



EXAMINATION OF SALIVARY CORTISOL LEVELS IN VOLUNTEERS DURING HUNGER AND EXPOSURE TO HOSPITAL STAFF NOISE

¹Mehdi Nouri, ²Raheel Shushtarizadeh, ³Behzad Fouladi Dehaghi, ⁴Kambiz Ahmadi

¹Master of occupational Health Engineering Jundishapur University of Medical Sciences Ahvaz, Iran

²Master of information technology management Islamic Azad University Dezful, Iran

³Department of occupational health engineering and work safety school of public health, Ahvaz, Jundishapur University of medical sciences, Ahvaz, Iran

⁴Department of biostatistics school of public health, Ahvaz Jundishapur University of medical sciences, Ahvaz, Iran

Corresponding Author: Mehdi Nouri

ABSTRACT

Introduction: Noise is a significant environmental pollutant that impacts quality of life, particularly in environments such as hospitals where peace is crucial due to the nature of the work. This research aimed to examine the combined effects of hunger and noise exposure, and their influence on the cortisol levels of healthcare workers in two selected teaching and non-teaching hospitals.

Methods: Seventy-five hospital employees participated in this study. To assess sound levels in various hospital departments, a calibrated sound level meter (CEL-231) was employed. Saliva samples were taken to measure cortisol levels during fasting and non-fasting conditions at both morning and evening sessions. Descriptive statistics, independent and paired t-tests, and analysis of variance (ANOVA) were utilized for data analysis.

Results: The study findings revealed that in both Amir al-Mu'minin (A) and Abuzar hospitals in Ahvaz, the mean and standard deviation of sound pressure levels were 6 ± 3.75 and 5 ± 9.76 decibels, respectively. Salivary cortisol concentrations indicated a significant difference between normal feeding and fasting conditions ($P < 0.05$). A notable difference in salivary cortisol levels was found between the non-exposure-to-noise condition and the hunger and noise exposure condition ($P < 0.05$). Regarding the influence of hospital environment on cortisol levels, there was a significant difference in cortisol secretion between the staff of the two hospitals ($P = 0.00$).

Conclusion: The findings of this study suggest that the average sound pressure level in workplace environments significantly affects workers' salivary cortisol concentrations. Additionally, the combination of noise exposure and fasting exerts a synergistic effect on salivary cortisol levels.

Keywords: Cortisol, hunger, blood oxygen concentration, noise effect.

INTRODUCTION

The environment plays a crucial role in the physical, psychological, and social well-being of individuals. Various environmental factors pose risks to human health, including physical, chemical, and biological elements (1). Among these, noise, a physical factor, has attracted considerable attention in recent years (2). Noise is an undesirable sound, often linked to unnecessary and inappropriate sounds at elevated volumes. Sound travels through the air and, depending on the environment, can penetrate buildings, walls, and rooms, affecting human health in various ways. These effects are typically categorized as auditory and non-auditory. Occupational exposure to high noise levels can lead to several harmful outcomes, such as elevated blood pressure, decreased work performance, sleep disturbances, confusion, stress, and ultimately hearing loss (3-5). A study by Salami, Alasonkafi, Ismail, and colleagues examining noise impacts on workers at a sock factory in Nigeria demonstrated that noise exposure could raise systolic blood pressure but had no effect on diastolic blood pressure (6). Beyond hearing loss and stress, noise pollution significantly influences the physical development of infants, as well as their ability to learn, concentrate on tasks, and retain information (7). Furthermore, research by Carla Teisler and her team on the effects of road traffic noise on 872 children up to age 10 in Belgium found that such noise exposure resulted in behavioral disorders and sleep disturbances in these children (8).

Noise in hospitals is a prevalent environmental hazard. Key sources of noise in hospitals include mechanical equipment, ventilation systems, conversations with patients, and interactions among medical staff and clients requiring services. The detrimental effects of noise on patient care and healthcare staff performance (including nurses, doctors, and support personnel) are well-documented (9-10). According to the World Health Organization (WHO) guidelines, the acceptable sound level in hospital environments should be between 35-40 decibels during the day and 30-40 decibels at night (11). A study conducted by Erdogan Gultekin and colleagues on noise pollution in polyclinics at hospitals in Istanbul, Turkey, found that the sound levels in these areas exceeded the WHO's recommended thresholds (12). Hospitals are crucial public service centers, and their operations require a calm, quiet, and peaceful atmosphere to meet both patient needs and staff working conditions. The consequences of noise in hospital environments include disruption of communication among staff and between staff and patients, distractions, reduced concentration and accuracy of personnel, neurological and psychological disorders, increased blood pressure, heart rate, and respiratory rate, sleep disturbances for patients, and longer hospital stays (13). Florence Nightingale, in her research, emphasized that unnecessary noise hinders patient recovery and negatively impacts both patients and staff (14).

Cortisol plays a key role in various physiological processes, including reducing inflammation, modulating immune responses, influencing metabolism, and raising blood sugar levels in the body. It is released in response to stress, inflammation, or low blood glucocorticoid levels. The secretion of cortisol is regulated by corticotropin-releasing hormone (CRH) from the hypothalamus, which stimulates the release of adrenocorticotrophic hormone (ACTH) from the pituitary gland, subsequently increasing cortisol secretion. Cortisol naturally peaks in the morning and reaches its lowest levels at night. Its secretion is heightened during the body's response to stress, and due to its involvement in stress-related changes, it is often referred to as the "stress hormone."

Numerous studies have explored the interaction between hunger and other factors in both animal and human models. A notable finding is the relationship between hunger and cortisol levels, with hunger leading to an increase in cortisol secretion. Furthermore, hunger is categorized in two ways: one perspective considers hunger as a stressor, which elevates the

production of reactive oxygen species (ROS) in the body. Some studies have demonstrated that elevated ROS levels contribute to cell death in tissues. For example, ROS in the cochlea has been found to damage hair cells, leading to hearing loss. Conversely, another set of studies suggests that prolonged hunger may reduce ROS production in the body (15).

In a 2014 study by Matthias Basner, Wolfgang Babich, and Adrian Davis, titled "Auditory and Non-Auditory Effects of Noise on Health," conducted in Germany, the researchers examined the effects of noise on human health through questionnaires and sound measurements in various work environments. The study investigated both auditory effects, such as hearing loss from professional and social noise exposure, and non-auditory effects, including cardiovascular impacts, increased blood pressure, sleep disturbances, confusion, and impaired medical care delivery in healthcare facilities and childcare centers. The results indicated that noise could significantly harm human health, both in auditory and non-auditory ways (16).

A 2013 study by Sergey Maksimovich, Natalia Sergeyevna Pogotogina, and Alexander Ivanovich, titled "Reducing Vehicle Noise Pollution in Russia," found that noise levels between 50 and 70 decibels contributed to increased blood pressure and heart rate by disrupting blood circulation, a major risk factor for cardiovascular diseases. The study also revealed that noise levels as low as 40 decibels had negative effects on the nervous system (17).

In a 2013 study by Salami Olasekanmi and Adabaio Edosot, titled "Noise Exposure as a Factor in Increased Blood Pressure in the Workplace: A Study of Workers in a Sock Factory in Nigeria," the researchers aimed to assess the link between noise exposure and increased blood pressure. The study involved 62 randomly selected workers with an average age of 31.6 years. Their systolic and diastolic blood pressures were measured before and after their shifts using a mercury sphygmomanometer while simultaneously measuring sound levels. The results indicated that noise exposure significantly raised systolic blood pressure, but there was no significant increase in diastolic blood pressure. Based on these findings, the researchers recommended that workers avoid exposure to noise levels exceeding 89 decibels (6).

In a 2013 study by Carla Tiesler, Matthias Brück, Elisabeth Tyrening, and colleagues, titled "Exposure to Road Traffic Noise and Behavioral Problems and Sleep Disturbances in Children" in Germany, 872 children aged 10 from two large schools in Munich were selected. Noise levels around the children's living areas were measured both during the day and night, and behavioral problems and sleep disturbances were assessed using a specialized questionnaire. The study found that exposure to traffic noise was linked to increased restlessness, anxiety, and heightened psychological symptoms in children, particularly sleep disorders (18).

In a 2012 study by Oji Oyedepo, Eri Ikoma, and K. Ajala, titled "Analysis of Traffic Noise along the Imehin-Oba-Ediswa Road in Akure, Ondo State, Nigeria," a quantitative analysis of noise levels along the road was conducted. Six sections of the road were selected, and sound pressure levels were measured during peak traffic hours using a digital sound meter. The findings revealed that the noise pollution caused by road traffic exceeded national standards in most locations, potentially having adverse effects on various activities (19).

In a 2011 study by Hamid Mehravaran, Saeed Zabani, and Nabi Bidehendi, titled "Noise Pollution Measurement as a Method for Identifying Critical Areas in Tehran," noise levels were regularly measured at two points during the day for 24 hours over a two-week period. A noise map of various areas and sources of noise was created, and based on the results, high-risk regions were color-coded. The study concluded that noise maps could be an effective tool in control programs for managing noise impacts (20).

In a 2010 study by G. Twamney, Miguel Fioravanti, D. Serati, and colleagues, titled "Professional Exposure to Noise and Cardiovascular System: A Comparative Analysis of Occupational Noise Exposure in Italy," 18,658 workers from three job categories across two

large factories were evaluated. Noise levels in their workplaces were assessed, and the workers were divided into three exposure categories (high, medium, and low). Vital signs were measured after exposure, and the results revealed a statistically significant increase in systolic and diastolic blood pressure, respiratory rate, and abnormal electrocardiograms in those with high noise exposure compared to those in other groups. The study recommended regular monitoring of blood pressure, heart rate, and respiratory rate for workers exposed to noise (21).

In a 2013 study by Adi Padma Kumar, D. Basing, and colleagues in India, titled "Noise Level Measurement in ICU Sections of Two Teaching Hospitals: A Prospective Study," noise levels in the ICU sections of two teaching hospitals were measured for 24 hours over five days. The study found that noise levels in both ICU sections exceeded the standard recommended by the World Health Organization (WHO), which states that the average ambient noise in hospitals should not exceed 35 decibels, and the maximum noise level at night should be under 40 decibels. The study suggested that noise reduction programs, including staff training and ICU design modifications, should be considered in future hospital construction (22).

In a 2013 study by Erdogan Gültkin, Ömer Nakati Duyel Oğlu, and colleagues, titled "Noise Pollution in Hospital Polyclinics in Istanbul, Turkey," noise levels were measured in five polyclinics in Istanbul using a RadioShack digital sound meter. The measurements were taken from 8:15 AM to 4:00 PM. The results were regularly recorded and compared with the guidelines recommended by the World Health Organization (WHO). The study found that the average maximum noise level was highest in polyclinic number 3, but there was no statistically significant difference compared to other centers. Ultimately, all measurements exceeded the WHO's recommended standards (12).

In a 2012 study by Hamam G. Al-Zubair, Asma Al-Jawadi, and colleagues, titled "Noise Pollution in Central Teaching Hospitals in Mosul, Iraq," noise levels in various areas within hospitals were assessed using a digital sound meter. A total of 80 locations within the hospitals were measured, with results recorded every 5 minutes and three evaluations done in each location. The study found that the internal noise levels in these hospitals exceeded the WHO's recommended limits. The study highlighted the need for continuous monitoring and control of noise pollution in hospitals to prevent its harmful effects (23).

In a 2010 study by Berklos, Márquez, and colleagues, the effects of hunger on cortisol, blood glucose, liver glycogen, and muscle glycogen in Rhamdia fish were investigated. The fish were divided into five groups: the first group was the control with regular feeding, the second group was starved for one day and then fed, the third group was starved for seven days and then fed, the fourth group was starved for fourteen days and then fed, and the fifth group was starved for twenty-one days and then fed. The results showed that the 7, 14, and 21-day fasting periods significantly increased blood cortisol levels compared to the control group (24).

Based on the studies conducted in this project, there has been no research exploring the combined effects of hunger and noise exposure on salivary cortisol levels. Therefore, the objective of this study is to examine the relationship between combined exposure to noise and hunger and their impact on salivary cortisol levels among hospital staff.

Methodology: This is a basic, semi-experimental study conducted in 2015 as a field and laboratory study among hospital personnel. The factors investigated in this study were the different departments and sections of two selected hospitals (one educational and one non-educational) in Ahvaz, namely Abu Zar and Hazrat Amir al-Mu'minin (PBUH), with a focus on noise levels and their effects on staff. Initially, 64 participants were required for the study; however, 75 individuals participated, consisting of 46 females and 29 males, with an average age ranging from 30 to 45 years.

To assess the harmful effects of noise on individuals, the study included the number of people exposed to noise. This indicator is derived from the relationship between the factor-weighted

data quotient, which is calculated by multiplying the number of individuals exposed to noise by the degree of damage caused by noise in relation to the sound level, and then applying this to the study population. The value is then calculated and compared with a standard table to determine its significance (25).

Formula (1) for calculating the noise impact index:

$$NII = \frac{SLWP}{P \text{ total}}$$

The noise damage level according to the sound level (W) =

The number of individuals exposed (P) =

To examine the effect of noise on cortisol levels in the participants, diagnostic samples were collected in two states (fasting and satiated) at two stages: at the beginning and at the end of their work shift. These samples were then transferred to a diagnostic laboratory for analysis.

Cortisol can be measured in blood, urine, or saliva. Blood and urine tests are typically used to diagnose conditions such as Cushing's syndrome and Addison's disease, which are severe adrenal disorders. Saliva cortisol tests are commonly used for diagnosing Cushing's disease and evaluating stress-related disorders. Saliva and urine tests are frequently used to assess potential cortisol-related disorders, particularly excessive cortisol production.

For blood cortisol, samples are often taken around 8 a.m., when cortisol levels are typically at their peak, and again around 4 p.m., when levels should decrease. Sometimes, a sample may be taken late at night when cortisol levels are naturally at their lowest (around midnight). Collecting multiple samples allows the doctor to assess the pattern of cortisol secretion throughout the day. A morning sample may be sufficient for diagnosing low cortisol levels. Urine tests may also be performed for cortisol, often requiring a 24-hour urine collection, although sometimes a morning sample will suffice. A 24-hour urine sample is useful for measuring the amount of free cortisol (unbound to proteins) excreted in the urine. However, it does not allow the doctor to evaluate variations in cortisol secretion over the day.

Saliva cortisol tests can be done as well, and while sample collection is generally less stressful than blood tests, it requires careful preparation. Saliva samples are typically taken between 11 p.m. and midnight when cortisol levels are naturally at their lowest (26).

The participants' general health was evaluated using the General Health Questionnaire (GHQ), created by Goldberg in 1972. This GHQ consists of 28 questions, each scored between 0 and 3. The total score for an individual can range from 0 to 84. A lower score indicates better mental health, while a higher score suggests poorer mental health.

To measure the sound pressure level in various areas of the hospitals examined, a CEL-231 sound level meter, produced by CASELLA CEL in the United Kingdom, was utilized. For the analysis and extraction of cortisol from the participants' saliva samples in the research project, diagnostic kits from the Cobas brand, manufactured in France, were employed. For statistical analysis, factors such as the staff's general health questionnaire results, cortisol levels before exposure to noise when satiated, cortisol levels before exposure to noise when fasting, cortisol levels in four conditions (beginning and end of the shift, and in fasting and satiation states), the influence of gender on cortisol secretion, and the effect of hospital type on cortisol secretion were analyzed using frequency distribution and relative frequency charts.

This research was conducted in two phases.

Phase one involved a preliminary visit to various sections of the selected teaching and non-teaching hospitals, measuring the sound pressure levels in the relevant areas, and calculating

the equivalent sound exposure level and the noise impact index for each section of the hospitals.

Phase two involved measuring blood pressure, heart rate, blood oxygen concentration, and saliva sampling from the selected staff members for the study in two conditions: fasting and satiated. Measurements were taken at two time points: initially (before exposure to noise) and at the end of the work shift (after exposure to noise). Finally, to assess other effects of noise on the study participants (such as headaches, stress and anxiety, sleep problems, etc.), their general health was evaluated using the 28-question Goldberg and Williams health questionnaire.

Findings

Given that one phase of the study involved diagnostic tests and sampling from humans, 75 individuals from the teaching and non-teaching hospitals were selected and met the inclusion criteria to participate in the study (Table 1).

Table 1: Demographic characteristics of participants based on gender.

	Gender of individuals	Frequency	Percentage	Valid frequency	Cumulative percentage
Gender	Female	53	70/7	7/70	7.70
	Male	22	29/3	3.29	100
Hospital of service	Amir al-Momenin	46	61/3	3.61	3.61
	Abuzar	29	38/7	7.38	100

Table 2: Results of other noise effects on the study participants, such as headaches, sleep disturbances, stress, excitement, and agitation.

	Frequency	Percentage	Valid percentage	Cumulative percentage
No sign	62	82/7	7.82	7.82
Mild sign		3.13	3.13	96
Moderate sign	3	4	4	100
Total sum	75	100	100	

Table 3: The relationship between gender and its impact on the general health of individuals.

	Analysis of test results			
Gender	Moderate sign	Mild sign	No sign	Total sum
Female	3	7	43	53
Total percentage	%4	%9.3	%57.3	%70.7
Male	0	3	19	22
Total percentage	%0	%4	%25.3	%29.3
Final total	3	10	62	75
	%4	%13.3	%82.7	%100

Table 4: Descriptive statistics of the effect of gender on the salivary cortisol secretion in the individuals studied.

Status and shift	Gender	Mean	Standard	Number
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			deviation	
In a fed state and at the end of the shift	Female	0.32806	0.97972	53
	Male	0.33109	0.104400	22
	Total sum	0.32895	0.99196	75
In a fed state and at the beginning of the shift	Female	0.32853	0.118438	53
	Male	0.37232	0.89196	22
	Total sum	0.34137	0.111883	75
In a fasting state and at the end of the shift	Female	0.20894	0.120112	53
	Male	0.22418	0.110766	22
	Total sum	0.21341	0.116912	75
In a fasting state and at the beginning of the shift	Female	0.26066	0.101786	53
	Male	0.25250	0.94220	22
	Total sum	0.25827	0.99063	75

Table 5: Lack of significant effect of gender on cortisol secretion in the individuals studied.

Source	Type of both genders	Degrees of freedom	Median	Frequency	Significance
Acceptance	23.747	1	23.474	736.965	000
Gender	0.006	1	0.006	.180	673
Error	2.484	78	0.32		

Table 6: Indicates a significant difference in the effect of hospital type on cortisol secretion.

Source	Type of both hospitals	Number	Standard deviation	Degrees of freedom	Significance
Source	23.978	1	23.978	1.2593	000
Type of hospital	1.004		1.004	52.682	000
Error	1.486	78	19.0		

Table 7: Summary of the results of four tests conducted on cortisol concentration levels in fed and fasting states.

	Mean before exposure to sound	Mean after exposure to sound	95% Confidence interval of the difference	Paired t-test p-value
Cortisol concentration in a fed state	0.34	0.33	0.01-0.04	0.36
Cortisol concentration in a fasting state	0.26	0.21	0.07-0.02	0.00

Table 8: Summary of the results of four tests conducted on cortisol concentration levels before and after noise exposure.

Paired t-test p-value	95% Confidence interval of the difference	Mean in a fasting state	Mean in a fed state	
0.00	0.11-0.05	0.26	0.34	Cortisol concentration before exposure to sound
0.00	0.15-0.09	0.21	0.33	Cortisol concentration after exposure to sound

DISCUSSION

Noise measurements were taken to assess the sound pressure level (LP), equivalent sound level (Leq), and noise impact index (Nii) across various areas of Amir al-Momenin and Abuzar hospitals in Ahvaz, covering 24 and 14 sections, respectively. The results revealed that areas like the boiler room, waste disposal system, and emergency and pediatric departments exhibited higher noise pressure levels and noise impact indices than other sections. This was attributed to industrial equipment, high patient traffic, frequent conversations among staff and visitors, patient distress calls due to pain, noise from ventilation and air exchange systems, loudspeaker announcements, and various medical devices. A study by Karami et al. on noise pollution in Golestan Hospital in Ahvaz and Fatemeh Zahra Hospital in Bushehr also found the highest noise pressure levels in the emergency department, primarily due to conversations, ventilation systems, and medical equipment usage, which aligns with our findings (27). Similarly, a study by Poursadeghi et al. on noise pollution in two hospitals in Mashhad reported similar results (28). The results further highlighted the direct impact of noise exposure on cardiovascular and respiratory function. A study by Salami Elasonkafi in Nigeria, titled "Exposure to Noise as a Major Factor in Increasing Blood Pressure Among Workers in a Sock Manufacturing Industry," showed that noise exposure significantly affected both systolic (maximum) and diastolic (minimum) blood pressure (6). Additionally, a study by Shaheed Muhammad et al. in Pakistan, titled "Effects of Hospital Noise Levels on Patients and Visitors at Faisalabad Hospital," confirmed that noise exposure at different times directly impacted blood pressure (systolic and diastolic), heart rate, and blood oxygen levels (5). Comparing these findings with our study showed strong similarities, further validating the consistency of results across these studies.

The findings showed that gender did not have a significant impact on the general health of the study participants. In other words, no statistically significant difference was found between gender and the effects of noise exposure on the participants ($p = 0.39$). Abbasi et al., in their study titled "The Effect of Wind Turbine Noise on the General Health of Workers in Wind Farms," found a significant correlation between equivalent sound levels and all aspects of general health, except depression (29). This aligns with our study, where two participants with moderate symptoms worked in departments such as mechanical facilities and emergency rooms—areas with the highest noise impact within the hospital. Similarly, another study by Zamanian et al., titled "The Effects of Occupational Noise Exposure on the General Health of Steel Industry Workers," showed a direct and significant relationship between noise exposure and general health conditions in certain workers (30), which is consistent with our findings.

Overall, the results indicated that cortisol secretion varied significantly in all conditions except when the participants were fed. Persson et al. demonstrated that salivary cortisol levels are influenced by stress and noise exposure at work, which aligns with our findings (31). Additionally, Miki et al. found that workplace noise exposure caused a significant increase in the level and concentration of salivary cortisol, supporting our results (32). Furthermore, Marquez et al. investigated the effects of hunger on cortisol, blood glucose, and hepatic and muscular glycogen levels in Rhamdia fish. Their study revealed that fasting for 7, 14, and 21 days significantly increased blood cortisol levels compared to the control group (24).

CONCLUSION

The study confirmed a significant difference between hunger and workplace noise exposure

regarding cortisol secretion. Specifically, sound pressure levels had a direct impact on cortisol secretion in a fasting state, leading to increased stress levels. However, this relationship was not observed when individuals were in a fed state and exposed to noise. Furthermore, the type of hospital where employees worked had a significant influence on cortisol secretion and, as a result, on stress levels. These effects can be mitigated through effective environmental controls and preventive measures.

Based on the findings, it is recommended to implement stress management educational programs for hospital staff, adjust daily working hours, introduce job rotation programs, and provide suitable personal protective equipment, such as noise-canceling earplugs, to reduce the harmful effects of noise exposure on employees.

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