



A Case Study on Speech Intelligibility in Hospital Triage Area

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ABSTRACT

Clear and effective communication is essential in hospital emergency departments (ED), where the timely and accurate exchange of information can significantly influence patient outcomes. This case study examines challenges related to speech intelligibility at triage counters within a busy urban ED. Employing a mixed-methods approach, the study integrates environmental assessments, and staff input to identify the primary factors that hinder verbal communication between patients and healthcare providers. Findings indicate that elevated ambient noise, inadequate acoustic design, protective barriers, speaker accents, and the distance and orientation between speakers and listeners all contribute to reduced speech clarity. These issues lead to frequent miscommunication, repeated exchanges, and delays in patient triage, ultimately affecting the efficiency and safety of care delivery. Staff members reported vocal strain and fatigue, while patients—especially elderly individuals and those with limited English proficiency—had difficulty comprehending spoken instructions. Based on the findings, a set of acoustic design recommendations was proposed and implemented by the hospital, following a comprehensive compliance review involving fire safety, infection control, and constructability, without compromising ED functionality. Feedback from hospital authorities indicated notable improvements in speech intelligibility for both staff and patients, leading to a more effective aural environment in this complex clinical setting.

1 INTRODUCTION

Effective communication is the cornerstone of high-quality healthcare delivery, especially within the fast-paced and high-stakes environment of hospital emergency departments (EDs). In such settings, the ability to quickly and accurately exchange verbal information between patients and healthcare providers is not only crucial for operational efficiency but can directly impact patient safety and clinical outcomes. Despite this critical importance, communication in EDs is often compromised by a variety of environmental, linguistic, and architectural challenges—factors that are frequently overlooked in hospital design and operations. This paper explores one such challenge: the issue of reduced speech intelligibility at triage counters within a busy urban emergency department.

The triage counter represents a critical first point of contact where patients are assessed, categorised, and prioritised for treatment. Any breakdown in communication at this stage can lead to delayed care, misdiagnosis, and increased risk of medical errors. This problem is further complicated by a combination of elevated ambient noise levels, poorly considered acoustic environments, physical barriers such as glass partitions or protective screens, and varying speech patterns and accents among both patients and staff. These conditions often result in repeated dialogue, misinterpretation of symptoms or instructions, and increased cognitive loads for all parties involved.

In addition to these environmental and systemic factors, individual differences among patients—particularly those who are elderly, hard of hearing, or have limited proficiency in the dominant language—further exacerbate the issue of speech intelligibility. Meanwhile, healthcare workers face the dual burden of ensuring accurate patient assessment while contending with vocal fatigue, background noise, and the physical strain of repeated communication attempts. Together, these challenges compromise the quality and safety of care, undermining the efficiency of the emergency department.

Recognising these issues, this study investigates the key contributors to poor speech intelligibility at triage stations, using a case study approach situated in a large urban ED. By employing a mixed-methods research design—including direct observations, and structured staff interviews—the study aims to identify the root causes of communication breakdowns and develop practical, evidence-based recommendations for improving verbal interactions in these high-pressure environments.

The outcome of this research is not merely diagnostic. In collaboration with hospital stakeholders, a set of targeted acoustic design interventions was proposed and implemented, following a rigorous review to ensure compliance with fire safety, infection control, and constructability requirements. Post-implementation feedback and acoustic testing suggests that these changes resulted in marked improvements in communication clarity, staff satisfaction, and patient experience. This paper presents the methodology, design recommendations arising from the study and the outcome of the speech intelligibility assessment, with the goal of informing future healthcare design and policy decisions that prioritise clear communication as a fundamental component of emergency care delivery.

2 FACTORS INFLUENCING SPEECH INTELLIGIBILITY IN HOSPITAL TRIAGE AREAS

Effective verbal communication in hospital emergency departments (EDs) is essential for ensuring accurate triage, timely care delivery, and patient safety. The triage area serves as the first point of clinical interaction where initial patient assessments are made, often under conditions of time pressure, high stress, and information overload. Speech intelligibility—defined as the degree to which spoken language can be correctly understood by a listener—is a critical determinant of communication effectiveness in such settings. However, multiple factors in busy ED environments can degrade speech intelligibility, leading to miscommunication, delays in care, and increased cognitive and physical strain for both patients and staff. This literature review examines the main factors influencing speech intelligibility in hospital triage areas, with a focus on background noise, reverberation, nurse vocal strain, and patient language proficiency. Each of these elements plays a distinct but interrelated role in shaping the quality and clarity of spoken communication in high-demand clinical environments.

Speech Transmission Index (STI) is an objective metric used to evaluate speech intelligibility in a given environment. It quantifies how well speech is transmitted from a talker to a listener, accounting for factors such as reverberation, background noise, and distortion. STI values range from 0 (completely unintelligible) to 1 (perfect intelligibility), and are classified into qualitative rating bands as follows:

Table 1: STI Ratings, IEC 60268-16:2020

STI Value	Qualitative Rating	Description
0.00–0.30	Bad	Speech is unintelligible
0.30–0.45	Poor	Speech is difficult to understand
0.45–0.60	Fair	Speech is partially intelligible
0.60–0.75	Good	Speech is mostly intelligible
0.75–1.00	Excellent	Speech is highly intelligible

STI is commonly used in environments where effective verbal communication is critical, such as healthcare facilities, classrooms, transportation terminals, and public address systems. It can be measured using test signals and instrumentation or predicted through acoustic modelling. Acoustic and non-acoustic factors affecting speech intelligibility are briefly described below:

2.1 Background Noise in the Emergency Department

Background noise is one of the most pervasive environmental challenges affecting speech intelligibility in hospital settings. According to the World Health Organization (2009), hospital noise levels should not exceed 35 dB(A) during the day and 30 dB(A) at night. However, studies consistently show that EDs often experience sound levels exceeding 65–75 dB(A) due to a mix of alarms, medical equipment, staff conversations, overhead paging, and general activities at the patient waiting areas (Busch-Vishniac et al., 2005; Bliefnick, Ryherd, & Jackson, 2019). The presence of elevated background noise reduces the signal-to-noise ratio (SNR), a key metric in determining how well speech can be understood relative to competing sound. Research shows that speech intelligibility begins to decline when the SNR drops below +10 dB, and it can deteriorate dramatically in more challenging acoustic conditions (Houtgast & Steeneken, 1984). In triage contexts, where critical information must be exchanged rapidly and accurately, elevated noise levels can force speakers to repeat themselves, speak louder than is comfortable, or unintentionally omit important information. This not only impairs communication but also increases staff fatigue and reduces overall operational efficiency (Welch, Cheung, Apker, & Patterson, 2013).

2.2 Reverberation and Acoustics of ED Spaces

Reverberation refers to the persistence of sound in a space after the original sound has stopped, caused by reflections from walls, ceilings, and floors. In many hospital triage areas, especially those built with hard, non-absorptive materials like plasterboard, glass, and tile, reverberation times can exceed the recommended thresholds for effective communication. The optimal reverberation time (RT60) for speech intelligibility in healthcare environments is generally cited as 0.4s to 0.6 seconds (NSW Health Guideline, AS2107). Longer RT60 values

cause overlapping sound reflections, which smear the temporal aspects of speech—especially consonant sounds that are critical for word recognition. Kang (2007) emphasizes that reverberation not only affects the clarity of speech but also the listener's ability to distinguish individual words, particularly in noisy settings. Excessive reverberation in triage areas can also contribute to listener fatigue and increased vocal effort for staff, as speakers unconsciously raise their voices to overcome acoustic challenges. Acoustic treatments such as ceiling baffles, sound-absorbing wall panels, and layout modifications have shown promise in reducing reverberation and improving overall aural comfort in healthcare environments (Ryherd & Waye, 2013).

2.3 Nurse Vocal Strain and Communication Load

Triage nurses are among the most frequent verbal communicators in the ED, often repeating similar instructions or questions to dozens of patients per shift. In environments characterized by high noise and poor acoustics, nurses must frequently raise their voices or repeat themselves, leading to increased vocal load and, over time, vocal fatigue or even injury. Sataloff (1987) has documented occupational voice disorders among healthcare workers, noting that vocal fatigue, hoarseness, and discomfort are common among nurses in high-demand settings. These symptoms not only impact on personal well-being but also affect professional performance by reducing speech clarity and audibility, particularly over long shifts. Garcia Martins et al (2014) suggest that ergonomic voice use, staff education on vocal health, and environmental modifications can help mitigate these issues. However, lasting improvement in speech intelligibility and vocal health also requires addressing systemic acoustic and workflow factors that contribute to excessive vocal effort.

2.4 Patient Language Proficiency and Communication Barriers

In urban and multicultural healthcare settings, such as many emergency departments, it is common for patients to have limited proficiency in the dominant language spoken by healthcare providers. Language discordance is a major barrier to speech intelligibility, particularly when compounded by poor acoustics or environmental noise. Bradlow and Bent (2002) found that non-native listeners experience significantly greater declines in comprehension under noisy conditions compared to native listeners. Flores (2006) further notes that patients with limited English proficiency (LEP) are at greater risk of misunderstandings, adverse events, and lower satisfaction due to communication breakdowns.

Patients who do not speak the same language as the triage nurse may rely on family members, ad hoc interpreters, or body language, all of which introduce risks of miscommunication. Moreover, elderly patients or those with hearing loss face additional difficulties, as they often require slower, clearer speech and greater contextual cues to understand spoken language. Healthcare organizations have attempted to address these issues through interpreter services, translated materials, and multilingual signage. However, in emergency triage settings, these resources are often unavailable or impractical due to time constraints. Diamond et al. (2019) emphasize the importance of proactive design measures—such as visual communication aids and simplified speech—to support equitable care delivery for linguistically diverse patients.

2.5 Interplay of Environmental and Human Factors

It is important to recognize that the factors affecting speech intelligibility in the triage area do not operate in isolation. Rather, they interact dynamically to shape communication outcomes. For instance, high background noise exacerbates the effects of reverberation, while both conditions increase vocal strain and reduce listener comprehension. Likewise, a non-native speaker's ability to understand speech is more severely impaired under poor acoustic conditions, illustrating the compounding effects of environmental and individual factors. Kang (2006) argues that effective communication in the ED requires an integrated approach that considers not only acoustics and language but also spatial layout, workflow design, and user behavior. For example, reducing ambient noise through behavioral protocols (e.g., limiting unnecessary conversations) and equipment modifications (e.g., quieter alarms) can complement architectural solutions aimed at improving the auditory environment.

3 ACOUSTIC DESIGN CRITERIA

NSW Health – Engineering Services Guidelines 2022 recommends design sound level and reverberation criteria for conditions affecting the acoustic environment within building interiors to ensure a healthy, comfortable and productive environment for the occupant and the users. These recommendations are also based on Australian Standard AS/NZS 2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors. The recommended background sound levels (LAeq) consider the function of the space and apply it to the sound level measured within the space unoccupied but ready for occupancy. The standard is applicable to steady-state or quasi-steady-state sounds. The reverberation times recommended are for the occupied state of the space.

Table 2 Recommended internal sound levels and reverberation times (NSW Health)

Room Type	NSW Health Criteria	
	Internal Noise Level, L_{eq} dB(A)	Reverberation Time (Sec)
Public Waiting Rooms, Reception Areas	40 to 50	0.4 to 0.6

Note: Reverberation time should be minimized as much as practicable for noise control. Acoustic treatment should have a minimum acoustic performance equivalent to NRC 0.7 covering at least 80% of the area of the ceiling. If acoustic materials with a higher NRC performance are proposed, the coverage area can be reduced proportionally.

4 PRELIMINARY SITE OBSERVATION AND ASSESSMENT

A site inspection was conducted in August 2024, at the triage reception and patient waiting lounge to assess ongoing acoustic concerns affecting speech intelligibility. Several key issues were identified during the visit. High background noise levels were observed in the patient lounge, and the reception area was found to be highly reverberant. The indoor noise levels within the reception were particularly elevated when individuals spoke, significantly impairing the audibility of staff at the reception desks. Both the walls and ceilings in the reception and waiting lounge areas consisted of hard, reflective surfaces such as timber, plasterboard, and large glazed surface, contributing to poor acoustic performance. Additionally, a full-height glass panel, installed at the reception for security and infection control purposes, functioned as a concave reflective surface, directing sound back toward the reception desk and exacerbating the noise problem. Furthermore, the adjacent store and photocopy area lacked acoustic isolation, allowing noise from these spaces to interfere with communication at the reception. Overall, the space demonstrated insufficient noise control measures to maintain an indoor sound environment conducive to clear speech intelligibility.

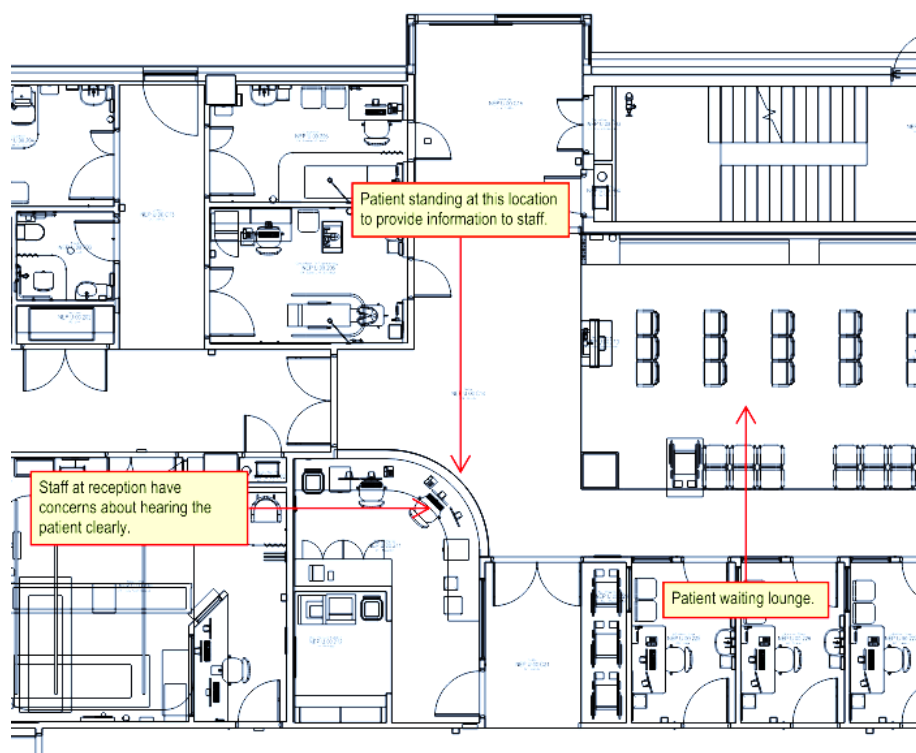


Figure 1 ED Triage Area and Patient Lounge

These observations were merely visual, rather than acoustically quantified as test measurements were not feasible due to live operation of the Hospital emergency department. Therefore, it was not possible to quantify the as-built acoustic performance of the space including background noise levels, sound insulation rating of wall partitions and reverberation time, which influences the speech intelligibility of the room. However, the contractor supplied scaled as-built drawings which allowed us to perform desktop assessment of reverberation time only. Consequently, the recommended design is based on noted site conditions and desktop reverberation assessment of the Triage Reception Room and ED Waiting Room. The desktop assessment predicts the reverberation time in both rooms before recommended acoustic treatment as shown in the Table 3.

Table 3: Predicted reverberation time assessment results (as built condition)

Room	Reverberation Time, sec Before Treatment (Predicted)	Acoustic Design Criteria Reverberation Time, sec
Triage Reception Room	0.9	0.40
ED Waiting Room	1.6	<0.70

Since background noise levels and reverberation time (RT) could not be measured on site, it was not possible to quantitatively assess speech intelligibility through standard acoustic metrics. However, site observations, along with feedback from the triage nurse, indicate that speech intelligibility in the triage area is significantly compromised. Nurses have expressed concerns about vocal strain during patient interactions, and patients reportedly experience difficulty in clearly understanding the communication, highlighting a critical issue in the acoustic environment of the space.

5 ACOUSTIC DESIGN RECOMMENDATIONS

5.1 Reverberation Control - Nurse Station, Triage Reception and patient Lounge

Based on the desktop assessment, acoustic absorptive ceiling (NRC 0.8) and walls panels (NRC 0.8) were recommended at strategic locations to minimise reverberation to an acceptable level at the Nurse Station, Patient Triage Area and Patient Lounge Area. A schematic diagram is provided in Figure 2.

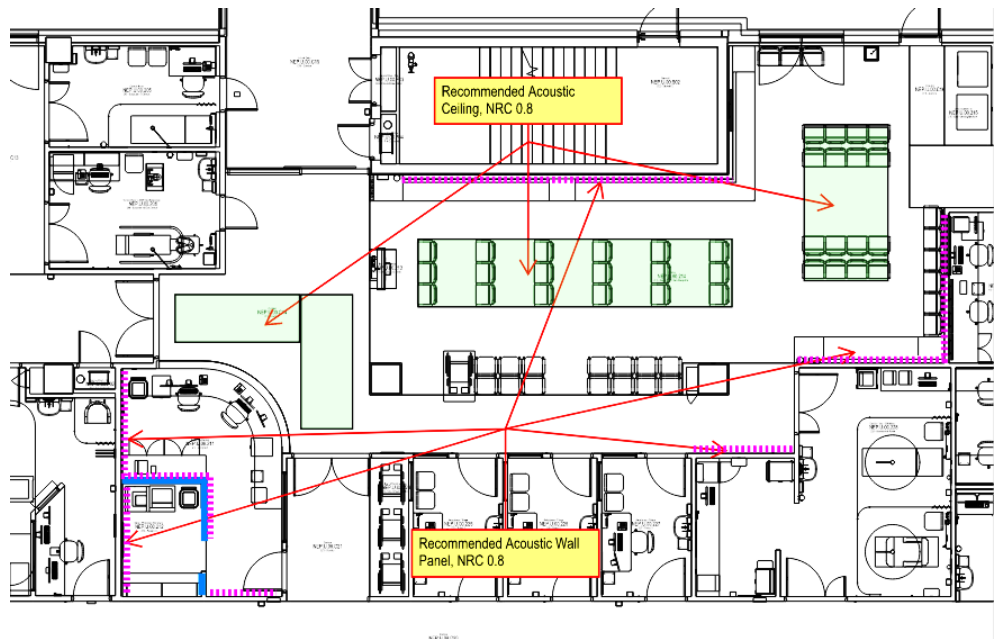


Figure 2 Recommended acoustic ceiling and absorptive panels locations

5.2 Above-Ceiling Treatment

To mitigate noise transmission between the Emergency Department waiting area and the triage reception office, particularly via ceiling cavities and service ductwork (commonly referred to as 'crosstalk'), acoustic treatment above ceiling at the glazed partition was recommended. The recommendations included installing 3mm Wavebar (mass-loaded vinyl, 6kg/m2) or baffle block (high density polyester, 16kg/m3, 40% compressed) to the entire width of the composite glazed/lightweight wall section.

5.3 Glazing Interventions

A visual and auditory assessment of the triage reception area identified a significant acoustic weakness through the full-height vertical slot opening in the existing glazed reception counter. Staff familiar with the space reported frequent disruption due to noise intrusion from the Emergency Department (ED) waiting area, resulting in poor speech intelligibility and increased annoyance during communication tasks.

Considering budget and ongoing operation of the ED, a retrofit solution was proposed which aimed at reducing the size of the open slot in the existing counter glazing, with minimal disruption to ongoing hospital operations. A secondary glazed or absorptive panel directly behind the existing glazing opening was proposed to minimise direct noise transmission from the patient area to the nurse station.

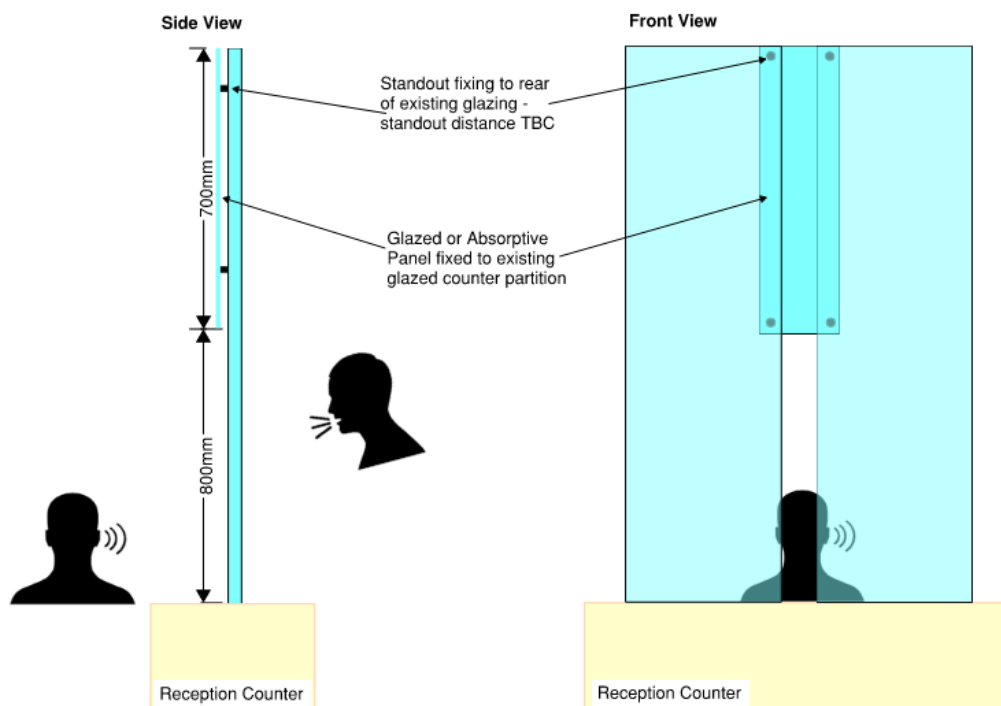


Figure 3 Recommendations for glazing treatment to minimize noise transfer from patient area to nurse station

5.4 Speech Reinforcement at Counter Partition

Considering the variable nature of the background noise (depending on the time of the day and number of patients), speech reinforcement using counter intercom system was also recommended for a better speech intelligibility and reducing the listener's effort towards effective conversation. These included systems from manufacturers such as Commend Australia Counter Intercom System, AdvanceIT Window Counter Intercom and SoundGear Australia Counter Intercom and Loops.

5.5 Optimising Spatial Layout for Improved Speech Intelligibility in the Triage Reception Room

A visual assessment of the Triage Reception Room layout identified several design elements that may obstruct or interfere with the clear transmission of speech. While some of these elements aim to support communication in a high-activity or acoustically challenging environment, they may inadvertently hinder speech intelligibility—particularly given the diverse range of speech characteristics, vocal intensity, and language proficiency exhibited by hospital patients. As discussed earlier, effective communication could be significantly impacted by poor spatial orientation between speaker and listener, both horizontally and vertically. To enhance speech comprehensibility in the triage setting, the following design recommendations were proposed. These modifications aim to improve the quality of verbal exchanges in the triage area by supporting better acoustic and visual alignment between patients and clinical staff.

- **Reorientation of Screens:** Computer monitors, and other visual obstructions should be repositioned to allow a clear visual and acoustic path between staff and patients during interactions.
- **Floor Markings for Patient Positioning:** The introduction of discreet floor markings can guide patients to stand at ideal locations during triage interactions. This low-impact intervention supports consistent speaker-listener distance and alignment, improving communication effectiveness without altering the physical infrastructure.

5.6 Acoustic Separation of the Printing Area

To reduce noise transmission from the photocopy and printing area situated in the southwest quadrant of the triage reception room, it is recommended that a partition be installed to acoustically separate this zone from the triage nurse work area. The proposed partition should be designed to achieve a minimum sound insulation rating of R_w 35, ensuring an adequate level of noise control to support clear communication and reduce auditory distractions in the clinical workspace.

6 Expected Acoustic Outcome

It was understood that on preliminary acoustic testing would not be feasible for this project due to live operation of the Hospital emergency department. Therefore, it was not possible to quantify the as-built acoustic performance of the space including background noise levels, sound insulation rating of wall partitions and reverberation time, which influences the speech intelligibility of the room. Consequently, the recommended design is based on noted site conditions and desktop assessment of the Triage Reception Room and ED Waiting Room. Predicted reverberation time in both rooms before and after treatment were as follows.

Table 4: Predicted reverberation time assessment results (Before and After Acoustic Treatment)

Room	Predicted Reverberation Time, sec		Acoustic Design Criteria Reverberation Time, sec
	Before Treatment	After Treatment	
Triage Reception Room	0.9	0.4	0.40
ED Waiting Room	1.6	0.6	<0.70

Table 4 illustrates that the predicted reverberation time would be within the recommended design criteria with the proposed recommendations, hence would considerably improve the soundscape of the room and result in higher speech intelligibility. Additionally, there have been recommendations on improving the acoustic separation between the rooms through the modification of desk layout and counter partition glazing in an approach to improve ergonomic design and acoustic efficiency between patient and clinical staff. All these were expected to improve the signal-to-noise ratio and therefore improve the overall speech intelligibility.

7 Construction Considerations – Functionality, Fire and Infection Control Requirements

While the design recommendations were developed in consultation with the Hospital Staff and contractor team supporting Hospital retrofit, the following implementation issues and departure from recommendations were realized through the construction which shaped the final design and implementation outcome:

- **Fibre-Shedding:** Infill acoustic insulation can pose a fibre-shedding risk, where fibres become loosened and enter the HVAC airstream thus impacting patient health. As such acoustic ceiling and wall panels in the triage area specially at the triage reception and patient lounge were chosen to meet these requirements.
- **Fire requirements of the acoustic ceiling and acoustic wall panels:** As required by the BCA, acoustic ceiling and wall panels were required to meet AS1530.3 & AS5637.1 for Group 1 Fire Rating (flame retardant).
- **Hygienic and Cleanability requirements:** For hospital, it is important to specify acoustically absorptive materials with a surface finish suitable for hygienic requirements, infection control, and has ability to be cleaned if required. Materials that are cleanable, with as few porous elements as possible are preferred. In addition, the acoustic ceiling and wall panels were required to be water and humidity resistant, easily maintained and washable for infection control. Considering the above, Stratocell Whisper® 50mm (NRC 1.0) was recommended both for ceiling and wall panels which satisfied the above requirements.
- **Acoustic Wall and Ceiling Panels:** Where the above requirements were not strictly applicable, such as the triage nurse area, Sontext SerenityLite Panels 50mm (NRC 1.0) were recommended for wall treatment while Stratocell Whisper 50mm (NRC 1.0) was recommended for ceiling.
- **Ligature Risk:** Any materials used for the purposes of acoustic treatment or noise control that could be used for hanging, strangulation or potential ligature points need to be recognised and addressed. To avoid ligature points, any hardware for acoustic treatment should be selected such that they are not accessible; or if accessible and removed, will not be able to be used for hanging or strangulation. The recommended acoustic ceiling and wall panels in the triage reception and patient lounge area (Stratocell Whisper 50mm) were deemed satisfactory as Stratocell Whisper were directly fixed to ceiling and wall using adhesives ensuring no weaponisation of fixing.
- **Acoustic partition separating the printing area:** Partition separating the printing area from the service desk was required to contain glazed panel for effective communication, thus hindered the acoustic objective due to introduction of reflective surface which directs the sounds towards the attending nurses at the desk.
- **Speech reinforcement:** Speech reinforcement using counter intercom system was not implemented and was on hold for further consideration on patients' privacy and additional backup power requirement to operate the system.

8 Measurements and Verifications

As discussed earlier, preliminary test measurements were not feasible to verify the baseline condition due to live operation of the Hospital emergency department. Therefore, it was not possible to quantify the as-built acoustic performance of the space including background noise levels, sound insulation rating of wall partitions and reverberation time, which influences the speech intelligibility of the room. Upon partial implementation of the recommended construction (acoustic ceiling, acoustic wall panels, acoustic separation of the printer and Spatial Layout), Hospital agreed to provide limited opportunity to conduct acoustic testing, while ED Triage area was in live operations. Considering the time limitations and the constraints due to live operations and presence of patients, the following measurements and strategies have been adopted:

8.1 Ambient Noise Measurement

Short duration noise measurements, using Type 1 Sound Level Meter, were conducted both at the Triage Patient Lounge and ED Reception areas. Measured data were stored for the measurement parameters L_{A10} , L_{A90} , L_{Aeq} and L_{Amax} during the noise measurement period. All measurements were taken on A-weighted fast response mode. The sound level meters were calibrated before and after all measurements, with no significant drift (not exceeding more than ± 0.5 dB(A)) in the calibration levels. All instruments are calibrated in NATA accredited laboratory and hold current traceable NATA certification.

8.2 Reverberation Time Measurement - Interrupted Noise Method vs Impulse Response Method

Reverberation time (RT60) is a critical acoustic parameter that quantifies the time required for sound to decay by 60 dB in a space. Two standard measurement techniques are commonly employed: the interrupted noise method and the impulse response method, each offering specific advantages depending on the measurement environment and application. Interrupted Noise method involves generating a steady-state broadband noise (typically pink or white noise) through a loudspeaker. Once a uniform sound field is achieved, the noise is abruptly switched off, and the decay curve of the sound energy is recorded using a measurement microphone. The reverberation time is calculated from the linear portion of the decay curve, often using regression analysis between -5 dB and -35 dB or -25 dB to extrapolate RT60. This technique is well-suited for on-site measurements in relatively quiet environments and complies with standards such as ISO 3382-2. Impulse Response method involves capturing the room's acoustic response to a short, high-energy sound, such as a starter pistol shot, balloon burst, or electronically generated sweep (e.g., sine sweep or maximum length sequence). The recorded impulse response is then post-processed to derive the energy decay curve. This method allows for a more detailed acoustic characterization, including early reflections, clarity, and other room metrics. It is advantageous in spaces where continuous noise generation is impractical or where time-domain precision is needed.

In acoustically sensitive environments such as hospital triage areas, accurate measurement of reverberation time (RT60) is essential to assess and improve speech intelligibility, privacy, and overall communication effectiveness. The impulse response method using a logarithmic sine sweep is particularly advantageous for such settings due to several key factors as follows. In this study, a sine sweep method was adopted to measure RT60 in both Triage Reception and Patient Lounge area.

- **High Signal-to-Noise Ratio (SNR):** Hospital environments often contain constant background noise from medical equipment, HVAC systems, and human activity. The sine sweep method generates a controlled, high-energy excitation signal that is resilient to ambient noise, thereby improving measurement accuracy even in non-ideal acoustic conditions.
- **Full Frequency Coverage:** A sine sweep can excite the entire audible frequency range (typically 20 Hz to 20 kHz), allowing for a detailed assessment of frequency-dependent reverberation. This is especially important in healthcare settings, where mid- and high-frequency clarity is critical for effective verbal communication.
- **Reduced Distortion and Reflections Isolation:** The impulse response derived from a sine sweep can be deconvolved to separate the linear system response from harmonic distortion. This results in cleaner data and allows for better identification of early reflections and decay characteristics, which directly impact speech intelligibility in a triage context.
- **Practicality in Occupied Spaces:** Unlike balloon bursts or pistol shots, which may be disruptive or inappropriate in a clinical environment, sine sweep signals are less intrusive and can be generated at moderate sound levels. This makes the method more acceptable for use in operational hospital spaces, with minimal impact on patients and staff.

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- **Post-Processing Flexibility:** The recorded impulse response can be used not only to calculate RT60 but also to derive additional room acoustic parameters such as clarity (C50, C80), definition (D50), and speech transmission index (STI). This provides a comprehensive acoustic profile of the triage area from a single measurement.

8.3 Speech Intelligibility (STI) Measurement

Speech intelligibility tests were carried out in the Emergency Department (ED) to assess communication clarity between the Triage Reception and the adjacent Patient Area. The NTi TalkBox was used to simulate live speech, with measurements conducted using a calibrated sound level meter in accordance with IEC 60268-16 standards (Edition 5). The primary objective was to determine how well speech could be understood under varying acoustic conditions in this critical communication zone. Multiple Speech Transmission Index (STIPA) tests were conducted using two types of speech signals: the Standard Signal of 60 dB(A) and the Lombard Effect Signal of 70 dB(A), which simulates raised speech in noisy environments. Measurements were taken at the reception desk within the Triage Nurse Station under a range of background noise conditions, representative of both quiet and moderately busy ED periods.

8.4 Reality Check -- Test Results

Measured test results are presented in Table 5 and Table 6 below. Table 5 shows that the RT in the Triage Reception room was improved from 0.9s (predicted) to 0.5s (measured) while it was targeted to achieve RT 0.4s. Noted that the wall separating the printer room was designed to have an absorptive finish near the nurse desk area, where in reality a glazed panel was installed for meeting functionality requirement of the space, communication between reception desk and printing area.

Table 5: Predicted reverberation time assessment results

Room	Predicted Reverberation Time, sec		Measured Reverberation Time, sec	Acoustic Design Criteria
	Before Treatment	After Treatment	After Treatment	Reverberation Time, sec
Triage Reception Room	0.9	0.4	0.5	0.40
ED Waiting Room	1.6	0.6	0.8	<0.70

Table 6: Measured STI Levels at different STIPA Signal and Background Levels, Measured at Triage Reception

Test Signal	Background, dB(A)	STI	Qualitative Rating
STIPA - Standard @60 dB	54	0.55	Fair
STIPA - Standard @60 dB	60	0.43	Poor
STIPA - Lombard @70 dB	54	0.65	Good
STIPA - Lombard @70 dB	65	0.38	Poor

Table 6 presents the Speech Transmission Index (STIPA) measured at different background noise levels with two different types of STIPA Signal from NTi TalkBox, one was Standard Speech 60 dB (Male spectrum in IEC 60268-16), and the other one was Lombard Speech @70 dB. With the Standard Signal @60 dB(A), test results showed that STI values varied depending on background noise levels at the current condition of the ED Triage Reception. During the measurement period, a STI 0.55 (Fair) was tested with a background noise level of 54 dB(A) which reduced to STI 0.43 (Poor) when background noise level was raised to 60 dB(A). In order to understand how the speech amplification at the reception might assist in improving the STI, Lombard signal of 70 dB(A) was used. With the Lombard Signal @70 dB(A), test results showed that STI values varied depending on background noise levels at the current condition of the ED Triage Reception. During the measurement period, a STI 0.65 (Good) was tested with a background noise level of 54 dB(A) which reduced to STI 0.38 (Poor) when background noise level was raised to 65 dB(A).

9 Concluding Remarks

The findings suggest the need for acoustic improvements or assistive communication systems to ensure speech clarity in the ED, especially during high-activity periods. This is made more prominent by the frequent reporting of both staff and patients experiencing significant complications driven by vocal strain, listening fatigue, miscommunication and annoyance. All these issues underscore a marked lack of efficiency in design; issues that sadly, are not often addressed or implemented in new construction and speak to a systemic lack of understanding surround-

ing acoustic interventions in high noise, confounding or elevated activity environments.

Several factors influencing speech intelligibility in hospital triage areas were identified and investigated insitu, including background noise (signal-to-noise), reverberation, communication practices (speaker – listener distance/angle) and barriers along with the dynamic interplay these factors exhibit within a 24-hr hospital emergency setting. In live operation, and after partial completion of works, RT at the triage desk improved from 0.9 s to 0.5 s (target 0.4s), while the ED waiting room remains ~0.8s vs <0.60s target, indicating residual control still needed in the public seating area. STI varied from "Good" to "Poor" as background levels rose, confirming SNR as the dominant driver of intelligibility at the counter. Because baseline testing was infeasible, verification focused on constrained in-situ measurements; and findings should be read in that context. Hospital feedback indicated noticeable communication improvements for staff and patients' post-works.

Emergency departments are distinctly unique, in that they are unable to be closed once opened, operate continuously and provide space to patients experiencing a wide spectrum of injuries or ailments and it is imperative that recommendations be made with these factors front of mind. Acoustic control recommendations for the area were varied and aimed to layer easily implemented changes to various modalities of preliminary and first-stage care identified on site. It is noted that some elements of the design are not yet fully implemented with notably the curved glazed partition being scheduled to design and install in the near future. Iterative assessment of speech intelligibility and reverberation in the emergency department will form future revisions of this paper.

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