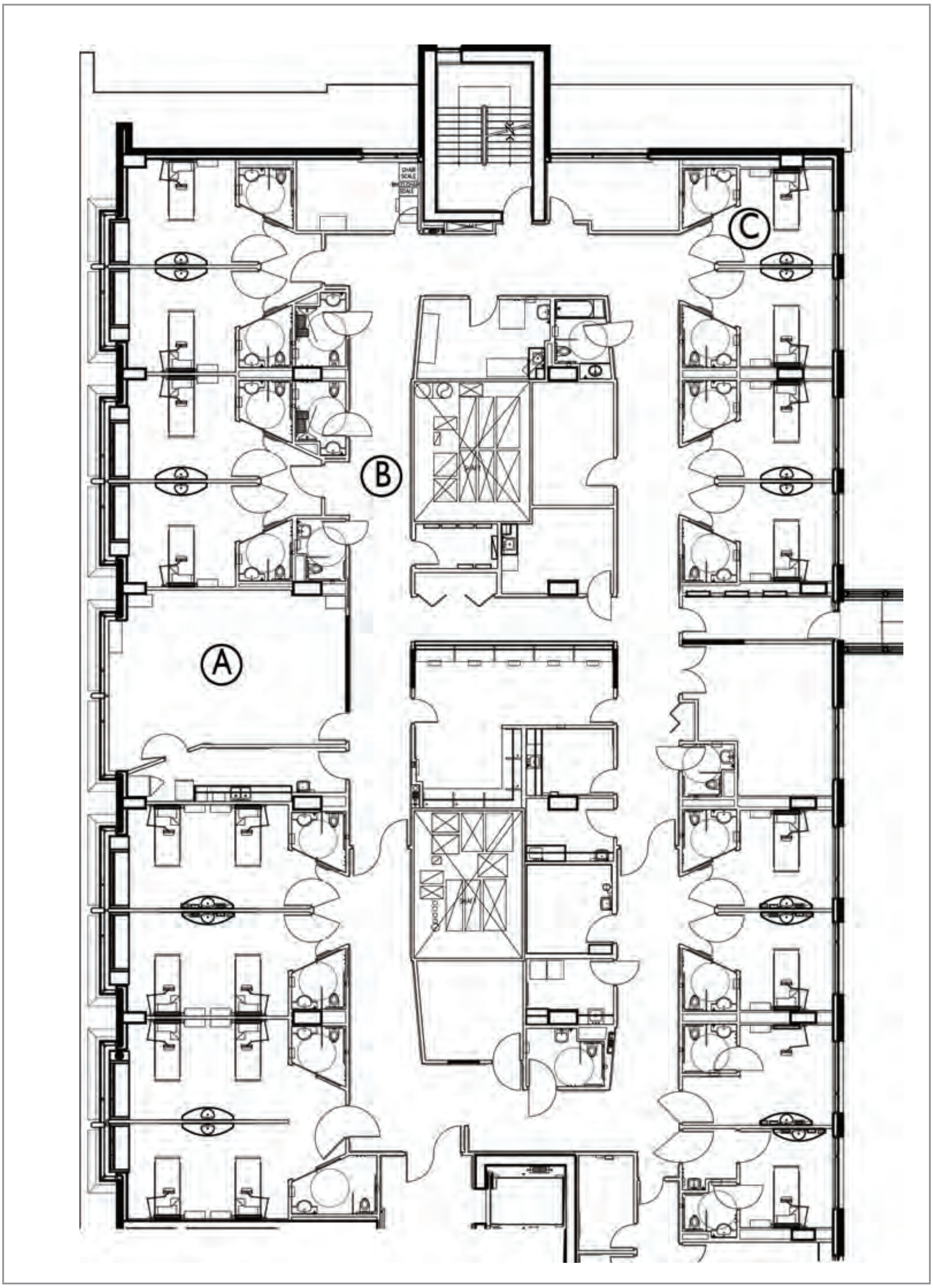
To continue your proposed research beyond March 04, 2019, you must submit a Renewal Form before February 25, 2019. REB approval must be issued before research is continued.

If your research ends on or before March 04, 2019, please submit a Final Report Form to close out REB approval monitoring efforts.

If you have any questions about the REB review & approval process, please contact the Christine Crisol Pineda, Manager, REB secretariat at (416) 977-6000 x4368 or cpineda@ocadu.ca.

If you encounter any issues when working in the Research Portal, please contact our system administrator via

Appendix C. Plan with locations



Appendix D. Questionnaire

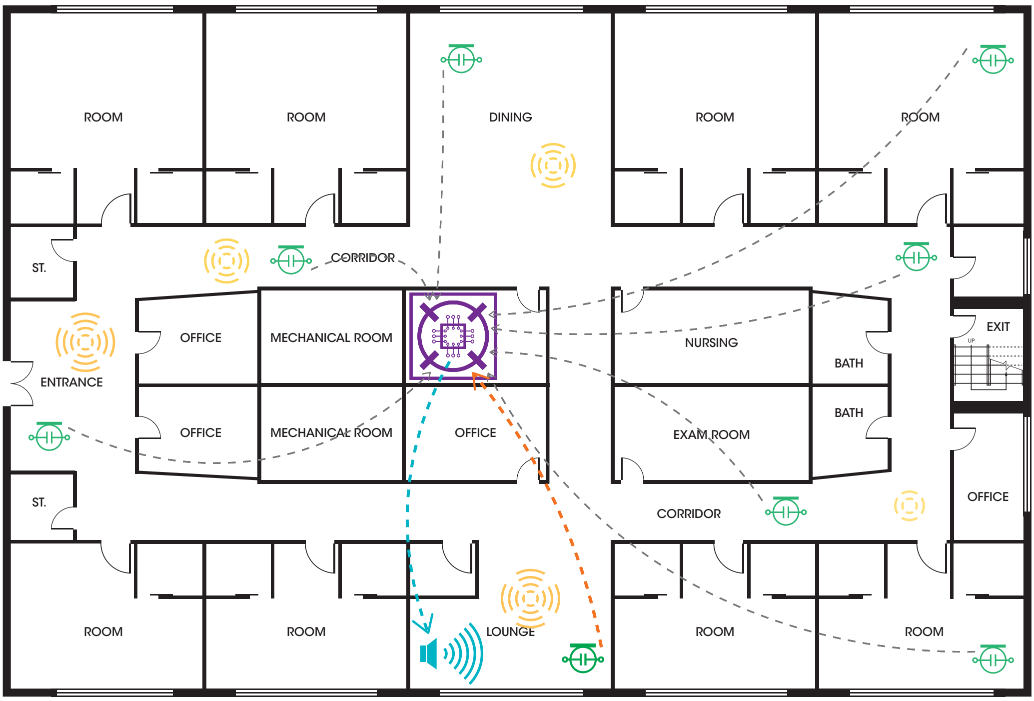
DATA COLLECTION LOG SHEET

Date: Location: Observer:

	Time	0:00	0:10	0:20	0:30	0:40	0:50	1:00		3:50	4:00
1. Overall, how would you describe the present surrounding sound environment?	Very bad <u>0 1 2 3 4 5 6 7 8 9 10</u> Very good										
2. Overall, to what extent is the present surrounding sound environment appropriate to the present place?	Not at all <u>0 1 2 3 4 5 6 7 8 9 10</u> Perfectly										
3. To what extent do you presently hear the following six types of sounds? Do not hear at all 0 1 2 3 4 5 6 7 8 9 Dominates completely 10	Installation sounds e.g., fan/ventilation noise, medical equipment, telephone										
	Operational sounds e.g., door slamming, trolleys passing-by, kitchen functions										
	Electronic sounds e.g., TV, radio, reproduced music, toys										
	Environmental noise e.g., transportation noise, construction noise, wind, rain, sounds from people outside										
	Human sounds VOCAL e.g., voices, laughter, sounds from individuals in the room										
	Human sounds NON-VOCAL e.g., footsteps, clapping hands, hitting objects										
4. For each of the ten scales below, to what extent do you agree or disagree that the present surrounding sound environment is... Not at all 0 1 2 3 4 5 6 7 8 9 Completely 10	Pleasant										
	Chaotic										
	Vibrant										
	Uneventful										
	Calm										
	Annoying										
	Eventful										
	Monotonous										
	Safe										
	Intimate										

Data collection log sheet Version 1.0 - 12/29/17

Appendix E. Schematic Design



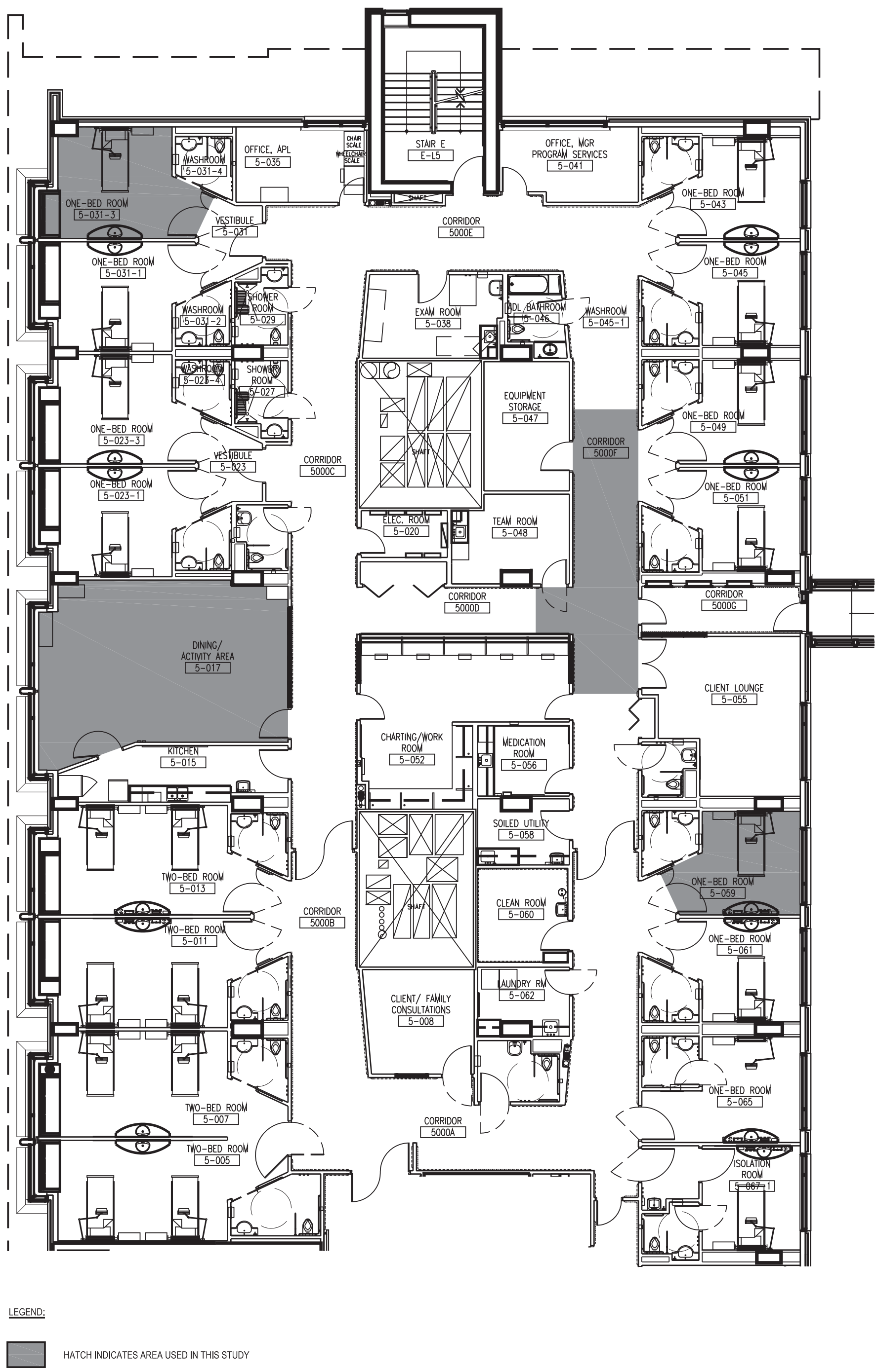
Active Feedback in Progress

EM2030 Sound Level Monitor

Simplicity and precision

Automated operation and simple online analysis	Continuous remote monitoring with no manual interaction
Extended measurement range with remote controlled setup	Reliable measurement for any application
Frequency analysis tools for detailed sound source investigation	1/1 and 1/3 octave analysis options
Flexible and automated audio sample recording options	Remotely capture audio clips to identify noise sources
Low power mode to extend battery life	Ready for long term remote measurement projects

Appendix G. Working Drawing



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No.	Issuance	Date

project north

project

SOUNDSCAPE SYSTEM

title

PLAN

project number

date

July 2018

scale

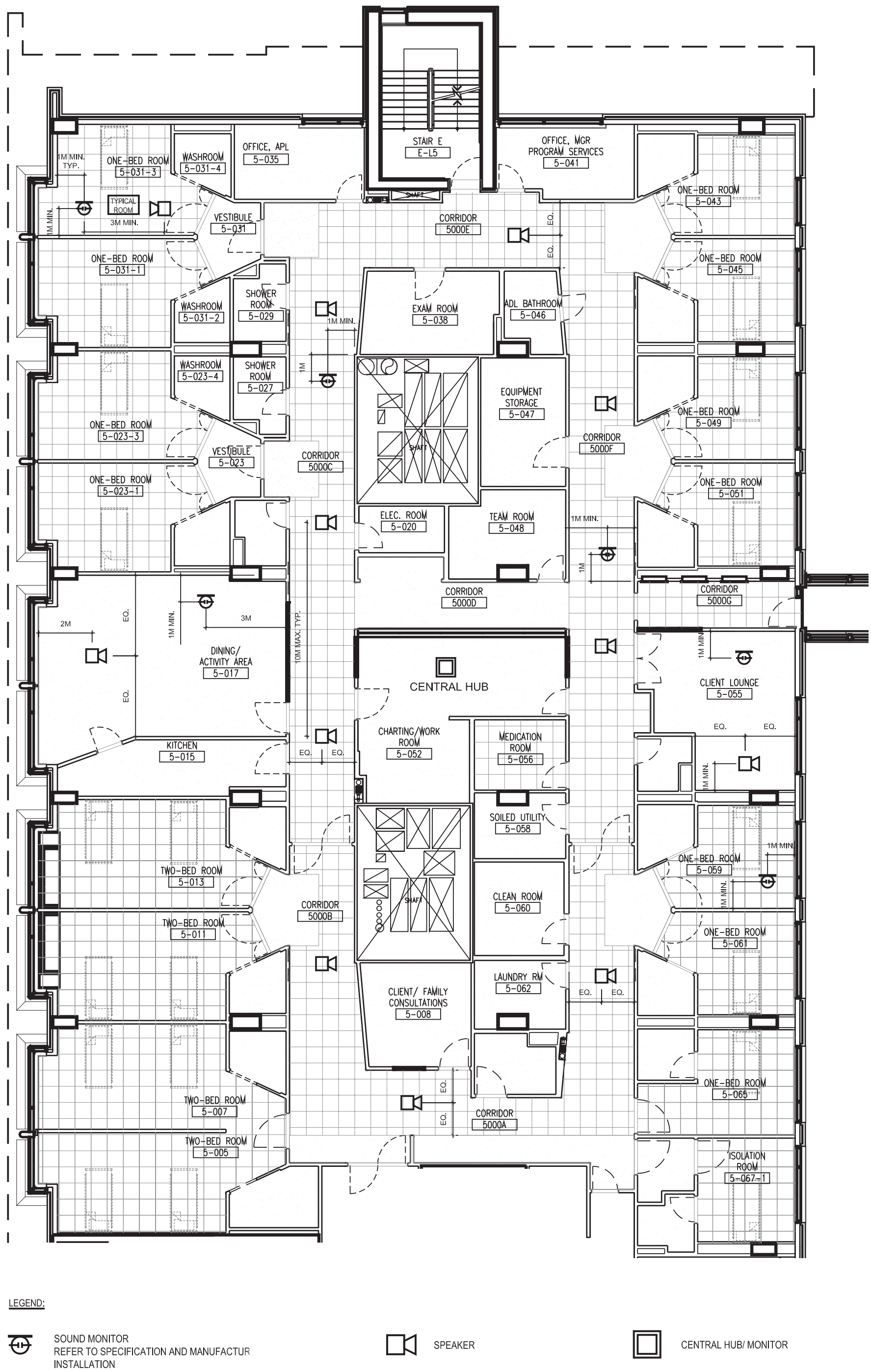
1:200

drawn by

AT

sheet

A01


STAIR E
E-L5
OFFICE, APL
5-035
OFFICE, MGR
PROGRAM SERVICES
5-041
WASHROOM
5-031-4
ONE-BED ROOM
5-031-3
1M MIN.
TYP.
TYPICAL
ROOM
3M MIN.
VESTIBULE
5-031
CORRIDOR
5000E
ONE-BED ROOM
5-043
ONE-BED ROOM
5-031-1
ONE-BED ROOM
5-045
WASHROOM
5-031-2
SHOWER
ROOM
5-029
EXAM ROOM
5-038
ADL BATHROOM
5-046
WASHROOM
5-023-4
SHOWER
ROOM
5-027
EQUIPMENT
STORAGE
5-047
ONE-BED ROOM
5-049
ONE-BED ROOM
5-023-3
VESTIBULE
5-023
CORRIDOR
5000C
SHAFT
CORRIDOR
5000F
ONE-BED ROOM
5-023-1
ONE-BED ROOM
5-051
ELEC. ROOM
5-020
TEAM ROOM
5-048
CORRIDOR
5000D
CORRIDOR
5000G
2M
3M
10M MAX. TYP.
DINING/
ACTIVITY AREA
5-017
CENTRAL HUB
CLIENT LOUNGE
5-055
KITCHEN
5-015
CHARTING/WORK
ROOM
5-052
MEDICATION
ROOM
5-056
SOILED UTILITY
5-058
ONE-BED ROOM
5-059
TWO-BED ROOM
5-013
CORRIDOR
5000B
CLEAN ROOM
5-060
TWO-BED ROOM
5-011
ONE-BED ROOM
5-061
CLIENT/ FAMILY
CONSULTATIONS
5-008
LAUNDRY RM
5-062
ONE-BED ROOM
5-065
TWO-BED ROOM
5-007
CORRIDOR
5000A
TWO-BED ROOM
5-005
ISOLATION
ROOM
5-067-1
LEGEND:
SOUND MONITOR
REFER TO SPECIFICATION AND MANUFACTUR
INSTALLATION
SPEAKER
CENTRAL HUB/ MONITOR

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project north

project

SOUNDSCAPE SYSTEM

title

REFLECTED CEILING PLAN

project number

date

July 2018

scale

1:200

drawn by

AT

sheet

A02

SoundEar®3

Measure, monitor and manage the noise with SE3–300

The mini display on SoundEar®3 – 300 and 310 is operated manually via the tuch panel on the front of the cabinet.

Eksternal microphone

USB key for export of data

SoundEar®3 software

SoundEar A/S

SoundEar®3 – 300 Specifications

Parameters:	Measures 3 measurements simultaneously LAF; LAS; LCpeak; Laeq, 1s, Laeq ¼ h, Laeq 1/2h, Laeq 1 h.
Resolution:	0,1 dB for all parameters
Measuring Ranges:	RMS: Total 30 – 120 dB
Deviation:	+/- 0.5 dB
Frequency Range:	20Hz- 20 kHz
Frequency Weightings:	A- weighting (RMS), C-weighting (Peak)
Time Weighting:	Slow(1S) & Fast (125 ms)
Dynamic Range:	90 dB and peak detection
Light setting:	full configurability through Soundear software including nightsetting
2 x outputs :	0-10 V or 4-20 mA
2 xUSB outputs:	Micro USB (power & PC) , USB OTG (Log, configuration)
Display setting:	LAS max, Leq (A)/15, Alarm settings, Temperature & Clock
Power Supply:	5VDC (Micro USB) / 24VDC (Screw terminal)
Current Consumption:	max 2,5 W
Internal memory:	16 MB(128 Mbit) (5-90 days log time, depending on log settings)
Real Time Clock:	Hi-precision type with battery backup (CR2032)
Microphone:	20 Hz- 20 kHz
Measurement 300 - 310:	Length 256 mm, Width: 205 mm, Height: 45 mm., Weight: 1,5 kg

Standards: IEC61672-2-2002, Type 2, ANSI S1,4 Type 260601-1: Medical electrical equipment- Part 1: general requirements for basic safety and essential performance. 60601-1-2_ Medical equipment – Part 1.2: General requirement – Part 1-2: General requirement for Basic safety and essential performance.

Connectivity accessories: GSM module, 4 G module for Cloud solution

TECHNICAL SPECIFICATIONS

SOUND LEVEL MEASUREMENT

Accuracy: IEC 61672 Class 1

Dynamic range: 20 to 121dB(A)

Frequency range: 20Hz to 20kHz

Frequency weighting: A and C weighting

Parameters: LEQ, L05, L10, L50, L90, L95, LMAX

LOGGING

Measurement period: 1, 5, 10, 15 or 30 minutes

Data storage capacity: 5 years (5 minute logging)

Procedure: Automatic measurement and logging

POWER REQUIREMENTS

Power input: 110V-240V AC

EM2030: 12V DC, up to 500mA

Power consumption: 2.4W

COMMUNICATONS

Wi-Fi (user interface)

3G SIM card supplied with each monitor

MICROPHONE

Sensitivity: 50mV/Pa

Connection: BNC to BNC (3m cable as standard)

Power supply: Constant current ICP, 18V 4mA

INTERFACE

The EM2030 and online interface are accessed using any standard web browser

Sonitus Systems

www.sonitussystems.com

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No.	Issuance	Date

project north

project

SOUNDSCAPE SYSTEM

title

SPECIFICATION

project number

date

July 2018

scale

1:200

drawn by

AT

sheet

A03

AREZOO TALEBZADEH

DECEMBER 2018

AREZOO
TALEBZADEH