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City hospitals in Turkey: a review of acoustical criteria and design principles

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ABSTRACT

Recently developed Integrated Health Campus or the so-called City Hospital projects in Turkey brings on the requirement of re-evaluation of acoustical design principles and criteria for healthcare facilities. In acoustical design process, determination of adequate acoustic design criteria is the primer topic, as for preventing over/under design and determination of suitable acoustical materials along with sustainability of hospital projects accommodated in more than one million square meter enclosed spaces including various public / medical utilities. Currently, acoustical design criteria mainly rely on "Turkish Regulation on Protection of Buildings from Noise ", "Health Buildings Minimum Design Standards", green building certification requirements and other international design guidelines, which are compared and discussed within this study in scope of building and room acoustics, mechanical noise and vibration control for functional units as common spaces, operating, patient and isolation rooms, lithotripter room and various medical, electromechanical installations and equipment. In consequence, a wide range of optimum values in different references are observed for some objective parameters as of sound transmission class, reverberation time and average sound absorption coefficient. For resolving these issues of defining the optimum objective criteria, the necessity of acoustic design guideline for healthcare facilities adopting a research based on subjective response of the users and an indoor soundscape approach is highlighted.

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1. INTRODUCTION

Acoustics is an important environmental factor in addition to the medical requirements in the architectural design process of healthcare facilities. Proper acoustical design provides the means of noise control and increase in either speech privacy or intelligibility depending upon the function of the space. Previous studies addresses the effects of noise on patients in hospitals [1][2] and staff [3]. World Health Organization has reported that physiological and psychological disorders such as sleep disturbance, stress, cardiovascular and cognitive disorders and increased breathing are observed in individuals who are exposed to continuous or rapid high noise levels[1] [7]. There are also several research on the relationship of hospital soundscape and health effects [4], perceived acoustic environment in special care facilities [5] and nursing homes [6]. Integrated health campuses are healthcare facilities that encompasses a large amount of medical functions and related building typologies that are gathered together in a common site. Accordingly, the healthcare context includes many different acoustical design issues including environmental noise control, façade design, noise control over building elements and mechanical systems, vibration control and room acoustics.

The integrated healthcare structure models of Turkey include large number of facilities. In their acoustical design process, determining the acoustic criteria in relation to the diversity of functions and adjacencies, has been the foremost and a critical step in lighting up the architectural and mechanical design decisions. However, having multiple acoustical design guidelines / manuals for healthcare centers in Turkey, together with the international design standards, and the variation or inadequacy of criteria, complicate the decision-making process. Another challenge is that, currently valid noise regulation had not yet been published on the dates when integrated healthcare projects had started to apply for building permits. For the projects already having the building permits in an on-going construction, the decision whether to adapt the enhanced criteria specified by the “Turkish Regulation on Protection of Buildings from Noise” [8] has been left to the investor.

In order to discuss the acoustical design issues and applicable criteria within the scope of this study, different integrated health campus projects are reviewed. Among the projects similar premises and adjacencies are identified that necessitate acoustical design measures. In addition, noise source or noise sensitive devices such as the electromechanical, medical and HVAC related devices and equipment used in the projects are determined. Later, guidelines and regulations which include acoustical design criteria regarding to building acoustics, room acoustics, mechanical noise control and vibration isolation topics are compared and discussed for related medical, private and public premises.

2. INTEGRATED HEALTHCARE CAMPUS PROJECTS IN TURKEY

The "Health Transformation Program" in Turkey was launched in 2013 with the Law No. 6428 on “Construction and Renovation of Facilities and the Procurement of Services via Public-Private Partnership” and the “Amendment of Certain Laws and Decree Laws”. This transformation program led to the emerge of “integrated health campuses” or the so-called “city hospitals” [9][10].

Within this scope, a total of 30 different Integrated Health Campuses are planned in 22 provinces (with a variety of sizes, bed capacities etc.). According to the information received from the Ministry of Health, the project agreement has concluded for 18 of them and 11 of them have started operating [11]. Due to the pandemic outbreak in 2020, the government informed that investments in city hospital projects will be increased. In Table 1, integrated health campus projects, their bed capacities and hospital buildings within projects are summarized.

Table 1. Operating City Hospitals in Turkey

Project Name	Bed Capacity	Opening Date	Total area (land) (m^2)	Total area (enclosed) (m^2)	Main Contractor	MH	PTR	HSFP	TSB
Adana City Hospital	1.550	September, 2017	318.504	539.824 m^2	Rönesans Holding	√	√	√	√
Mersin City Hospital * * First operating city hospital project in Turkey	1.300	February, 2017	232.000	374.128	DIA Holding	√	-	√	√
Isparta City Hospital	755	March, 2017	194.989	222.571	Akfen Construction	√	-	-	√
Yozgat City Hospital	475	April, 2017	117.812	141.235	Rönesans Holding	√	-	-	√
Kayseri City Hospital	1.607	May, 2018	467.143	464.094	YDA Construction	√	√	√	√
Eskişehir City Hospital	1.081	October, 2018	188.535	333.303	Akfen Construction	√	-	√	√
Manisa City Hospital	558	October, 2018	97.515	178.204	YDA Construction	√	√	-	√
Elazığ City Hospital	1.038	August, 2018	347.173	355.752	Rönesans Holding	√	-	√	√
Ankara Bilkent City Hospital	3.704	February, 2019	866.398	1.285.798	CCN Group	√	√	√	√
Bursa City Hospital	1.355	July, 2019	830,813	474.677	Rönesans Holding	√	√	√	√
İstanbul Başakşehir Çam and Sakura City Hospital	2.682	May, 2020	789.031	1.019.000	Rönesans Holding	√	√	√	√

MH: Main Hospital Building *
**** Includes;***
Cardiovascular Diseases Hospital,
Oncology Hospital,
Women and Children's, General and Psychiatric Hospital.
PTR: Physical Therapy and Rehabilitation Hospital Building
HSFP: High Security Forensic Psychiatry Hospital Building
TSB: Technical Service Building **
***** Includes;*** *trigeneration plant.*

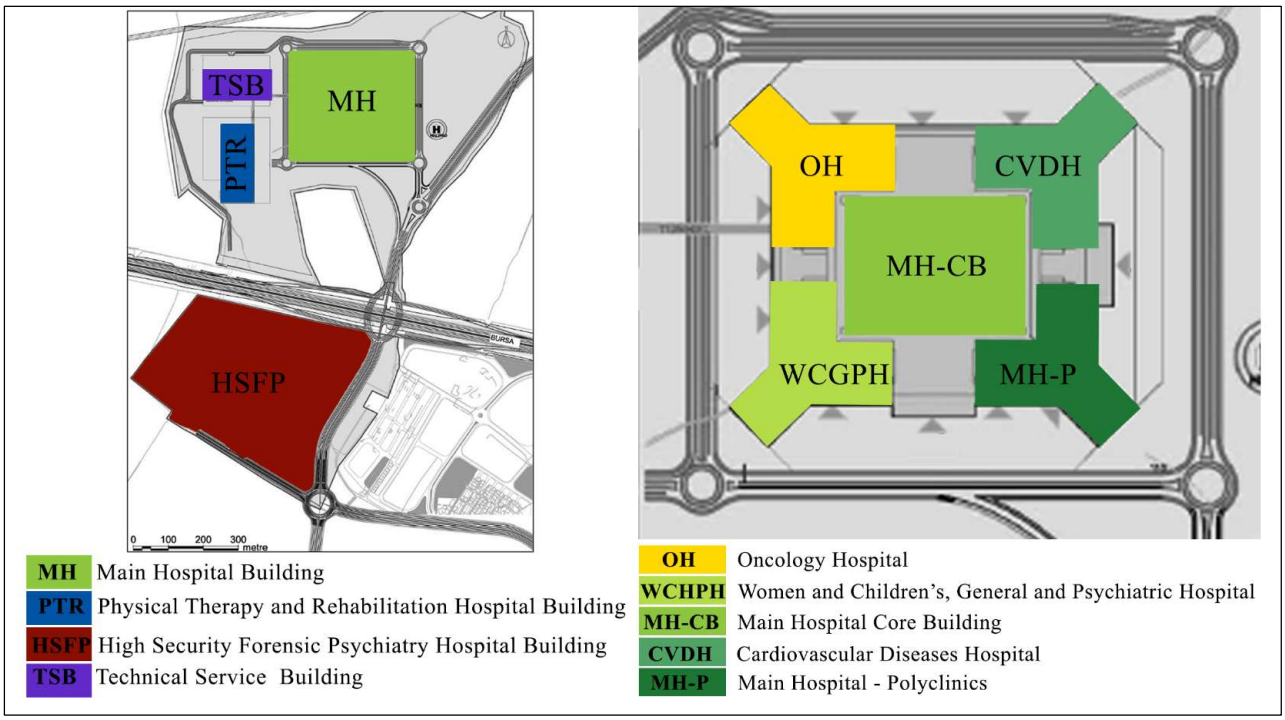

Figure 1. A typical integrated healthcare campus, Site plan (left), main hospital buildings (right)

3. Acoustical Design Criteria in Healthcare Facilities

In Turkey, there are various guides and legislations in effect of acoustical design criteria of hospitals. For instance, new construction, renovation or repair of existing healthcare structures , between the years 2010-2018, were liable to "Turkey Health Buildings Minimum Design Standards , 2010 Guide" [12]. This manual specifies minimum required airborne sound insulation values for certain adjacencies. In addition, maximum permittable indoor noise levels are indicated in “Integrated Health Campus Specifications” prepared by Republic of Turkey Ministry of Health [13]. On the other side, indoor noise limits due to environmental noise for noise sensitive spaces are specified in “Environmental Noise Control Act” published in 2010 by Ministry of Environment and Urban Planning [14] .

In 2017, “Turkish Regulation on Protection of Buildings from Noise” was published. Accordingly, after 31st May 2018, all building projects has to comply with this regulation in order to entitle construction permits [8]. Within its framework, the regulation specifies acoustical design criteria for specific building typologies including healthcare buildings. Acoustical design criteria for different performance classes (C class being the minimum code for new construction) are set covering different topics as of building acoustics, room acoustic, mechanical noise control.

In addition to the regulations, there are also design criteria of green building rating systems (LEED, BREEAM, DGNB, IISBE, GREENSTAR, CASBEE etc.). LEED v4.1 (new construction) has been the most widely applied rating system for integrated city hospital projects in Turkey. Therefore, this certification system is also included as a reference in this study [15].

Accordingly, acoustical design criteria for different premises or adjacencies are gathered from various design guidelines and commonly accepted references from world literature . The comparisons are compared in Table 3-7. The references used in Table 3-7 are summarized in Table below.

Table 2. References and Codes given in Table 3-7.

Ref A	Minimum Design Standards 2010 Guide for Healthcare Buildings in Turkey [12]
Ref B	Turkish Regulation on Protection of Buildings from Noise [8]
Ref C	Environmental Noise Control Act [14]
Ref D	ASHRAE HVAC Applications Handbook [19]
Ref E	Sykes, David etal. Sound & vibration 2.0: design guidelines for health-care facilities [17]
Ref F	LEED v4.1 New Construction [15]
Ref G	Integrated Health Campus Tender Specifications. Part 1: Architectural and Construction Work Specs [13]
	No Criteria

Table 3. Maximum Allowable Interior Noise Levels (dBA)

Premise	Maximum Allowable Interior Noise Levels (dBA)						
	Ref A	**Ref B**	**Ref C***	**Ref D**	**Ref E**	**Ref F**	**Ref G**
Single Patient Room		34	25	35-39	35-45	45	40
Conference Rooms, Praying Room		39	30	35-39	30-40	40	
Neonatal Intensive Care Units (NICU)					30-40	35	36
NICU staff and family areas						40	
Meeting Room		39	35	39-44			
Labor Delivery and Recover Room (LDR)							36
Labor Delivery, Recover and Postpartum Room (LDRP)							36
Operating Room / Surgery room, Angiography		39		35-44	40-50	55	36
Multiple Occupancy Room / ward		39		39-44	40-50	50	
Recovery – Prep-Room							40
Isolation (Quarantine) Room							40
Treatment Room		39	25			45	40
Intensive Care Unit (Icu), Critical Care Unit (Ccu)							40

Doctor's Examination Room		39			35-45		40
Pharmacy – Medicine Supply Room							40
Offices		44	45-50	44-48		45	
Presentation, Teaching and Lecture Room		39	35	39-44		35	
Physiotherapy and Hydrotherapy Room							44
Laboratory, Research Lab.		44	45	44-53	45-55		44
Circulation Areas: Corridors, Reception, Registration, Foyer, Waiting Room and Public Spaces		49		44-53 48-52	40-50	50	44
Relaxation Room		44	25				
Dining - Cafe		49	45	48-52		40	
Retail		49	60	57-67			
Technical Corridor							
Laboratory (Silent)						60	
Laboratory (Loud Voiced)						55	
Silent/Quiet room						35	
Natatorium						50	
*Leq(dBA) limits in Environmental Noise Control Act for closed windows							

Table 4. Internal Noise Criteria Regarding to HVAC Systems

Mahal	Internal Noise Limits Regarding to HVAC Systems $L_{Aeq,nT}$ **(dBA)**					
	Ref A	**Ref B**	**Ref C**	**Ref D , Ref E**	**Ref F**	**Ref G**
Single Patient Room		30 (NC 25)		35 (NC 30)		
Conference Room, Praying Room		35 (NC 30)		35 (NC 30)		
Meeting Room		35 (NC 30)		35 (NC 30)		
Operating Room / Surgery Room		35 (NC 30)		40 (NC 35)		
Multiple Occupancy Room / Ward		35 (NC 30)		35 (NC 30)		
Treatment Rooms		35 (NC 30)		40 (NC 35)		
Doctor's Examination Room /		35 (NC 30)		40 (NC 35)		
Offices		40 (NC 35)		35 (NC 30)		
Presentation, Teaching and Lecture Room		35 (NC 30)		35 (NC 30)		
Laboratory, Research Lab		40 (NC 35)		55 (NC 50)		
Circulation Areas: Corridors, Reception, Registration, Waiting Room		45 (NC 40)		45 (NC 40)		
Relaxation Room		40 (NC 35)				
Dining - Cafe		45 (NC 40)				
Retail		45 (NC 40)				

Table 5. Airborne Sound Insulation Criteria for Different Adjacencies: Walls (Horizontal) and Floors (Vertical)

Premise	**Adjacent Premise**	**Ref A (STC/Rw)**	**Ref B ($D_{nT,w}$ +C)**	**Ref C**	**Ref D**	**Ref E (STCc)**	**Ref F (STCc)**	**Ref G**
Patient Room	Patient Room (Horizontal)	45	52			45	45	
Patient Room	Patient Room (Vertical)	45	52			50	50	
Patient Room	Corridor	45	52			35	35	
Patient Room	General (Public) Area (Horizontal)	55	52			50	50	
Patient Room	General (Public) Area (Vertical)	40	52			50	50	
Patient Room	Service Area (Horizontal)	65	58			60	60	
Patient Room	Service Area (Vertical)	45	58			60	60	
Examination Room	Patient Room		52					
Outpatient room/Examination Room	Corridor (Horizontal)	65	49			35	35	
Outpatient room/Examination Room	Corridor (Vertica)	45	49			35	35	
Examination / Consulting Room	General (Public) Area (Visitors' area)		49			50	50	

Examination / Consulting Room	MRI Room		55			60		
Examination / Consulting Room	Examination / Consulting Room (without electronic masking)		49			50	50	
Examination / Consulting Room	Examination / Consulting Room (with electronic masking)		-			40	40	
Outpatient room	Corridor (Horizontal)	65	49			35	35	
Outpatient room	Corridor (Vertical)	45	49			35	35	
Patient Room WC	General (Public) Area		52			45		
General (Public) Area	MRI Room		52			50	50	
MRI Room	Patient Room						60	
MRI Room	Examination / Consulting Room						60	
Examination / Consulting Room	Laboratory		49					
Examination / Consulting Room	Conference Hall		55					
Examination / Consulting Room	Exercise Hall		55					
Examination / Consulting Room	Doctor’s Office		49					
Examination / Consulting Room	WC		55					
Examination / Consulting Room	Dining Room		55					
Examination / Consulting Room	Maintenance /Repair Room		55					
Operating Room / Surgery room	Operating Room / Surgery room		46				50	
Operating Room / Surgery room	Sheltered Corridor		52					
Operating Room / Surgery room	Observation Room		52					
Labor Delivery and Recover Room (LDR)	Labor Delivery and Recover Room (LDR)		58					
Labor Delivery and Recover Room (LDR)	Corridor		52					
Labor Delivery and Recover Room (LDR)	Patient Room		58					
Patient Room	Presentation, Teaching and Lecture Room		58					
Doctor’s Office	Presentation, Teaching and Lecture Room		55					
Waiting Area / Corridor	Presentation, Teaching and Lecture Room		52					
Office	Presentation, Teaching and Lecture Room		55					
Doctor’s Office	Corridor / hall		49					
Doctor’s Office	Common WC		55					
Presentation, Teaching and Lecture Room	Common WC/Shower		58					
Meeting Room	Meeting Room		52					
Meeting Room	Corridor / hall		52					
Meeting Room	Office		52					
Meeting Room	Praying Room		58					
Office	Office		49					
Office	Corridor / hall		49					
Office	Cafe		55					
Office	Retail		55					
Relaxation Room (Staff)	Corridor		49					
X-Ray	Corridor		49					
Intensive Care Unit (ICU)	Intensive Care Unit (ICU)		52					
Intensive Care Unit (ICU)	Meeting / Therapy Room		52					
Psychotherapy Room	Psychotherapy Room		52					
Psychotherapy Room	Corridor		52					
Group Therapy Room	Corridor		52					

Therapy Hall	Therapy Hall		52					
Therapy Hall	Neurological Pool		52					
Therapy Room	WC		58					
Physiotherapist Room	Conference Hall		55					
Conference Hall	WC		58					
Conference Hall	Corridor		52					
Conference Hall	Office		55					
Music -Carpenter Atelier	Ceramic, Painting, Gardening Atelier		55					
Parking Garage	Relaxation Room (Staff)		61					
Parking Garage	Office		61					

Table 6. Impact Sound Insulation Criteria for Different Adjacencies

Source Room	Receiving Room	Ref A	Ref B		Ref C	Ref D	Ref E	Ref F	Ref G
			$L'_{nT,w}$, dB	Impact Isolation Class (dB)					
Patient Room	Not Specified		54	IIC 56					
Examination / Consultation Room			54	IIC 56					
Circulation Area			54	IIC 56					
Operating Room / Surgery Room			58	IIC 52					
Laboratory			58	IIC 52					
Technical Center			48	IIC 62					

Table 7. Criteria for Reverberation Times and Average Sound Absorption Coefficients

Premise	Ref A	Reverberation Time (s)	Ref C	Ref D	Average Sound Absorption Coefficient ($\bar{\alpha}$)		Ref G
		Ref B			Ref E	Ref F	
Single Patient Room		0,5			0,15	0,15	
Multiple Occupancy Room / Ward		1,0			0,15	0,15	
Examination / Consultation Room		0,8			0,15	0,15	
Operating Room / Surgery Room		0,8					
Presentation, Teaching and Lecture Room		0,8					
Laboratory		0,8					
Doctor's Office		0,8			0,15	0,15	
Dining / Cafe (Enclosed)		1,0					
Meeting Room		0,8					
Conference Hall							
Circulation Area		1,2			0,15	0,15	
Waiting Room		1,2			0,25	0,25	
Atrium					0,10	0,10	
Quite room						0,2	
Natatorium						0,1	

As some listed in this section (Tables 3-7), acoustical criteria for spaces such as restaurants / cafeterias, meeting rooms, retail areas, offices, conference halls, circulation areas, lecture room / classrooms, sports halls and praying rooms., which are commonly found in public buildings, are frequently accessible in the national and international literature. However, acoustical design criteria for healthcare-related spaces covering the scope of building acoustics, room acoustics, mechanical noise and vibration control such as operating rooms, lithotripsy and other medical devices, and electromechanical installations, HVAC equipment are quite rare in the literature. Besides, there are differences among existing criteria. The biggest challenge in this issue is the determination of acoustical design criteria for hospital or medical – specific spaces. In addition, since the acoustical design guidelines are different, it is expected that there will be differences in the acoustical performances among hospital projects, which obtained construction permission before or after the release of mandatory noise regulation in Turkey.

4. Results and Discussion

4.1. Building Acoustics Criteria

Required sound insulation values for vertical and horizontal adjacencies in hospital buildings are specified first in “Turkey Health Buildings Design Standards” and later “Turkish Regulation on Protection of Buildings from Noise”. However, indicated sound insulation values in these two main references are in conflict for some specific adjacencies as can be followed from Table 5. Hence, to overcome the gap between different acoustical criteria in Standard and Regulation; international resources like design guideline for healthcare facilities [17] and LEED green building performance requirements [15] should be referred to design proper wall and floor sections for specific adjacencies in hospitals.

For instance, if the references are compared for patient by patient room adjacencies: the proposed sound transmission class criteria for horizontal adjacencies is specified as STC 45 in Standard [12], while Regulation [8] proposes DntA 52 for the same adjacency. In another example, proposed sound transmission class by Standard for adjacencies of the examination room - public circulation area is STC 65, on the other hand, for similar adjacencies Regulation indicates DntA 49. International references [15] [17] indicate composite sound transmission class criteria which take into account windows or doors which can be on the assessed wall section as a weak link. Composite sound transmission class criterion for patient room – patient room adjacencies in these international references is specified as STCc 45 in coherence with the criteria mentioned in the Turkey Health Buildings Design Standards.

Dry-wall systems built by plasterboards are not suitable for patient rooms in psychiatric clinics, because of safety issues. Therefore, thicker double wall sections out of aerated concrete block or pumice concrete block materials are commonly applied, to reach higher sound insulation values as DntA 52. On the other hand, Design Standards for Healthcare Buildings in Turkey [12] indicates that seclusion rooms in psychiatric clinics need to be soundproof. However, objective seclusion room sound insulation design criteria are not defined in Standard or other references.

Among the compared Standard [12], Regulation [8] and Guidelines [15][17], the most detailed sound insulation criteria for building acoustics considerations of hospitals are given in the Turkish Regulation on Protection of Buildings From Noise. Hospital units are classified in accordance with their noise sensitivity and noisiness levels. However, for rooms accommodating medical mechanic equipment like MRI, ESWL (Extracorporeal Shock Wave Lithotripsy) are not covered in the scope of this classification. For medical equipment which produce noise, case specific acoustical design criteria need to be assessed in octave bands rather than a singular sound insulation index/metric. Sound insulation criteria of the Regulation for high noise level and most sensitive adjacencies can still provide a guidance.

Impact sound insulation criteria are only defined in the Turkish Regulation on Protection of Buildings and for noise source rooms as patient room, examination room, operating room, laboratories, circulation area and technical spaces (Table 6). These values are set regardless of the floor below (receiver room), which is a deficiency of the Regulation. Impact sound insulation criteria for patient rooms is indicated to be at max Lntw 54. Providing impact sound insulation requirements in hospitals is important for providing acoustical comfort levels especially in patient rooms. However, this criterion is mostly overlooked during tender stage due to the costly application of floating screed or material costs of isolation pads or mats. Optimizing the impact sound insulation criteria might be needed for realistic and reasonable applications in million square meter city hospitals.

4.2. Room Acoustics Criteria

The most important room acoustics parameter that should be controlled to provide acoustical comfort in hospital is reverberation time. Control of reverberation time enables the control of suspended sound within a space, that otherwise can cause noise build up and disturbance. The reverberation time criteria in Turkish Regulation on Protection of Buildings from Noise are specified for the average of 250 Hz, 500 Hz, 1000 Hz and 2000 Hz octave bands. However, the Regulation sets almost identical criteria for many sub-spaces regardless of their volume. Since, reverberation time is a volume dependent parameter, outlier spaces especially with high ceiling height, like foyers atriums, could not be assessed according to the Regulation. To overcome this shortcoming, international sources like design guidelines for healthcare facilities[17] and LEED green building performance requirements [15] are referred. These mentioned sources specify average sound absorption coefficient rather than reverberation time (Table 7), which are more reasonable.

Operating rooms, laboratories, are covered in scope of the Regulation (Table 7). Since, the priority in such spaces is the hygiene requirements, antibacterial sound absorber materials have to be chosen. Furthermore, Minimum Technical Standards to Follow in Existing and New Health Facilities by Ministry of Health [20] indicates that antibacterial sound absorbers need to be applied on ceiling surfaces of natal / intensive care units.

Average sound absorption coefficients are indicated for waiting rooms and atrium / entrance spaces in LEED green building requirements. In estimation of average sound absorption coefficient, occupied area by sound absorber material and total surface area of the room are considered. So, the scale of the space is taken into calculation by total surface area. On the other hand, Turkish Regulation on Protection of Buildings from Noise indicates a reverberation time criterion as 1.2 s for circulation areas in hospital as a sole criteria, regardless of the volume of the circulation or gathering space. Integrated health campus projects include main entrance, gathering, waiting and circulation spaces. These main entrance halls: generally integrated with cafes, shops, and main circulation corridors of the hospital. Ceiling heights sometimes reach to 10 meters. Hence, Acoustical designs aim to obtain 1.2 s reverberation time, causes excessive sound absorber usage in these halls. Therefore, the reverberation time criterion needs to be re-defined in the Regulation considering the room volume to avoid unnecessary acoustical material use. On the other hand, “Technical Standards to Follow in Existing and New Health Facilities by Ministry of Health” brings another regulation for such gallery, hall and corridor spaces and indicates that 30% percent of wall surfaces need to be covered by sound absorber materials or scattering surfaces. The degree of scattering or the frequency ranges are not even mentioned.

Speech privacy criteria have to be satisfied in hospitals to fulfill the LEED green building requirements. Speech privacy criteria are defined in LEED requirements for patient room, exam room, treatment room, consultation room, NICU space, and public space. In addition to that, other hospital units which are not mentioned directly can be assessed according to their privacy level. In LEED green building requirements, speech privacy criteria can be defined for any enclosed or open space (like open plan offices), and privacy levels as normal, confidential, or secure. However, speech privacy criteria normally conflict with the average sound absorption coefficient criteria, that effects reverberation time, defined in LEED requirement. Higher absorption means higher intelligibility but lower privacy. In that case, the solitary solution is using electronic sound masking systems. The given speech privacy requirement for patient room, exam room, treatment room, consultation room and NICU is questionable in terms of acoustical comfort and function of the space. In such rooms patient and doctors need to communicate and understand each other clearly. Hence, hospital units which require speech privacy precautions and sound masking systems need to be specified in consideration with the number of people using the space and specific communication requirements. On the other hand, the preference

over speech intelligibility or speech privacy for specific functional units should better be assessed through a subjective study.

4.3. Mechanical Noise and Vibration Isolation Criteria

Background noise levels for noise sensitive spaces which have adjacencies with mechanical rooms are assessed in scope of mechanical noise control studies. Maximum permitted background noise levels (LAeq) due to service equipment are presented in Turkish Regulation on Protection of Buildings from Noise (Table 4). In addition to that, AHRI and ASHRAE HVAC Applications Handbook is used to evaluate internal noise levels caused by ventilation units like FCU, AHU etc. [19][21]. Emitted noise from mechanical equipment including pumps, cooling towers, chillers, generators, AHU, FCU and other fan units are assessed in octave bands. It is preferred to use 1/3 octave bands in calculations to consider the noise spectrum of the mechanical equipment. However, some manufacturers cannot provide 1/3 octave band noise spectrum. In such cases, rough estimations are held using 1/1 octave band noise data. Rather than single background noise criterion like LAeq, noise curves are utilized to assess background noise levels in adjacent noise sensitive rooms.

Intruded mechanical noise via façade is assessed utilizing Turkish Environmental Noise Control Act as a primary reference [14]. Maximum allowable interior noise levels are indicated in Integrated Health Campus Tender Specifications and Turkish Regulation on Protection of Buildings from Noise as presented in Table 1.

In addition to air-borne mechanical noise control studies to prevent structure-borne noise, appropriate vibration isolation precautions are necessary [21]. There are no guidance in the Design Standards for Healthcare Buildings in Turkey [12] or Regulation on Protection of Buildings From Noise for selection of vibration isolation units/hangers or requirements of a floating floor assemblies. In those area where no design criteria are set by the Regulations common knowledge and previous experience is consulted. Placement/location of the mechanical equipment in buildings and technical features of the equipment (as of rpm, horsepower, static pressure) are considered, while vibration isolation measures are set. Accordingly, floor sections, isolator types and deflection values of the vibration isolation elements are defined [22].

5. CONCLUSION

In this study, integrated healthcare campus projects in Turkey are studied, in order to understand and determine the acoustic design criteria for healthcare structures. As a first step, all the premises and adjacencies are analyzed along with medical and mechanical equipment. Afterwards, national and international guidelines, regulations and standards are evaluated and compared in scope of room acoustics, building acoustics, mechanical noise and vibration control.

It is observed that, healthcare-specific units, such as medical equipment or psychiatric departments, are not included in evaluated acoustical design guidelines. Hence the current design guidelines seem insufficient to determine acoustical criteria for an integrated healthcare facility. In addition, there are notable differences in limit values of acoustic metrics among different guidelines.

Reverberation time criteria is important to express the room acoustics conditions. However, adhering to a single reverberation time value for a functional unit, as it is given in evaluated guidelines, without considering the volume, may lead the designer to use excessive amount of

sound absorber material, especially in large volumes. Hence, average sound absorption coefficient can be preferred to evaluate larger volumes with high ceilings.

Moreover, acoustical design criteria given in the Standard [12], Regulation [8] and guidelines [13][15][17][18] are mainly objective parameters. One of the main reasons is that, for many years, the sound has been approached as “noise”. Because of this, until recently, national and international acts have mainly focused on "noise control" and disregarded the user perception aspect [25]. However, it is understood that, to be able to fully understand the user comfort, perception and preferences, objective and subjective parameters need to be assessed together as well as with psychoacoustic parameters, which can be achieved with a Soundscape approach.

The related standards defines Soundscape as an approach to understand and assess the user perceptions/experiences of an aural environment with all its complexity, independent from any positive / negative judgements [22][23][26]. It is a framework rather than a “one size fits all” approach. Since each physical environment, geographical location, and social aspects are different from each other, each acoustical environment should be evaluated within itself. When the world literature is examined, it is understood that there is a lack of a frame model for soundscape in terms of health structures. As a result, it is recommended that objective and subjective parameters should be used or considered together to improve acoustical design guidelines for healthcare facilities.

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