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TÜRKİYE SOMA HAVZASINDA YERALTI MADEN İŞÇİLERİNİN MARUZ KALDIKLARI GÜRÜLTÜ ETKİLERİNİN İSTATİSTİKSEL ANALİZİ

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Anahtar Kelimeler
Gürültü Etkisi,
Yeraltı Madenciliği,
İşçi Sağlığı,
İstatistiksel Analiz,
Kardiyovasküler Riskler.

Öz

Gürültünün yarattığı sorunların pek çok ortamda psikolojik, sosyal ve çeşitli sağlık sorunlarına yol açtığı bilinmektedir. Gürültü maruziyetinin en etkin şekilde gözlemlendiği ortamlardan biri de çalışma alanlarıdır. Son zamanlarda mesleki gürültüye maruz kalmanın işçi performansı ve sağlığı üzerindeki etkilerine ilişkin çalışmaların sayısı tüm dünyada artmıştır. Bu çalışmada gürültüye maruz kalmanın kardiyovasküler sistem üzerindeki etkisinin belirlenmesi amaçlanmıştır. Yeraltı madenciliği sektöründe çalışan veya çalışacak 100 işçinin çalışma ortamında maruz kaldıkları gürültünün etkileri incelenmiştir. Kişilerin kan basıncı, oksijen satürasyonu, nabızları, solunum hızları ve elektriksel aktiviteleri gibi fizyolojik sinyalleri ölçülmüştür. Elde edilen veriler istatistiksel olarak incelenmiştir. Çalışmanın istatistiksel olarak gürültünün kardiyovasküler bir risk faktörü olduğunu göstermektedir. Kardiyovasküler değişikliklerin gürültü seviyeleri ve maruz kalma süresi ile ilişkili olduğu ve bu etkilerin bireysel duyarlılıktan da kaynaklanabileceği varsayılabilir. Sonuç olarak, çalışmadan elde edilen sonuçlar, yeraltı madenlerinde çalışan işçilerde kardiyovasküler problemlerin varlığını ve bu sektörde çalışan işçiler için kardiyoloji taramasının yararlılığını göstermektedir.

STATISTICAL ANALYSIS OF NOISE EXPOSURE OF WORKERS IN THE UNDERGROUND MINING IN THE SOMA BASIN OF TURKEY

Keywords
Noise Effect,
Underground Mining,
Worker Health,
Statistical Analysis,
Cardiovascular Risks.

Abstract

It is known that the problems created by noise cause numerous psychological, social, and various health consequences in many environments. One of the environments where noise exposure is observed most effectively is work areas. Recently, the number of studies on the effects of occupational noise exposure on worker performance and health has increased globally. In this study, it was aimed to determine the effect of exposure to noise on the cardiovascular system. The effects of the noise in the working environment of 100 workers who work or will work in the underground mining sector were examined. Physiological signals such as blood pressure, oxygen saturation, heart rate, respiratory rate, and electrical activity of individuals were measured. The obtained data were analyzed statistically. Our study statistically suggests that noise is a cardiovascular risk factor. It can be assumed that cardiovascular changes are related to noise levels and exposure time, and these effects may also be due to individual susceptibility. In conclusion, the results obtained from this study show the existence of cardiovascular problems in workers working in underground mines and the usefulness of cardiology screening for workers working in this sector.

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STATISTICAL ANALYSIS OF NOISE EXPOSURE OF WORKERS IN THE UNDERGROUND MINING IN THE SOMA BASIN OF TURKEY

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Highlights

- Noise is a problem to be considered for those working in underground mines.
- The cardiovascular effects of noise have been determined experimentally.
- The obtained data were analyzed statistically.

Graphical Abstract

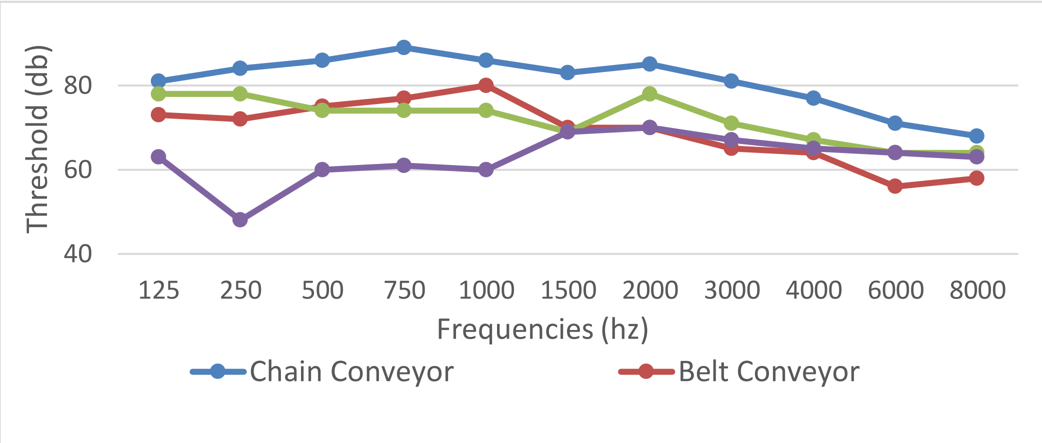

Figure. Noise İntensity Per Frequency Of Noise Sources İn Underground Mining

Purpose and Scope

In this study, it was aimed to determine the effect of exposure to noise on the cardiovascular system.

Design/methodology/approach

The effects of the noise in the working environment of 100 workers who work or will work in the underground mining sector were examined. Physiological signals such as blood pressure, oxygen saturation, heart rate, respiratory rate, and electrical activity of individuals were measured. The obtained data were analyzed statistically.

Findings

This study statistically suggests that noise is a cardiovascular risk factor.

Practical implications

The results obtained from this study show the existence of cardiovascular problems in workers working in underground mines and the usefulness of cardiology screening for workers working in this sector.

Social Implications

This study will highlight the importance of occupational health and safety. It will encourage the use of protective equipment that should be used against noise.

Originality

There is almost no study in the world investigating whether the noise level in the underground mining sector creates a cardiovascular risk factor in the mines. This study will contribute to future studies.

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1. Introduction

Today, rapidly developing technology includes many positive developments to make life easier. However, these developments also have aspects that negatively affect human health. The noise is one of the negative effects on human body.
Sound is a physical phenomenon consisting of the varying compression and expansion of air radiating from a source in all directions. These alternating compressions and expansions can be defined as small pressure changes around atmospheric pressure. The frequency of the variations determines the pitch of a sound: a high-pitched tone (for example, 4,000 Hz) indicates a squeaking sound, a low-pitched tone (for example, 200 Hz) indicates a humming sound (Passchier-Vermeer et al., 2000).
There have been many studies examining the negative effects of noise on human health. In the study of respiratory system (Castelo Branco et al., 1999), immune system (Zheng and Ariizumi, 2007), audiometric problems (Thuthula, 2022), endocrine system (Tomei et al., 2003), reproductive system (Hrubá et al., 1999) on the other hand, cognitive systems (Brattico et al., 2005), and (Kavzan, 2015) emphasized that noise affects negatively in their study. In addition, its effect on arterial hypertension and cardiovascular diseases has been mentioned recently. The authors emphasized that noise causes an increase in heart rhythm. (Aydin and Kaltenbach, 2007), hypertension (Nawaz and Hasnain, 2010), and EKG abnormalities (Tomei et al., 2003). Cardiovascular diseases (CVDs) are classified as major and chronic non-communicable diseases (WHO (World Health Organization), 2008). Smoking and obesity, which are risk factors for cardiovascular diseases like hypertension and heart rhythm disorder, can be prevented, while factors such as gender, race, age, and lifestyle cannot be prevented (Capozzella et al., 2015). In addition to these prominent risk factors, exposure of workers in some occupations to noise creates different effects (Kerns et al., 2018, Liu et al., 2020). For instance, high temperature (Aydin and Kaltenbach, 2007, Rathod et al., 2021) may also cause cardiovascular diseases. Experimental and epidemiological research has also shown that occupational noise affects hypertension and cardiovascular diseases (Liu et al., 2020). Kalantary et al. investigated whether exposure to noise has any effect on the blood pressure and heart rate of employees in the automotive parts industry (Kalantary et al., 2015).
In the literature, studies have been carried out on the health of workers exposed to noise in various work areas. For example, a study on industrial noise monitoring using a noise mapping technique (Ahmed et al., 2022), In their study, (Engin I.C. et al, 2019), investigated the noise level and noise emission during the operation of natural stone cutting-processing machines used in natural stone workshops. The general study of all workers exposed to noise by Stokholm et al. (Zara Ann Stokholm et. al., 2020), Ziyu Tao et al., In their study, the effect of ventilation noise originating from the subway depot with a rail platform structure on workers and nearby residents was evaluated (Ziyu Tao et. al., 2019). The researchers have studied the effects of sound on different sector employees such as construction workers (Jinjing Ke et al., 2021) tobacco factory workers (Xingsong Wang et al., 2020), workers (Hansell et al., 2014), worked in the automobile manufacturing unit (Jamal et al., 2016; Sensogut and Cınar 2007) underground mining, the effects of the noise they are exposed to were examined. (Tekin et al., 2022) in their first study, examined the Noise Intensity Occurring in Underground Mining. In their second study (Tekin et al, 2022), they analyzed the neurological effects of noise statistically.
While there are studies investigating the cancer risks of workers in coal mines (Alif et al., 2021), very few studies in the world evaluate the noise level in underground mines and its effects on quality of life. [Varga et al, Bo Y et al.] and their number is increasing day by day.
In this study, the effects of noise exposure of workers working in the underground mining sector on cardiovascular conditions such as hypertension, heart rhythm disorder, body temperature and oxygen saturation were experimentally observed.

2. Materials and Methods

In this study, the effects of noise exposure of workers working in the underground mining sector on cardiovascular conditions such as hypertension, heart rhythm disorder, body temperature and oxygen saturation were experimentally observed.
In the experiment, 100 male volunteers who work or will work in mining companies in Soma, which has the highest quality lignite reserves in Turkey, were studied. Workers are constantly exposed to high noise, poor air quality and dust in working conditions. In the light of the information obtained because of the survey conducted with the workers, the characteristic features of the workers were formed as in Table 1. In addition, all volunteer workers were subjected to audiometric testing with the AMPLIVOX 240 brand audiometer device and as shown in figure 1 the workers whose hearing limit was below the sound produced by the noise sources weren't included in the experiment.

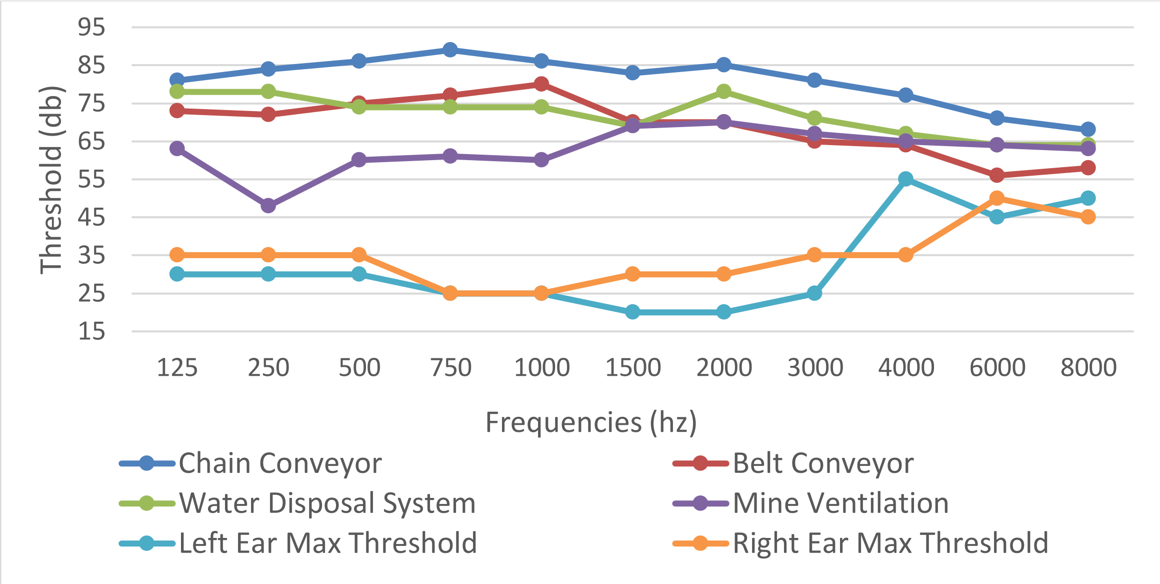

Figure 1. Comparison of Noise Intensity Per Frequency of Noise Sources Against Minimum Hearing Thresholds Per Frequency of Participants

As can be seen in Table 2, workers are exposed to the noise of various mining machines when looking at the sound intensities in the working environments in the underground mining sector. In the measurement results, it was seen that the highest of these sound intensities was 94 dB(A). When the audiometry tests performed during the determination of the workers to be included in the experimental study were examined, it was observed that 4 of 104 workers could not hear the working noise frequency threshold of the mentioned machines, and these workers were not included in the scope of the experiment. The remaining 100 workers were selected voluntarily for the experiment.

Table 1. Characteristics of the Worker Population

		Workers (N:100)		P-Value
Age (years)				
Mean ± SD	Min-Max	24 ± 5	19 - 49	,000
Weight (kg)				
Mean ± SD	Min-Max	76,4 ± 16,8	55 - 115	,000
Height (cm)				
Mean ± SD	Min-Max	176,6 ± 5,8	166 - 186	,000

There are many systems that are a constant source of noise in underground mining operations. These are chain conveyors, belt conveyors, water discharge systems, ventilation, etc. systems. The measurements were made in the underground mine training mine where these systems are together.

Figure 2. Underground Training Mine Where the Study Was Carried Out

The noise levels of each of the noise sources were measured with a calibrated PCE-430 brand noise measuring device as listed in Table 2 and the noise intensity was observed to vary between 84 -94 dBA.

Table 2. Continuous Noise Sources and Noise Intensities of Underground Mines

Noise Sources	Noise Intensity (dB)
Chain Conveyor	94
Belt Conveyor	86
Water Disposal System	84
Mine Ventilation	88

The measurements were carried out in three stages as listed in Figure 3. In the first case, called "MEASUREMENT1", when the noise sources were not turned on, the cardiovascular values, pulses, respirations, and oxygen saturations of the worker were recorded with the COMEN Star8000 brand bedside monitor. Afterward, the worker was exposed to the noise of all the machines for a while. In the second case called "MEASUREMENT2", the workers were exposed to noise and their measurements were made under the noise and the data were recorded. Then the noise sources were stopped, and in the 3rd, case called "MEASUREMENT3", post-noise recordings were taken.

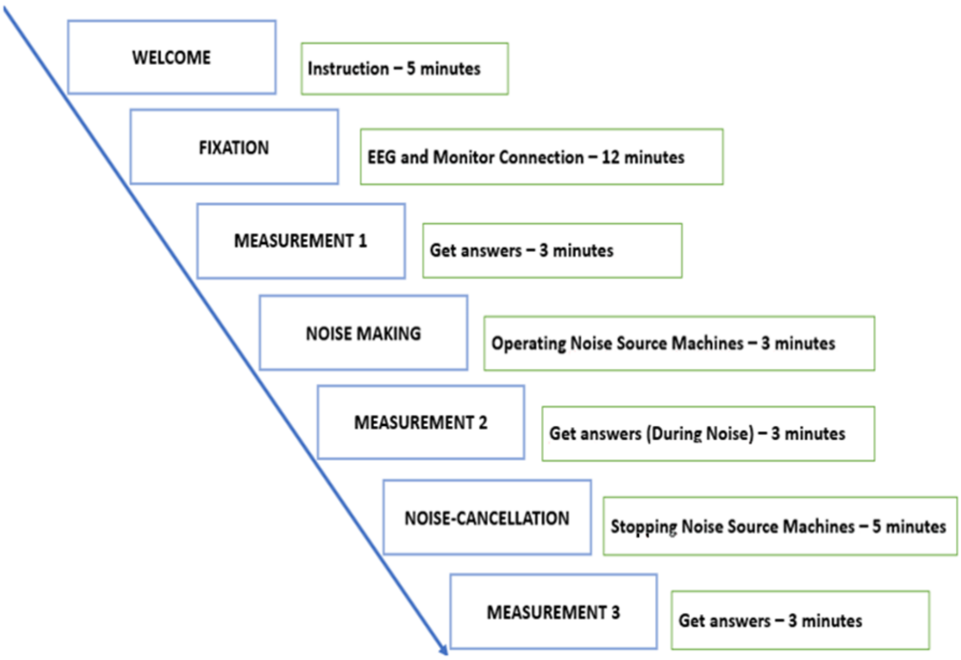

Figure 3. The Testing Procedure For Each Experimental Personnel

3. Statistical Analysis

The data obtained from the research were analyzed as dependent data in the SPSS statistical analysis program. In the statistical analysis of the data, the arithmetic means and standard deviation (SD) of each variable were calculated. Whether the data violated the assumption of normal distribution was checked using Kolmogorov-Smirnov's Lilliefors Significance Correction and Shapiro-Wilks Test. As a result of the controls, the tests of the workers and the scores they got from the attitude scale were compared using the Parametric T-Test for Related Samples, the Nonparametric T-Test for Unrelated Samples, and the Wilcoxon Test.

4. Results

The data were recorded as the moment of noise and after the noise, and the evaluations were made by comparing the individual's own measurement data. When the 2nd case and 3rd case data of the volunteer group are examined in Table 3, While analyzing the data, the significance level (p) was taken as 0.05. it is seen that according to Kolmogorov-Smirnov's test result, only the HR and PR values for the post-noise situation do not violate the normal assumption ($p>.05$). When Shapiro-Wilk test results are examined, it is seen that diastolic pressures do not violate the normal assumption of blood pressure and body temperature after noise ($p>.05$). It is observed that the other data of the experimental group violated the normal distribution assumption for both test methods ($p<.05$).

Table 3. Normal Distribution Assumption Test Table of 2nd and 3rd Case Data of Participants

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
SYS²	.109	100	.005	.947	100	.001
DIA²	.094	100	.029	.979	100	.102
MEAN²	.091	100	.039	.950	100	.001
HR²	.120	100	.001	.958	100	.003
PR²	.106	100	.008	.956	100	.002
SPO2²	.242	100	.000	.885	100	.000
RR²	.124	100	.001	.951	100	.001
T²	.123	100	.001	.971	100	.029
SYS³	.126	100	.000	.923	100	.000
DIA³	.129	100	.000	.980	100	.139
MEAN³	.142	100	.000	.951	100	.001
HR³	.083	100	.083	.976	100	.062
PR³	.082	100	.091	.970	100	.022
SPO2³	.211	100	.000	.765	100	.000
RR³	.135	100	.000	.965	100	.010
T³	.114	100	.003	.975	100	.052

a: Lilliefors Significance Correction 2: Situation two, 3: Situation three
(SYS: systolic blood pressure, DIA: diastolic blood pressure, MEAN: Mean of the blood pressures, HR: Heart Rate, PR: P-R Interval, SPO2: Oxygen Saturation, RR: R-R Interval, T: Temperature)

Since the systolic pressures violated the assumption of normal distribution in the tests, whether there was a significant difference between the values taken during and after the noise was tested with the Wilcoxon Test, one of the non-parametric tests. In the findings presented in Table 4, it is seen that there is a statistically significant difference in the mean values of both systolic and diastolic blood pressure compared to the controls. ($p < 0.05$ and $p < 0.05$, respectively).

Table 4. Systolic And Diastolic Blood Pressure Values of Workers for During and After Noise

	Case II	Case III	p-Value
Systolic Blood Presure (mmHg)			
Mean ± SD	118.3 ± 8.6	117.2 ± 8.7	.003
Min-Max	89-135	88-132	
Diastolic Blood Presure (mmHg)			
Mean ± SD	72.1 ± 6.5	70.1 ± 6.7	.000
Min-Max	56-92	54-90	
Blood Presure Mean (mmHg)			
Blood Presure Mean ± SD	86.3 ± 6.3	84.3 ± 6.5	.000
Min-Max	68-102	65-97	

Persons with clinical blood pressure >140 mm Hg and/or <90 mm Hg are at risk of hypertension. Persons with blood pressure >140 mm Hg are defined as systolic, and those below <90 mm Hg are defined as diastolic hypertension (Mancia et al., 1997). When the cardiovascular data of the people working and will working in the underground mining sector were examined, it was determined that the frequency of systolic hypertension cases was 3% ($p < .05$, Table 5), and the frequency of diastolic hypertension cases was 1% ($p < .05$, Table 5).

Table 5. Prevalence Of Hypertension in The Worker Population

	Worker N.100
Systolic Hypertension	
No Subject (%)	3 (%3)
Diastolic Hypertension	
No Subject (%)	1 (%1)

In the paired Wilcoxon Test results of the systolic, diastolic, and mean blood pressure values collected during and after the noise of 100 people working or will working in the underground mine, a significant result was observed in the paired differences ($p < 0.05$, Table 6). Although the individual normal distribution variations ($p<0.05$, Table 3) in the volunteers' heart rate, rhythm rates, oxygen saturation, R-R range, and body temperature gave a significant value, no significant result was observed in the paired differences in the Wilcoxon Test results ($p > 0.05$, Table 6).

Table 6. Paired Differences Table Of All Data Of The Worker Population In Noisy And Noiseless Environments

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	SYS^2 - SYS^3	1.130	3.719	.371	.392	1.867	3.03	99	.003
Pair 2	DIA^2 - DIA^3	2.050	3.967	.396	1.262	2.837	5.16	99	.000
Pair 3	$MEAN^2$ - $MEAN^3$	1.980	3.595	.359	1.266	2.693	5.50	99	.000
Pair 4	HR^2 - HR^3	.570	5.459	.545	-.513	1.653	1.04	99	.299
Pair 5	PR^2 - PR^3	.020	4.213	.421	-.816	.856	.047	99	.962
Pair 6	$SPO2^2$ - $SPO2^3$	.090	.683	.068	-.045	.225	1.31	99	.191
Pair 7	RR^2 - RR^3	.260	2.038	.203	-.144	.664	1.27	99	.205
Pair 8	T^2 - T^3	-.001	.061	.006	-.013	.011	-.16	99	.870

2: Situation two, 3: Situation three

5. Discussion

In this study, the effects of noise exposure of workers working in the underground mining sector on cardiovascular conditions such as hypertension, heart rhythm disorder, body temperature, and oxygen saturation were experimentally observed.
When the observations are examined; It is seen that the results of (Capozzella et al., 2015). in their study in which they investigated whether employees in the sanitary ware industry are at risk of developing cardiovascular disease, and specifically evaluated whether chronic noise influences cardiovascular problems, are in parallel with

the results related to hypertension found statistically in this study. In other words, people working in the underground mining industry show a higher prevalence of systolic and diastolic hypertension when exposed to noise in their work areas.

The main results produced in the study are:

- It has been determined that occupational exposure to noise in the working environment in the underground mining sector increases both diastolic and systolic blood pressure values.
- No significant difference was observed when the heart rate, rhythm rates, oxygen saturations, Pulse Rate, R-R intervals, and body temperature of the volunteers were compared now of noise and after the noise.
- In the measurements made, it was determined that 4% of the volunteer group had blood pressures above the hypertension values. Such a result was not surprising due to the low mean age of the group studied.

While cardiovascular affects due to noise are possible for all workers exposed to noise in underground mines, they can also be the result of the irregular use of hearing-related personal protective equipment. For this reason, it is recommended to provide training aimed at raising awareness among employees about the harmful role of noise in the working environment on hearing and all physiological systems, and about reducing noise levels. Employers are advised to evaluate risk factors by controlling noise measurements in the occurrence of cardiovascular disease by organizing health examinations and health education of their employees.

The study statistically suggests that noise is a cardiovascular risk factor. It can be assumed that cardiovascular changes are related to noise levels and exposure time, and often these affects may also be due to individual susceptibility. In conclusion, outputs of our study prove the occurrence of cardiovascular problems among underground mine workers and benefits of cardiac screening.

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Conflict of Interest

No conflict of interest was declared by the authors.

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