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Research Article

Determination of Noise Pollution and Noise Dose Level of Kahramanmaras Sutcu Imam University Medical Faculty Hospital

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Abstract

Noise pollution is one of the most important environmental problems waiting to be solved today. For this reason, in this study, to determine the noise level and dose in the hospital environment, which is one of the areas heavily used by society, noise measurement was made in the polyclinic corridors of the KSU Medical Faculty Hospital. In all corridors of the hospital, which has 10 outpatient corridors in total, from Monday to Friday, at 08:00-09:07, 10:00-11:01, 12:00-13:01, 14:00-15:01, 15:01 and 16:00-17:01 at hours noise intensity measurements were made as dB(A) by Testo 815 noise meter. The measurements were averagely performed at each point for 15 minutes, and repeated at least three times. The equivalent noise level (L_{eq}) calculated from the measurement results varies between 27.39 and 50.68 dBA. Most of the L_{eq} values calculated for many corridors are greater than the limit value (35 dB) of the Republic of Turkey Ministry of Environment and Forestry and WHO. But, it was determined that the values of the noise dose calculated for the corridors of the KSU medical faculty hospital (except for ground floor) were smaller than the acceptable noise dose value (D≤1) defined by the authorized institutions or organizations.

Keywords: Sound, noise dose, noise pollution, dBA and health

Kahramanmaraş Sütçü İmam Üniversitesi Tıp Fakültesi Hastanesi Gürültü Kirliliği ve Gürültü Doz Düzeyinin Belirlenmesi

Öz

Gürültü kirliliği günümüzde çözüm bekleyen en önemli çevre sorunlarından biridir. Bu nedenle bu çalışmada toplumun yoğun olarak kullandığı alanlardan biri olan hastane ortamındaki gürültü seviyesi ve dozunun belirlenmesi amacıyla KSÜ Tıp Fakültesi Hastanesi poliklinik koridorlarında gürültü ölçümü yapılmıştır. Toplam 10 poliklinik koridoru bulunan hastanenin tüm koridorlarında Pazartesiden Cumaya kadar 08:00-09:07, 10:00-11:01, 12:00-13:01, 14:00-15:01, 15:01 ve 16:00-17:01 saatlerinde Testo 815 gürültü ölçer ile dB(A) olarak gürültü şiddeti ölçümleri yapılmıştır. Ölçümler ortalama olarak her noktada 15 dakika süreyle yapıldı ve en az üç kez tekrarlandı. Ölçüm sonuçlarından hesaplanan eşdeğer gürültü seviyesi (Leq) 27,39 ile 50,68 dBA arasında değişmektedir. Birçok koridor için hesaplanan Leq değerlerinin çoğu, T.C. Çevre ve Orman Bakanlığının ve DSÖ'nün sınır değerinden (35 dBA) daha büyüktür. Ancak KSÜ tıp fakültesi hastanesinin koridorları için hesaplanan gürültü dozu değerlerinin (zemin kat hariç) yetkili kurum veya kuruluşlar tarafından belirlenen kabul edilebilir gürültü doz değerinden (D≤1) daha küçük olduğu tespit edilmiştir.

Anahtar Kelimeler: Ses, gürültü dozu, gürültü kirliliği, dBA ve sağlık.

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1. Introduction

The environment is the area in which people live and carry out all their life-related activities. However, various factors within this field can affect people as positively or negatively. Developments such as rapid population growth due to the development science, industry and technology in recent years have led to the emergence of many environmental problems. Noise pollution still is one of the most important environmental problems today. In the last decade, more and more people are trying to cope with the noise problem in their daily life. The main source of noise is sound waves. The sound is a vibration that can propagate in the air or other medium and can be detected when it reaches the human ear or a suitable receiver (Kara, 2011). If the sound propagates from one point in an enclosure to another observation point, it not only follows the direct path, but also multiple reflections (Kuttruff and Mommertz, 2013). This situation, which is a physical process, causes the sound produced in the environment to be heard for a while after the sound source is turned off (ISO 3382-1, 2009). The noise resulting from human activities is rapidly changing the natural sound balance of the Earth (Connelly et al., 2022; Kight and Swaddle, 2011; Shannon et al., 2016). It has been shown by research that noise pollution can cause serious health effects such as hearing damage, cardiovascular diseases, increased stress, and sleep disturbance in humans (Passchier-Vermeer and Passchier, 2000; Frei et al., 2014; Fyhri and Aasvang, 2010; Basner et al., 2014; Halperin, 2014). The intensity of sound is measured in decibels (dB). The decibel is a ratio of any two of the three components of sound, power, pressure, and intensity. Since the decibel scale is a ratio, a baseline called a filter is used to measure a single sound source. There are three standard filters as called A, B, and C. Filter A is often used to measure ambient noises as it is less sensitive to very high and very low frequencies. Filter B is located between A and C, while filter C is generally used to measure high frequencies. When using a sound meter, it is also very important to choose the filter suitable for the nature of the measuring environment and to determine which filter was used when recording the measurements. It should be noted that the decibel is not an absolute measure of sound pressure, but rather the ratio of the measured sound pressure to the reference sound pressure. However, since this sound scale is exponential, a sound of 10 dB has intensity 10 times greater than a sound of 0 dB, and a sound of 20 dB is 100 times more intense than 0 dB (Field and Long, 2018). Sound is one of the most important communication tools for people. But, when sound turns into noise, it can cause many negative effects on human health. The noise can be defined as unwanted sounds that can adversely affect people's physiological or psychological states, or audible acoustic energy that disturbed and disturbs the peace of any person (Cantrell, 1975). Although sound is an objective concept that can be measured individually and cannot be changed noise is a very subjective concept. Therefore, sounds that are pleasant and beautiful for one person may be disturbing for another. Noise is one of the most common occupational health problems for deafness. Besides the noise-induced hearing loss is generally irreversible. Therefore, to protect from negative consequences of noise exposure, the noise levels should be kept at acceptable levels. The acceptable, that is, safe sound level depends on the severity of the sound, exposure time and frequency of exposure. The medium noise contains all the sounds in an environment. The noise level in an environment can be measured at any time by using a decibel meter. In this sense, a single dBA measurement taken can usage provide a lot of information about ambient noise, and the most common measurement level of environmental noise is dBA. The investigated noise is measured over a time interval of at least 15 minutes or, if the noise persists for less than 15 minutes, over the duration of the noise to determine that the measured value is adequately representative of the noise in question (WHO, 2019). Exposure to loud sounds, i.e. noise, for any length of time, can cause fatigue of the ear's sensory cells, resulting in temporary hearing loss such as tinnitus or humming in the ear. However, when the exposure time is long, regular, or high, it can cause permanent damage to sensory cells and other structures, resulting in irreversible hearing loss (WHO, 2019). In addition to hearing loss, noise has numerous physical effects on the body. These include pupil dilation, increase production of thyroid hormone, increased heart rate, increased adrenaline production, increases in corticotrophy, increase stomach and abdominal movement, muscle reaction, and constriction of blood vessels. Hearing impairment is typically defined as an increase in the hearing threshold (WHO, 1994). The recommended safe level for daily noise should be below 80 dB and equal to Laeq, 24h equal to 70 dBA for a maximum of 40 hours per week (WHO, 2018, 2019; Neitzel and Filgor, 2017). Noise pollution is one of the important environmental pollutions that can cause hearing health problems in people in developed and developing countries. In recent years, while the number of people living in apartments has been increasing, the noise level caused by the technological devices used in most modern houses with poor sound insulation are affected the quality of life of people negatively (Peterso, 1980).

The aim of this study is to measure the noise level in dBA of Kahramanmaraş Sütçü İmam University (KSU) Medical Faculty Hospital for five days from Monday to Friday, and to calculate the equivalent noise level and noise dose. In addition, it is to draw attention to noise pollution which is one of the most important environmental problems of today and to the negative health effects caused by this pollution.

2. Material and Method

2.1. Testo 815 Sound Intensity Meter

The Testo 815 is the ideal instrument for measuring noise or sound intensity. The testo 815 sound meter (decibelmeter) used for measuring sound frequencies has sound level measurement ranges of 32-80 dB, 50-100 dB and 80-130 dB, two time and frequency ranges, maximum/minimum function and a tripod screw. The device, which has slow and fast time intervals, can collect incoming audio signals in the range of 1s to 125 ms. The Testo 815 noise meter has an accuracy of ±1.0 dB and a resolution of 0.1dB. The device is especially used to measure sound levels with A-weighted frequency standards. The photographs of the Testo 815 decibel meter (a) and CEM SC-05 sound level calibrator devices (b) used are given in Figure 1. Before starting the measurements, the Testo 815 sound level or noise meter was calibrated with the CEM SC-05 sound level calibrator, which has ±0.5 dB sensitivity.

Figure 1. (a) The photographs of the Testo 815 decibelmeter, and (b) CEM SC-05 sound level calibrator devices.

2.2. Measurement of the Sound Intensity

The first stage of noise control is the sound level measurement, and determination of the frequency and intensity of the affecting noise. There are 10 different polyclinic corridors in total in KSU Medical Faculty Hospital. Since the corridors were so long, three points were determined in each corridor for measurements, and the sound pressure levels of the noise in the outpatient corridors were measured on the A-weighted (dBA) decibel scale. The measurements were made at 08-09, 10-11, 12-13, 14-15 and 16-17 hours every day of the week at selected points. Measurements were started on 14 April 2019 and finished on 12 July 2019. That is, it took three months to complete measurements in all corridors of the hospital. Testo 815 decibelmeter was used to measure sound intensity in hospital corridors. The probabilities of reflection of sound waves from walls, ceilings and other objects were taken into account while making the measurements, and therefore the measurements were made 1.5 m away from the walls and at a height of 1m from the ground. If the measurements were made more than one meter away from the person's, measurement errors could occur. The measurements were made at a distance of at least 30 cm and 50 cm from the body in order to avoid similar errors. Measurements were made at each measurement point for at least 15 minutes or during the noise period, and each measurement was repeated three times. A photo of the moment of measuring in one of the corridors is given in Figure 2. The list of outpatient clinics located in the corridors is given in Table 1.

Figure 2. Photograph of one of the hospital corridors where measurements were made

Table 1. Lists of polyclinics in the corridors of KSU Medical Faculty Hospital

Ground floor	
Corridor A	Physical Medicine and Rehabilitation, Urology and Nephrology
Corridor B	Child Health and Diseases, Newborn and Healthy Child, Pediatric Endocrinology, and Pediatric Neurology
Corridor C	Internal Medicine, Nutrition and Dietetics, and Gastroenterology
Corridor D	Cardiology, Cardiovascular Surgery, Infectious Diseases and Clinical Microbiology, and Endocrinology and Metabolism
Corridor E	Brain and Nerve Surgery, Neurology, Orthopedics and Traumatology, and Rheumatology
First floor	
Corridor A	Ear, Nose and Throat Diseases
Corridor B	Chest Diseases, Thoracic Surgery, Plastic, Reconstructive and Aesthetic Surgery, General Surgery, Child and Adolescent Psychiatry and Diseases, and Forensic Medicine
Corridor C	Skin and Venereal Diseases, Gynaecology and Obstetrics
Corridor D	Eye Diseases, Mental Health and Diseases
R**adiology corridor**	Radiology polyclinic

2.3. Calculation of Equivalent Noise Level (L_{eq})

Equivalent noise level (L_{eq}) should be calculated in sound intensity or noise measurements. Because in many measurement situations, the widely fluctuating display data of a conventional sound level meter can make it extremely difficult to detect the correct sound level. The equivalent noise level, L_{eq}, is a noise scale in dB(A) that gives the average value of sound energy or sound pressures continued over a given period, and can be calculated by the following equation (Ministry of Environment and Forestry, 2008),

$$L_{eq} = 10\log \ \text{dB(A)} \quad (1)$$

where L_{eq} is the equivalent noise level, n is the number of sample data noise measurements, L_i is the noise value over the specified measurement time interval, and its unit is dB(A). Equivalent continuous level L_{eq} can also be defined as the level of a constant level sound that has the same total energy as the corresponding sound in a given time interval. The noise dose can be calculated in two ways, depending on whether the noise level is constant or consist of periods of different noise levels:

If the sound level L is constant over the entire working time (shift), the noise dose D, in percent, is calculated as follows:

$$D = 100x\frac{C}{T} \quad (2)$$

where D is the dose level as in percent, C is the total length of the working day (hours), and T is the reference time level corresponding to the measured sound level (L).

But, if the daily noise exposure consists of periods of different noise levels, the daily dose D, in percent, is calculated according to the formula given below, and D equals or cannot exceed 100 (NIOSH, 1998; Field and Long, 2018).

$$D = \left[{C_1}/{T_1} + {C_1}/{T_1} + \cdots + {C_n}/{T_n} \right] x100 \quad (3)$$

where C_n is the total exposure time at a given noise level, and T_n is the exposure time at which noise at that level becomes dangerous (the reference duration for that level). The first equation determines the dose for those exposed as a percentage, and the maximum allowable dose is 100%. The reference duration level, T, is calculated using the following equation (Field and Long, 2018);

$$T = \frac{8}{2^{\left(L - \frac{90}{5}\right)}} \quad (4)$$

where T is reference duration, and L is dBA exposure which is the measured sound level. The daily dose, on the other hand, can be converted to an 8-hour time-weighted average (TWA) according to the formula (NIOSH, 1998):

$$TWA = 10xLog(D/100) + 85 \quad (5)$$

where 85 dBA is the recommended exposure limit, and exposures above this level are considered hazardous. However, continuous, variable, intermittent or impulsive noise exposure should not exceed 140 dBA (NIOSH, 1998; Field and Long, 2018).

3. Results and Discussion

The noise measurement values made with the Testo 815 decibelmeter on the dBA scale in the corridors where the polyclinics of Kahramanmaraş Sütçü İmam University Medical Faculty Hospital are located are given in Tables 2 and 3. The equivalent noise levels calculated for all corridors are given in Tables 4 and 5. The calculated percentages of noise dose are given in Tables 6 and 7. As seen from Table 4 and Figure 3, the highest equivalent noise level in corridor A of the ground floor was measured as 31.03 dBA on Monday, while the lowest noise level was measured as 27.39 dBA on Thursday. For the ground floor B corridor, the highest equivalent noise level was calculated as 50.68 dBA on Monday, while the lowest equivalent noise level was calculated as 41.48 dB on Thursday. While the highest equivalent noise level calculated from the sound intensity measurements made in the ground floor C corridor was 47.72 dBA on Wednesday, the lowest equivalent noise level was calculated as 43.08 dBA on Monday. In the calculations made using sound intensity measurements made in the ground floor D corridor, the lowest equivalent noise level was calculated as 41.58 dBA on Thursday, while the highest equivalent noise level was calculated as 47.12 dBA on

Wednesday. The highest equivalent noise level for the ground floor E corridor was calculated as 43.33 dBA on Friday, while the lowest equivalent noise level was calculated as 39.90 dBA on Wednesday.

As seen from Table 4 and Figure 4, the highest equivalent noise level was found as 47.80 dBA on Thursday, and the lowest equivalent noise level was found at 32.99 dBA on Friday, from the calculations made using the sound intensity data made in the radiology corridor on the minus first floor. As seen from Table 5 and Figure 5, the average equivalent noise level achieved from the calculations for the ground floor corridors was found to be 29.09 dBA for corridor A, 45.55 dBA for corridor B, 45.04 dBA for corridor C, 44.91 dBA for corridor D and 41.39 dBA for corridor E, respectively. Similarly, the average equivalent noise level for the minus first-floor radiology corridor was 41.80 dBA. The limit value of the equivalent noise level (L_{eq}) in health institutions has been accepted as 35 dB by national and international institutions and organizations (Republic of Turkey Ministry of Environment and Urbanization, 2017; NESREA, 2007).

As seen from Table 4, in the radiology corridor on the minus first floor, the equivalent noise level calculated for all of the other days except Friday is greater than the limit value of 35 dBA. The value of the equivalent noise level calculated for all days in corridor A on the ground floor is smaller than the 35 dBA limit value. The values of the equivalent noise level calculated for all days in corridors B, C, D, and E on the ground floor are bigger than the 35 dBA limit value.

Table 2. The values of the sound intensity measured in dBA in the corridors on the first floor of KSU Faculty of Medicine in between Monday and Friday, April 15-19, 2019.

Hours	Monday	Tuesday	Wednesday	Thursday	Friday	
08:00-09:01	68±2.12	72.65±1.34	69.45±0.91	72.80±2.54	72.65±1.13	**A Block**
10:00-11:01	77.40±5.37	74.20±0.84	82.2±3.11	79.55±10.81	81.1±4.94	
12:00-13:01	64.40±5.93	72.45±1.76	78.10±8.48	66.70±10.18	65.30±6.08	
14:00-15:01	81.55±8.69	74.65±5.02	75.40±3.11	83.95±0.35	75.70±4.38	
16:00-17:01	61.45±0.35	62.50±0.56	78.10±17.11	64.85±8.83	72.70±2.12	
Mean	**70.56±4.50**	**71.29±1.90**	**76.65±6.54**	**73.57±6.54**	**73.49±3.75**	
08:00-09:01	71.90±0.15	69.20±3.22	78.87±4.95	77.43±2.75	70.00±3.15	**B Block**
10:00-11:01	80.83±1.05	80.97±1.20	77.30±4.45	79.83±4.73	81.00±4.90	
12:00-13:01	70.63±9.26	70.60±3.43	71.00±0.51	68.93±5.55	74.53±1.78	
14:00-15:01	71.17±2.10	77.73±3.44	78.73±3.15	63.17±5.64	78.77±6.26	
16:00-17:01	67.94±5.16	58.17±2.19	61.50±3.61	75.00±4.43	61.27±6.36	
Mean	**72.52±3.54**	**71.33±2.70**	**72.45±3.33**	**72.81±4.62**	**72.40±4.50**	
08:00-09:01	73.50±1.67	64.73±3.94	72.6±5.54	73.2±5.23	79.9±12.32	**C Block**
10:00-11:01	79.60±4.01	72.06±3.07	66.06±8.76	77±2.81	67.9±8.69	
12:00-13:01	70.50±10.67	71.56±7.26	65.66±7.03	67.4±7.23	60.43±0.92	
14:00-15:01	79.43±7.87	74.26±1.94	74.26±3.70	79.1±3.67	70.20±1.47	
16:00-17:01	60.13±7.48	56.3±5.18	60.7±6.29	62.93±12.36	63.10±4.46	
Mean	**72.63±6.34**	**67.79±4.28**	**67.85±6.26**	**71.92±6.26**	**68.30±5.57**	
08:00-09:01	71.90±1.40	71.91±4.01	73.06±0.57	68.73±0.72	72.76±4.17	**D Block**
10:00-11:01	80.86±8.85	77.93±4.36	78.43±4.40	71.13±1.13	75.63±10.65	
12:00-13:01	70.20±6.58	67.50±0.90	77.46±10.37	67.10±6.78	59.80±2.86	
14:00-15:01	70.90±2.55	75.66±4.57	77.80±5.65	78.70±7.56	76.10±3.89	
16:00-17:01	65.73±5.51	65±7.86	60.66±1.25	67.56±3.04	60.90±1.11	
Mean	**71.91±4.98**	**71.60±4.34**	**73.48±4.45**	**70.64±3.85**	**69.03±4.54**	
08:00-09:01	72.46±6.65	71.9±1.47	71.66±3.70	76.33±5.39	68.13±6.50	**Radiology floor**
10:00-11:01	74.7±5.28	80.23±4.82	78.33±3.83	76±1.47	72.6±0.21	
12:00-13:01	70.6±6.32	73.66±4.64	78.56±1.40	76.9±4.71	69.1±0.96	
14:00-15:01	70.83±3.67	76.2±2.68	76.96±7.80	73.7±6.23	68.6±2.10	
16:00-17:01	62.83±3.30	61.9±3.76	59.33±1.47	63.23±4.89	63.83±4.53	
Mean	**70.28±5.04**	**72.77±3.47**	**73.56±3.64**	**73.23±5.54**	**68.45±2.86**	

Table 3. The values of the sound intensity measured in dBA in the corridors on the ground floor of KSU Faculty of Medicine in between Monday and Friday, April 15-19, 2019

Hours	Monday	Tuesday	Wednesday	Thursday	Friday	
08:00-09:01	63.56±2.20	99.25±0.98	62.60±2.86	66.13±3.18	64.46±4.86	A Block
10:00-11:01	63.70±2.07	66.73±4.47	71.56±7.26	68.70±4.60	71.16±2.18	
12:00-13:01	75.73±0.29	61.93±5.16	62.30±5.03	59.00±1.31	67.56±2.23	
14:00-15:01	112.80±1.49	67.10±6.78	73.00±2.95	64.16±5.42	67.66±7.35	
16:00-17:01	62.43±2.40	66.40±2.50	55.63±3.36	60.70±6.29	63.53±2.17	
Mean	**75.64±1.69**	**72.28±4.00**	**65.01±4.29**	**63.73±4.16**	**66.87±3.86**	
08:00-09:01	74.60±2.64	69.73±4.13	76.8±6.84	74.26±3.70	72.70±3.12	B Block
10:00-11:01	77.06±5.04	77.13±4.31	76.9±4.55	71.63±1.50	75.13±0.64	
12:00-13:01	76.00±1.48	74.26±12.73	74.53±2.94	70.63±2.51	76.53±3.69	
14:00-15:01	81.33±7.91	81.66±10.27	71.90±7.35	72.66±3.07	75.00±1.14	
16:00-17:01	64.86±4.74	61.66±3.32	63.16±6.15	59.50±0.62	64.86±4.31	
Mean	**74.77±4.36**	**72.88±6.95**	**72.65±5.57**	**69.73±11.40**	**72.84±2.58**	
08:00-09:01	72.64±3.59	72.15±3.07	69.42±4.11	69.56±3.85	68.96±1.72	C Block
10:00-11:01	70.43±6.25	73.75±2.31	71.75±0.70	71.03±6.33	69.03±3.88	
12:00-13:01	51.76±5.47	61.24±3.30	63.73± 5.79	67.34±40.04	59.56±34.62	
14:00-15:01	71.55±3.91	70.25±2.27	70.99± 5.06	71.09±5,42	70.39±1.17	
16:00-17:01	41.36±35.59	44.24±37.53	52.78±37.07	42.07±36.85	42.20±35.26	
Mean	**61.54±10.96**	**64.37±9.70**	**65.73±10.56**	**64.218±12.50**	**62.02±15.33**	
08:00-09:01	73.43±3.63	73.10±3.01	74.30±3.81	74.23±8.21	71.00±2.40	D Block
10:00-11:01	71.97±0.80	53.40±4.12	74.80±2.49	78.00±0.75	71.70±2.34	
12:00-13:01	72.27±1.48	68.27±7.23	76.60±5.40	68.07±5.77	72.20±3.13	
14:00-15:01	70.07±3.18	70.43±0.55	75.40±0.77	73.67±3.62	73.40±0.75	
16:00-17:01	66.93±5.38	93.25±1.60	67.37±7.77	78.83±10.12	71.07±2.16	
Mean	**70.91±2.89**	**69.67±3.30**	**73.69±16.76**	**73.00±5.70**	**71.85±2.16**	
08:00-09:01	72.46±2.89	69.33±0.51	69.53±2.90	68.6±2.27	71.56±6.40	E Block
10:00-11:01	75.16±0.66	75.16±5.25	75.63±4.98	76.13±2.60	74.7±1.64	
12:00-13:01	68.36±7.31	77.8±5.65	70.66±2.49	68.53±4.53	76.46±3.70	
14:00-15:01	76.56±2.25	75.8±4.57	78.86±9.60	70.06±0.32	75±1.13	
16:00-17:01	63.53±1.90	65.13±6.75	65.23±3.98	63.1±5.89	58.86±1.70	
Mean	**71.21±6.42**	**72.64±5.55**	**71.98±4.79**	**69.28±3.12**	**71.31±2.90**	

Table 4. The equivalent noise level calculated for the ground floor and minus the first-floor corridors (dBA)

Corridors/Days	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Mean**
Corridor A	31.03	29.27	28.39	27.39	29.38	29.09
Corridor B	50.68	43.87	47.74	41.48	44.00	45.55
Corridor C	43.08	44.36	47.72	46.51	43.54	45.04
Corridor D	45.77	46.80	47.12	41.58	43.30	44.91
Corridor E	40.06	42.37	39.90	41.30	43.33	41.39
Minus the first floor*	41.57	42.80	43.68	47.80	32.99	41.80

*The corridor of the radiology polyclinic

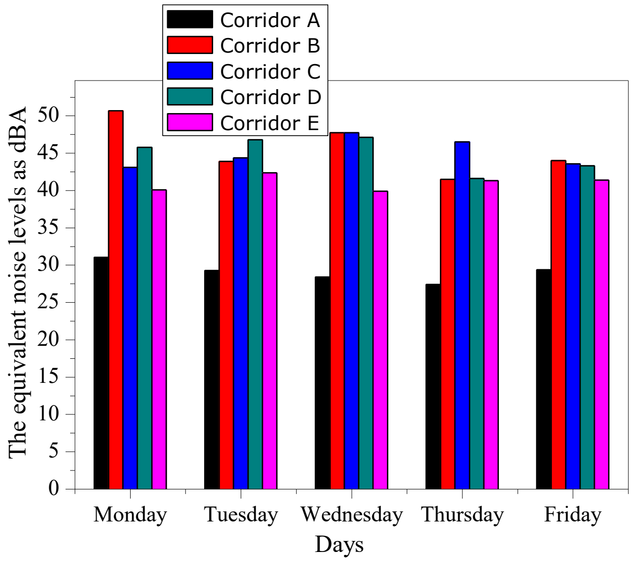

Figure 3. Variation of equivalent noise level calculated as dBA for ground floor corridors according to days

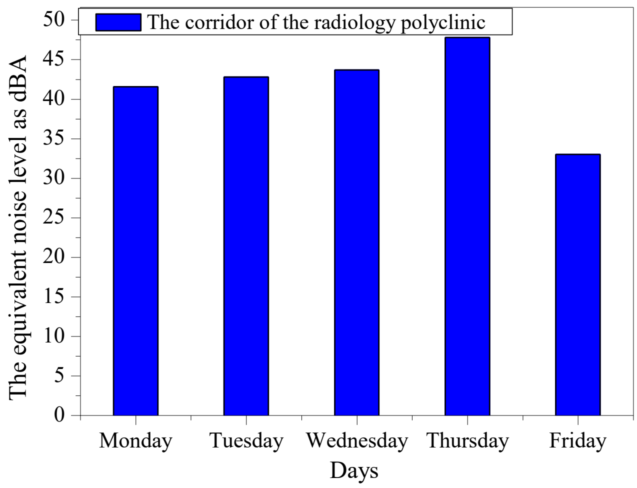

Figure 4. Variation of the equivalent noise level calculated in dBA for the corridor of the radiology polyclinic on the minus first floor, according to days

As seen from Table 5 and Figure 5, in the calculations made for the corridors on the first floor, the highest equivalent noise level was calculated as 44.38 dBA on Tuesday in corridor A, 47.22 dBA on Monday in corridor B, 53.57 dBA on Monday in corridor C and 46.80 dBA on Thursday in corridor D. Similarly, again, in the calculations made for the corridors on the first floor, the smallest equivalent noise level was calculated as 34.68 dBA on Monday and Friday in corridor A, 38.70 dBA on Friday in corridor B, 44.90 dBA on Friday in corridor C and 36.92dBA on Friday in corridor D. The average equivalent noise levels for these corridors was calculated as 39.18 dBA for A corridor, 43.09 dBA for B corridor, 48.60 dBA for corridor C and 43.27 dBA for corridor D, respectively. As seen from Table 5, the value of the equivalent noise level calculated for all of the other days, except for Monday and Friday, in corridor A on the first floor is bigger than the 35 dBA limit value. The value of the equivalent noise level calculated for all days in B, C and D corridors on the first floor are greater than the 35 dBA limit value. In addition, to determine the average equivalent noise level of each floor, when take the average of all corridors on each floor, the mean equivalent noise levels were calculated as 41.80 dBA for minus the first floor (radiology corridor), 41.20 dBA for the ground floor and 43.54 dBA for the first floor, respectively. All of these calculated values are bigger than the 35 dBA limit value determined by national and international institutions and organizations.

Table 5. The equivalent noise level calculated for first-floor corridors (dBA)

Corridors/Days	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Mean**
Corridor A	34.68	44.38	40.00	42.18	34.68	39.18
Corridor B	47.22	43.41	42.40	43.70	38.70	43.09
Corridor C	53.57	46.03	47.18	51.27	44.90	48.60
Corridor D	41.70	44.80	46.12	46.80	36.92	43.27

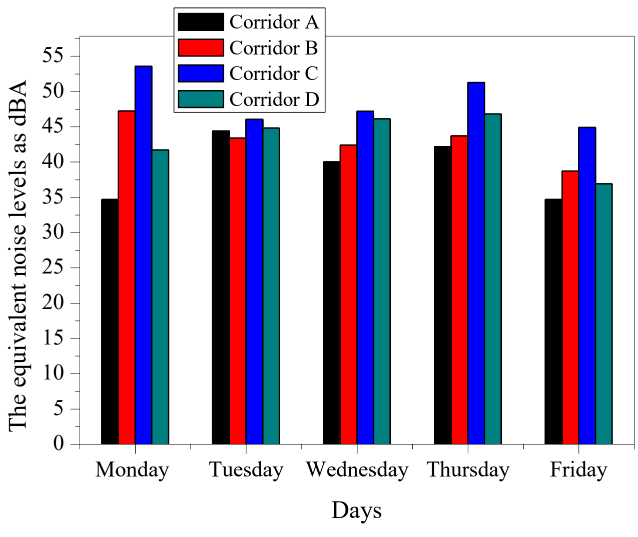

Figure 5. Variation of equivalent noise level calculated as dBA for the first floor corridors according to days.

As seen from Table 6 and Figure 6, the percentage of noise dose was also calculated for the ground floor corridors where sound intensity measurement was made. The highest noise dose percentage calculated for corridors on the ground floor was 0.00% for corridor A, 0.23% for corridor B, 0.12% for corridor C, 0.10% for corridor D and 0.03% for corridor E, respectively. As seen from Table 6 and Figure 7, the maximum percentage of noise dose calculated according to the measured data in the corridor of the radiology outpatient clinic on the minus first floor is 0.12.

Table 6. The calculated the percentage of noise dose for the ground floor and minus the first-floor corridors

Corridors/Days	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Corridor A	0.00	0.00	0.00	0.00	0.00
Corridor B	0.23	0.05	0.12	0.13	0.05
Corridor C	0.05	0.05	0.12	0.09	0.05
Corridor D	0.07	0.10	0.10	0.03	0.04
Corridor E	0.02	0.03	0.02	0.03	0.02
The minus the first floor*	0.03	0.04	0.05	0.12	0.00

*The corridor of the radiology polyclinic

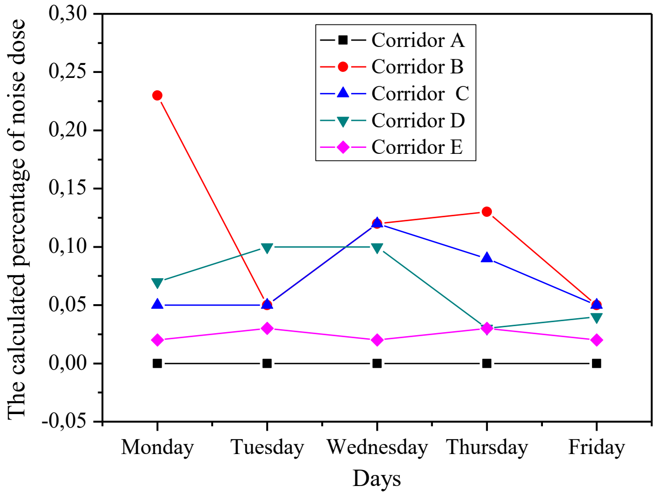

Figure 6. The variation of the calculated percentage of noise dose for the ground floor corridors according to days

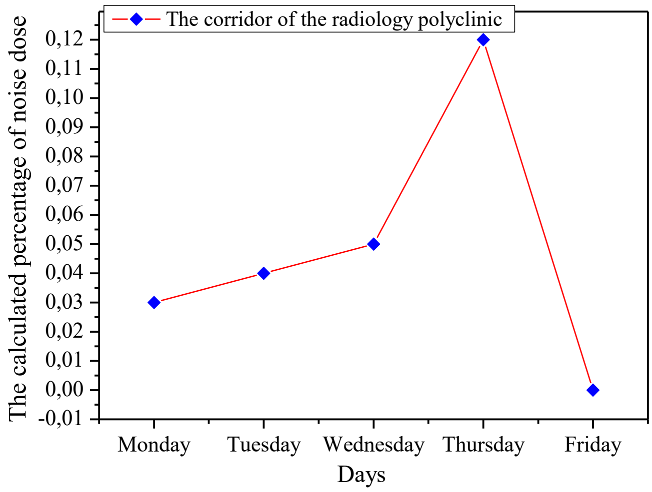

Figure 7. The variation of the calculated percentage of noise dose for the minus the first floor (the corridor of radiology polyclinic) corridors according to days.

As seen from Table 7 and Figure 8, the highest noise dose percentage calculated for the first-floor corridors was 0.06 for corridor A, 0.11 for corridor B, 0.04 for corridor C and 0.08 for corridor D, respectively. As seen from Table 6 and Figure 8, in the radiology polyclinic corridor on the minus first floor, the highest noise dose percentage was calculated as 0.12 on Thursday, and the lowest noise dose percentage was also 0.00 on Friday.

Table 7. The calculated the percentage of noise dose for the first-floor corridors

Corridors/Days	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Corridor A	0.01	0.06	0.02	0.03	0.02
Corridor B	0.11	0.04	0.03	0.05	0.01
Corridor C	0.04	0.01	0.01	0.03	0.01
Corridor D	0.03	0.06	0.08	0.02	0.01

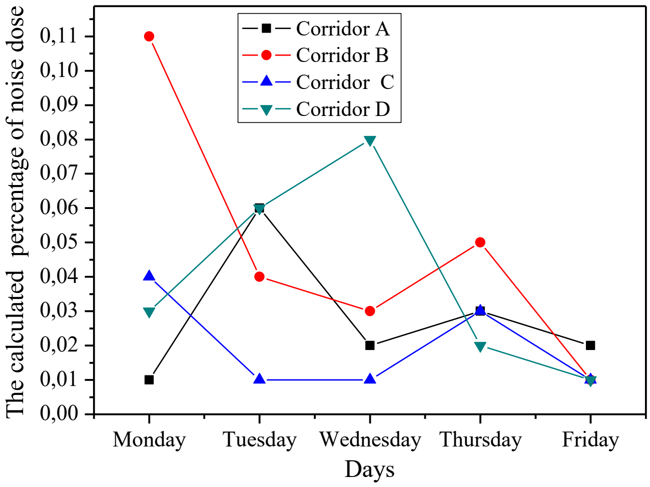

Figure 8. The variation of the calculated the percentage of noise dose for the first floor corridors according to days

The acceptable equivalent noise level (L_{eq}) for health buildings and hospitals was accepted as 35 dBA in the noise control directive of the Ministry of Environment and Forestry of the Republic of Turkey, which was published in the Official Gazette dated 11.12.1986 and numbered 19308. The World Health Organization Guidelines for Community Noise and the National Environmental Standards and Regulations Enforcement Agency have defined the equivalent noise level for indoor and outdoor noise levels in health institutions as 35 and 55 dBA, respectively (Berglund et al., 1999; NESREA, 2007). As seen from Table 4 and Figure 3, the equivalent noise levels calculated for the ground floor corridors vary between 27.39 dBA and 50.68 dBA. Again, as seen from Table 4 and Figure 4, the equivalent noise levels calculated for the minus first-floor corridor vary between 32.99 dBA and 47.80 dBA. As seen from Table 5 and Figure 5, the equivalent noise levels calculated for the first-floor corridors vary also between 34.68 dBA and 53.57 dBA. But, the values of the equivalent noise level calculated for all corridors were generally found to be greater than 35 dBA, which is the acceptable limit value for health facilities (hospitals). Noise pollution in hospitals is an important problem that needs to be solved for both healthcare professionals and patients.

Because the noise ruins performance, and it can be created some physiological responses mediated by the autonomic nervous system (increased heart rate and blood pressure), nausea, headache, argumentativeness, and mood and anxiety changes that can affect the patient-physician relationship (Gültekin et al., 2013). In a study conducted by Tijunelis et al. in 2005, they determined that there is an excessive noise level that can vary and is regular in the emergency room of a hospital. In a study conducted in 2011, it was reported that the noise level in intensive care units and emergency services was above the limit values (Khademi et al., 2011). Mohamed et al., in 2021, have prepared a book chapter titled Noise Pollution and its impact on human health and the environment, and in this chapter they have given very important basic information about sound, noise and the environment. A study was conducted on the noise pollution caused by vehicles in the province of Tokat, Turkiye, and the measurement values were found to be much larger than the limit values in most of the measurement points (Ozer et al., 2009). In a study conducted in Australia in 2021 has been investigated the impact of environmental noise from road traffic, airplanes, trains and industry on mental health and psychological distress by 31,387 participants using a 19-year longitudinal data set. In the study, it was concluded that perceived residential noise has a negative effect on mental health (Li et al., 2022). According to the findings of the World Health Organization (WHO), noise pollution is the second biggest environmental problem for human health after air pollution. Because the World Health Organization defines the state of being healthy as a state of complete physical, mental and social well-being in the absence of disease or infirmity. The noise should be considered an environmental pollutant that negatively affects human health and should be evaluated accordingly. Regarding its properties, it should be classified as a physical and atmospheric pollutant. The noise can harm human health and well-being; adversely can affect ecosystems and ecological services. With this, when long-term exposure to noise pollution can also occurs serious health problems such as hearing impairment, cardiovascular diseases, sleep disorders and negative social behaviours. Extreme emerged noise in hospitals reduces the intelligibility of speech, disrupts communication, causing discomfort, irritation, and tiredness, and reduces the quality and safety of healthcare services. In addition, it has been reported to play a role in the development of intensive care psychosis (mental balance disorder), stress caused by hospitalization, increased pain sensitivity, high blood pressure, and poor mental health (Xyrichis et al., 2018; Grumet,1993; Choiniere, 2010; Buxton et al., 2012).

Conclusions

This study was carried out to determine the noise level in the outpatient clinic corridors of the KSU Medical Faculty Hospital and to raise awareness about the negative effects of noise on human health. As seen in Table 2, the average sound intensity level measured on the first floor was calculated as 71.61 dBA. The average sound intensity measured on the minus first floor, that is, in the corridor where the radiology outpatient clinic is located, was calculated as 71.66 dBA. As can be seen from Table 3, the average sound intensity measured on the ground floor was also calculated as 69.72 dBA. As can be seen from Table 4, while the average equivalent noise level of the ground floor was calculated as 41.20 dBA, the average equivalent noise level of the radiology polyclinic corridor, that is, minus the first-floor, was calculated as 41.80 dBA. As can be seen from Table 5, the average equivalent noise level of the first floor was calculated as 43.54 dBA. As a result, the measured sound intensity level and the calculated equivalent noise level in approximately all corridors and floors of the KSU Medical Faculty hospital are above the limit value of 35 dBA.

As can be seen in Tables 6 and 7, on average, the noise dose percentage-calculated for the floors is 0.057 for the ground floor, 0.048 for minus the first floor (the corridor of the radiology outpatient clinic), and 0.034 for the first floor. As a result, since the acceptable noise dose percentage is $D \leq 1$, it can be seen that the values of all corridors and days meet this condition and the noise dose in all the areas is not exceeded. But, since the calculated total noise dose percentage in the ground floor corridors is 1.40, it is greater than the limit value of $D \leq 1$. For all that, the percentages of the total noise dose calculated for the corridors on the other floor are less than the limit value of $D \leq 1$.

Noise pollution is an intense, common anthropogenic discomfort that can have highly damaging effects on natural populations, societies and ecosystems around the world. Therefore, research on noise and its health effects should be done locally and solutions should be made locally. That is, it should be investigated by considering where (such as educational institutions, business environment, health institutions and so on) and in which groups the noise is effective. In particular, the building standards and public-policies should focus on both reinforcing areas with weak noise profiles and having consistent and stable standards for urban planning and substructure design (Li et al., 2022). The noise levels above the standard values defined by national and international organizations can seriously affect the treatment of patients and the quality of staff services. For this reason, noise reduction measures should be taken in corridors and even floors where the noise levels are above the limit values. For this, first of all, devices and instruments with low noise levels should be purchased to reduce noise levels in Hospitals. Secondly, if possible, only one polyclinic should be left in the corridors on the hospital floors instead of more than one. Thus, since the patient density in the corridors is reduced, human-induced noise is reduced. Thirdly, the hospital building should be built to absorb sound waves, especially when constructing corridor walls and ceilings. In conclusion, a multidisciplinary approach should be applied to hospital management, academic, administrative, and all other ancillary services along with all personnel in order to reduce noise in the hospital in general.

Ethics in Publishing

This study was planned as a master's thesis in 2019, and since the measurements will take about three months, ethics committee approval was obtained from the institutional ethics committee (dated: 12/03/2019, number: E.10619 and decision no:2019-3).

Author Contributions

The authors did not declare any contribution.

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