VYTAUTAS MAGNUS UNIVERSITY
LITHUANIAN FOREST RESEARCH INSTITUTE

Jurgita Lekavičiūtė

TRAFFIC NOISE IN KAUNAS CITY AND ITS INFLUENCE ON MYOCARDIAL INFARCTION RISK

Summary of Doctoral Dissertation
Biomedical Sciences, Ecology and Environmental Sciences (03 B)

Kaunas, 2007

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LIETUVOS MIŠKŲ INSTITUTAS

Jurgita Lekavičiūtė

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Introduction

In the Agenda 21 of the global action plan of the United Nations' Conference held in Rio de Janeiro in 1992 (UN 1993) health-related target areas were described. Community noise was one of them. Reduction of the health risks related to environment, investigation of health problems in cities and protection of the sensitive groups in the action programme were projected (Schwenk 2000). Nationally determined action programmes should include development of indicators for maximum permitted safe noise exposure levels and promote noise assessment and control as part of environmental health programmes. Transportation noise was addressed as a major factor of concern in this respect in the Green Paper of the European Commission on future noise policy. At the 3rd European Ministerial Conference held in London in 1999 (European Commission 1996; WHO 1999) big attention was also addressed to noise problems. The issue of action plans to reduce harmful effects of noise exposure is addressed in the European Directive relating to the assessment and management of environmental noise (Directive 2002/49/EC 2002). However, the criteria for a quantitative risk assessment are not yet established, that is why, for this European Commission pay prioritized attention in it‘s scientific programmes – FP6 and FP7.

Approximately 30% of the European Union's population (close to 120 million people) is exposed to levels of road traffic noise of more than 55 dB(A). Many people are annoyed and disturbed during their sleep at these levels. Exposure to high noise levels has decreased substantially in some countries since 1980 due to technological decisions, change of road surfaces, implementation of noise barriers and regulation of traffic flows. Nevertheless, noise levels are expected to rise again in the next decades in relation to the growth in traffic volumes, unless additional measures are taken (Staatsen et al., 2004).

Geographical information system (GIS) is used for defining environmental pollution and modeling of dispersion in the last years. More and more often GIS is applied in environmental epidemiological studies. GIS uses range from simply locating the study population by geocoding addresses (assigning mapping coordinates) to using proximity to contaminant source as a surrogate for exposure to integrating environmental monitoring data into the analysis of the health outcomes. Using GIS in exposure assessment for epidemiological studies involves geospatial science, environmental science and epidemiology. GIS can be used to determine exposure-response relationship in different stages. These stages are: defining the study population, identifying source and potential routes of exposure, estimating environmental levels of target contaminants and estimating personal exposures (Nuckols et al., 2004).

The scientific researches data suggest, that noise can cause hearing problems, annoyance, stimulate progress of ischemic heart disease (van Kempen et al., 2002; Babisch 2001; 2002; Schwela, 2000). Negative noise effect on human health has been determined in 1960 using occupational exposure outcomes. However, noise management policy has no scientific base till now because of insufficient consistent epidemiological studies at the population level. The biggest obstacle is determination of personal exposure while carrying out environmental epidemiological studies. Decision-making and risk management depend on a quantitative health risk assessment and determination of causal relationship (Gražulevičienė, 2005). As most of the risk factors studied in relation with noise increase risk of cardiovascular disease for persons exposed to noise; therefore the main attention in noise epidemiology is given to mostly spread ischemic heart disease (IHD). IHD is one of the most important reasons of premature death in economically developed countries and in Lithuania (Doll, 1992; WHO, 1999; Domarkienė ir kt., 2003).

Mostly this disease is spread among middle-age persons; therefore great attention is paid for clarification of causes and search of risk factors, which stimulate initiation and progress of disease. Nowadays particular attention is given to explore dangerous environmental factors and to study possibilities to control them. Through evaluation of situation permits affirm, that preventive measures, used in some European countries, may prolong healthy person's life to five years (WHO, 2000). For this reason study of environmental noise exposure to myocardial infarction risk is relevant for both – creating modern environmental monitoring system in the Europe Union and proposing health prevention measures.

Environmental noise measurements and standardized epidemiological studies permit to estimate which part of diseases in population may start because of noise exposure and how changes the risk, when one of the potentially confounding factors is changing. There is scientific evidence that steady noise at work increases the risk of ischemic heart disease and myocardial infarction; however there are only few studies on environmental noise exposure to health and their results are ambiguous, very often statistically non-significant. It is necessary to determine individual noise exposure and have appropriate system of gathering new cases of myocardial infarction aiming at evaluation of traffic noise influence on myocardial infarction risk. The most suitable research methods must be chosen in order scientifically proven measures for risk decrease would be proposed.

In this research environmental epidemiological study was used to determine traffic noise effect on people's health. Transport noise modeling using GIS was carried out in Kaunas city; personal exposure level to all participants of the study was rated and the relationship between noise exposure and myocardial infarction risk was established.

Objective and goals of the research

The objective of this research is to assess road traffic noise in Kaunas city and to evaluate its influence on myocardial infarction risk. The research is based on the hypothesis that traffic noise can influence myocardial infarction incidence among men in the age group of 25-64.

For the fulfillment of the objective the following goals were set:

1. To assess traffic noise pollution in the districts of Kaunas city and to estimate changes of traffic noise in 2001-2006.
2. To estimate exposition by noise on population, using GIS.
3. To identify factors that may influence the relation between traffic noise and myocardial infarction risk.
4. To create and approve integration methods of noise exposure and health data for estimation of myocardial infarction risk changes in different noise exposure zones.
5. To assess the relationship between noise exposure and myocardial infarction risk.
6. To put forward proposals of life quality improvement associated with environmental noise.

Scientific innovation

In this research traffic noise effect on human health assessing individual exposure of living place and controlling influence of confounding factors was assessed for the first time in Lithuania. A lot of GIS functions were used in this research: address geocoding, spatial analysis and modeling, scientific visualization of analysis results. Noise modeling was performed using Mapnoise software, integrated environmental and health database was created. For the first time in Lithuania 24 hours and night time noise exposures in living place for myocardial infarction risk was assessed applying modeling for determination of individual exposition.

Methodology

It was used short-term single noise measurements data (2001-2002) for noise exposure assessment; noise dispersion data in three Kaunas districts (Dainava, Eiguliai, Šilainiai) were also modeled. Strategic noise map data of Kaunas municipality was used as well: noise measurements (2005-2006) and modeled noise dispersion data in Kaunas city (2005-2006). For noise level changes analysis in 1995-2005 noise level measurements data of ecological monitoring were used. Performed study plan is given in Figure 1.

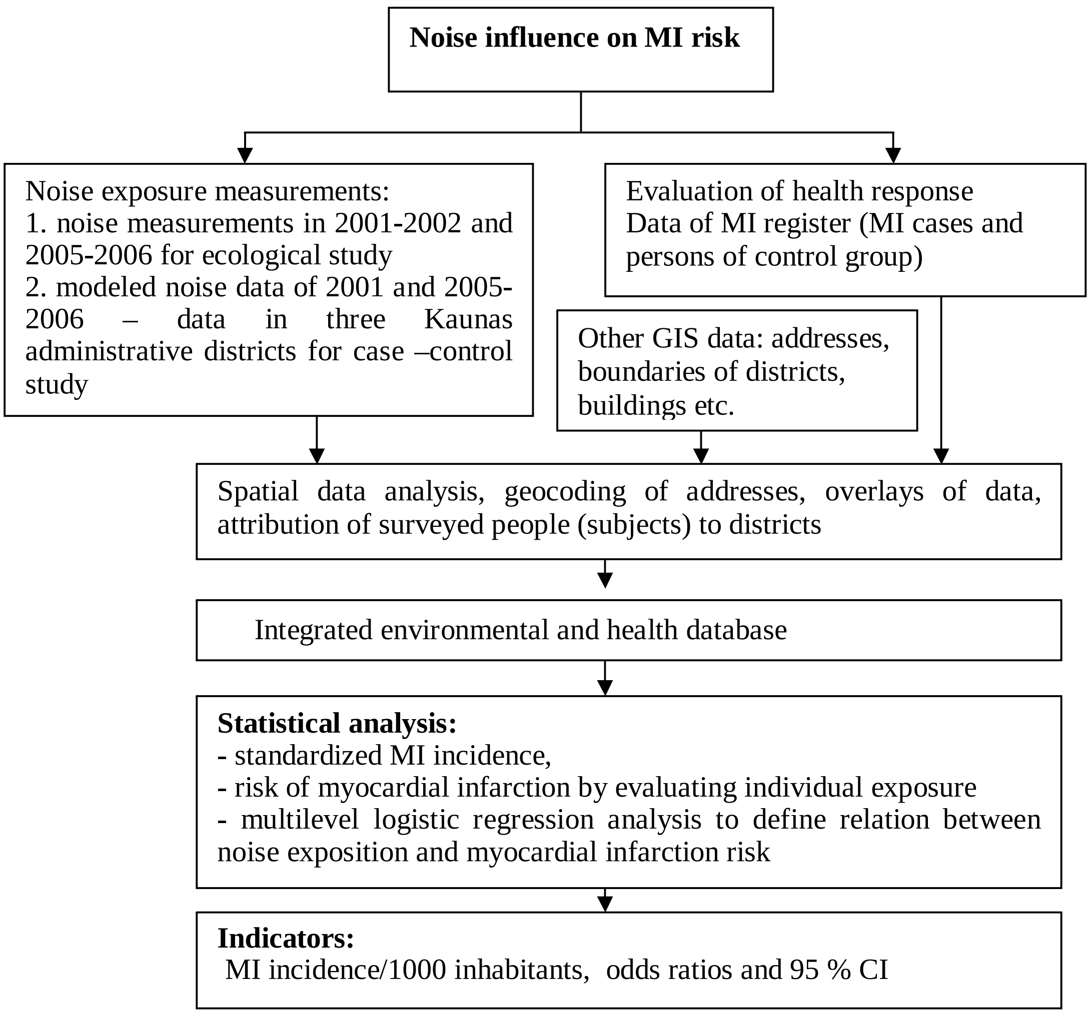


Figure1. Study plan of noise influence on myocardial infarction risk

Noise measurements were carried out together with scientists from Lithuanian University of Agriculture, using Bruel&Kjaer Precise Noise Meter type 2203 and noise level analyser type 4426. The purpose was to assess the average noise level measurements of 10 min. These measurements were taken in all main streets (continuous traffic flow during day-time) and many side streets (single-event traffic). All streets with measured noise level had been attributed to 10 districts and average noise levels in districts were calculated.

Noise measurements data of Kaunas strategic noise map in years 2005-2006 were used to distinguish different noise exposure zones for ecological study. Digital noise modeling database was used as a base for noise modeling in 2001.

Noise modeling was performed to assess analysis of noise exposure changes and to determine noise dispersion in the city in 2001. Three districts of Kaunas city (Dainava, Eiguliai and Šilainiai) were chosen for noise modeling, where the highest and the lowest average noise levels (according to noise measurements data) and the biggest number of MI cases occurred.

The following data for noise modeling was used: administrative units, topographical elements, intensity of traffic flows. Data on traffic flows and composition were taken from study "Traffic intensity estimated by means of automated traffic counters-classifiers in the streets of Kaunas city", performed by Transport and Road Research Institute in 2001. The study involves measurements of traffic intensity, composition of flows and driving speed.

Traffic flow data were prepared for noise modeling on the basis of GIS database of strategic noise map of Kaunas municipality. Traffic flows were recalculated and divided to six clusters that correspond to strategic noise map database on purpose to compare modeled noise changes from years 2001 to 2006. The same clusters were attributed to all streets of 3 districts, where differences of the values of traffic flows were not higher than 20 %. This was done preparing data for both – 24 hours period noise modeling and for night noise modeling, where reduced volumes of traffic flows were calculated.

Noise modeling was performed in laboratory of GIS education and science centre of Environmental Institute in Lithuanian University of Agriculture using MapNoise software, which was given by Hnit-Baltic company.

ArcGIS module Spatial Analyst was used for spatial interpolation to visualize received noise modeling results. Inverse distance weighting (IDW) algorithm was chosen to perform analysis. Spatial Analyst was also applied to create the maps of noise level differences and to evaluate noise level differences from 2001 to 2006. Logical schema of spatial analysis used in this research is given in Figure 2.

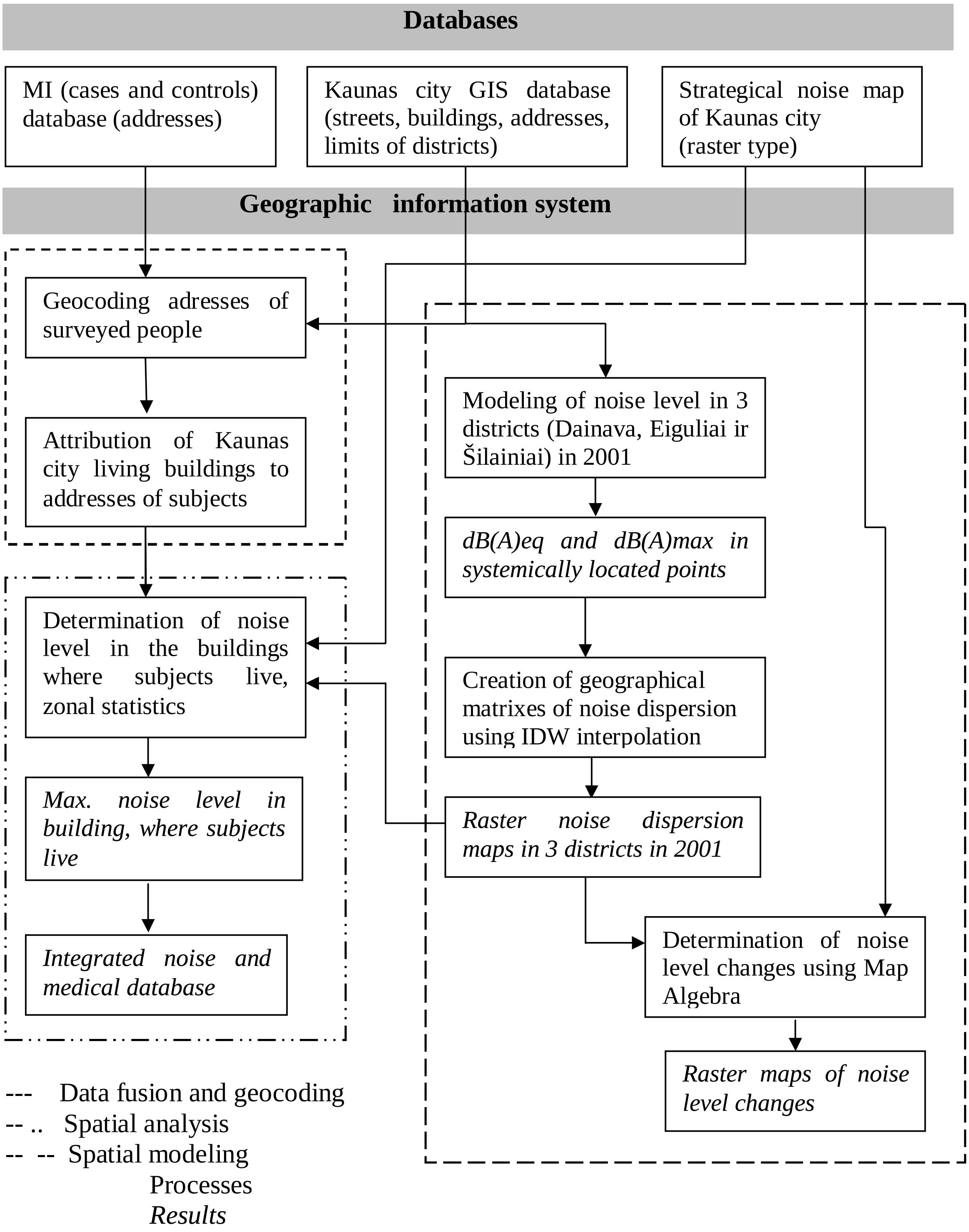


Figure 2. Logical schema of spatial analysis used in the research (dB(A)eq and dB(A)max – equivalent and maximal noise levels, results and processes are displayed and written in different type)

Integration of environmental and health databases

To attribute noise exposure size to every patient - case and control, health (MI) and environmental (noise) databases were joint, assigning appropriate noise level to every subject from used medical database by applying different GIS functions and possibilities (Figure 2). Firstly, geocoding of addresses was performed, i.e. address of every subject was linked with Kaunas addresses database. Geocoded MI cases and controls were joined with living buildings, according to their place of living while using spatial data join. Using overlay functions, buildings and noise disperrsion data, was determined noise level to every building there subjects lived. Hereby appropriate noise level was attributed to every subject. Zonal statistics was performed to determine average, minimum and maximum noise levels to each subjects‘ living house. Maximum noise level of buildings was used, for determining the nearest to the streets houses with high noise levels.

To attribute noise level to every subject the following methodology was chosen: for subjects, who were hospitalized in years 1999-2002 noise level modeled in 2001 in 3 districts of Kaunas was attributed; and for those subjects, hospitalized and added to medical database later – noise level modeled in 2005-2006 was assigned.

Modeling of number of residents in Kaunas in 2001 was performed aiming at figuring out which part of population lived in disturbing noise zones. This modeling was based on residents’ number in Kaunas city electoral districts, using such GIS information layers as living buildings and information of their height; layer of electoral districts with information about residents’ number and density was also applied. Surface of every building was calculated, assessing density of residents and number of residents in that house was modeled.

Traffic noise outcome evaluation

To evaluate outcome of traffic noise pollution on myocardial infarction risk, changes on incidence and risk in different level noise exposure zones were examined. In this research ecological and case-control studies were performed. Databases collected in the Laboratory of Environmental Epidemiology, Institute of Cardiology were used to calculate age-adjusted myocardial infarction incidence. The eligible myocardial infarction cases were persons with a clinical diagnoses coded I21 of the 10th review of the International Classification of Diseases in the hospital registry. All men surviving the first myocardial infarction between January 1, 1999 and December 31, 2004 were considered eligible for the ecological study. There were 994 registered myocardial infarction patients among 25-64-year-old men. Data of all these patients were used to calculate age-adjusted MI incidence rates for 1000 residents per year. To determine residents’ noise exposure in ecological study 10 Kaunas districts were classified to three noise exposure zones, according to calculated average day, night and 24 hours period noise levels. Changes of MI risk in three different level noise exposure zones were calculated.

In order to determine causal relationship between residents’ exposition with noise and incidence of MI, a case-control study was performed. Case-control study comprised all 25-64-year-old men from 3 Kaunas districts (Dainava, Eiguliai and Šilainiai), surviving the first myocardial infarction between January 1, 1999 and September 23, 2005. 1099 persons from control groups and 496 cases from 3 chosen districts were interviewed in their local hospital using standardized questionnaires, which included questions about psychosocial, socioeconomic, lifestyle and living environment factors. Control subjects were considered eligible if their cases met the requirements of age and the length of hospitalization; and if no clinical diagnosis of ischemic heard disease was recorded in their medical documents. In case-control study individual noise exposure of living place received from modeling dispersion of traffic noise level in the living district was assessed.

Statistical evaluation

To assess traffic noise influence on risk of MI, noise pollution was analyzed as exposure categorical variable. Noise pollution individual exposure categories – noise exposure zones were distinguished for 24 hours period and for night period:

Noise zones, for 24 hours period: 1) < 60 dB(A), 2) 60-65 dB, 3) > 65 dB(A)

Noise zones for night period: 1) < 50 dB(A), 2) 50-55 dB(A), 3) > 55 dB(A)

In 10 Kaunas districts noise pollution was distinguished to three noise zones according to average day, night and 24 hours period noise level in years 2005-2006 as well as according to measured average noise level in the districts in years 2001-2002. For attributing Centras and Vilijampole district, additional criterion - % of surface of 65 dB(A) in 24 hours period was evaluated. The first zone was used as the reference category (low exposure), second and third – respectively, medium and high exposure zones.

The effect of noise pollution on myocardial infarction risk was estimated in three stages:

1) Effect of noise pollution was roughly estimated, age-adjusted myocardial infarction incidence rate was calculated;
2) Effect of noise pollution, estimating individual exposure in living place (according to current address);
3) Effect of noise pollution was adjusted by including potential confounders into multivariate logistic regression model.

To detect potential confounding factors odds ratios (OR) were calculated. An odds ratio is the ratio of the odds of exposure among the cases and the odds of exposure among the controls. The confidence interval (CI) was based on 0,95 confidence level (P). The testing of statistical hypotheses was done at 0,05 significance level.

25-64 years old men age-standardized incidence of MI and rough relative risk of MI in different noise exposure zones were calculated. Odds ratios for potential confounding MI risk factors were also estimated. Multivariate logistic regression was used to evaluate effect of confounding factors while analyzing relationship between independent variable (noise) and dependent variable (myocardial infarction). Values of side independent factors were considered to be consistent and risk received as the result of noise pollution was determined. Multivariate regression analysis model comprised the factors, which occurrence was more frequent between subjects with MI than between control group subjects: age, arterial blood pressure, psychological status, body mass index, smoking, current living place, subjective noise annoyance at home and objective noise level.

SPSS version 13, OPEN-EPI version 2, EPI – INFO version 6 statistical analysis programs and Microsoft Office Excel 2003 were used. To create maps ArcGIS ArcMap standard GIS software and MapNoise software were used. For data analysis and modeling were used such ArcGIS modules as: Spatial Analyst, Geostatistical Analyst, also ArcINFO WorkStation, GIS tools for ecological analysis Hawths tools were applied.

Results

The results of noise measurements in 2001-2002 show that daytime road traffic noise levels ranged between 58 and 82 dB(A) (Table 1).

Table1.Average noise levels in the districts, according to measurements near main streets in rush hour

District	Average noise level, dB(A)	Standard deviation	95 % CI for mean	Min value, dB(A)	Max value, dB(A)
Aleksotas	68,8	4,55	63,2 - 74,5	64	75
Centras	75,0	7,00	70,3 – 79,7	60	82
Dainava	71,33	5,59	67,0 – 75,6	62	79
Eiguliai	71,71	4,35	67,7 – 75,7	66	79
Panemunė	68,00	1,41	55,3 – 80,7	67	69
Petrašiūnai	69,67	7,23	62,1 – 77,3	58	78
Šančiai	68,20	2,86	64,6 – 71,8	65	72
Šilainiai	66,57	6,73	60,4 – 72,8	58	74
Vilijampolė	72,50	4,65	65,1 – 79,9	66	77
Žaliakalnis	75,86	4,30	71,9 – 79,8	70	82
Kaunas city	71,35	6,03	69,8 - 72,9	58	82

The highest noise level was in the districts of Žaliakalnis (75,86 dB(A)) and Centras (75 dB(A)), the lowest noise level was in Šilainiai district (66,57 dB(A)).

In 2005-2006 noise measurement data (Kaunas municipality data) involved 3 periods: day, evening and night. 288 noise measurements were performed in each time period in the entire city. Factual noise measurement data, recalculated from primary noise measurements were used; the purpose was to receive statistically significant data according to short-time measurements results. 24 hours noise indicator was derived from day, evening and night noise indicators. Factual noise levels were used for day, night and 24 hours period. Statistical evaluation of 24 hours period noise levels is presented in Table 2. The highest average noise level in 24 hours period was in Eiguliai district (71,48 dB(A)) and the lowest – in Panemunė district (65,9 dB(A)).

Traffic noise modeling was performed in three Kaunas districts according to traffic flows data in 2001 for 24 hours period and night period. These districts were: Dainava, Eiguliai – with highest 24 hours exposition (according to measurements data) and Šilainiai – one of the lowest 24 hours exposition and the lowest exposition in 2001-2002. Figures 3 - 8 show the noise maps with modeled traffic noise levels in 24 hours and in night periods.

Table 2. Average 24 hours noise levels (dB(A))in the districts (according to Kaunas municipality data)

District	Average noise level, dB(A)	Standard deviation	95 % CI for mean	Min value, dB(A)	Max value, dB(A)
Aleksotas	68,56	4,52	67,0 – 70,1	57,59	74,77
Centras	66,96	4,76	65,8 – 68,2	56,16	76,09
Dainava	70,83	1,97	70,0 – 71,6	66,56	73,32
Eiguliai	71,48	2,51	70,1 – 72,8	66,80	75,77
Panemunė	65,9	3,91	64,2 – 67,6	57,34	73,34
Petrašiūnai	68,44	5,0	66,6 – 70,3	57,27	75,17
Šančiai	67,46	3,97	65,5 – 69,4	56,66	71,69
Šilainiai	67,65	5,26	65,2 – 70,1	55,49	75,57
Vilijampolė	68,13	5,28	66,0 – 70,2	56,50	75,22
Žaliakalnis	69,53	2,56	68,6 – 70,5	64,75	74,98
Kaunas city	68,28	4,46	67,8 - 68,8	55,49	76,09

Noise dispersion in 2001 showed that 55 dB(A) noise limit in 24 hours period was exceeded in all main streets of three districts, 70 dB(A) was exceeded in some main streets or some places in the main streets (Taikos pr., Tunelio and K.Baršausko streets, in some places of V.Krėvės, Draugystės streets). The highest noise - 75 dB(A) or higher was in ring type streets in Dainava district (Pramonės, Taikos and VI fort rings), in Eiguliai district – in Jonava street, and, especially, in Islandijos street. The highest noise in Šilainiai district was in Vakarinis lankstas and Islandijos pl., where 24 hours period's noise was higher than 75 dB(A). In the night period the maximum allowed noise level, according to Hygienic norm, was exceeded in almost all main streets, where 24 hours noise level was exceeded 70 dB(A) and 75 dB(A) (Figures 4,6 and 8).

To assess noise level exposure changes from 2001 to 2006 in 3 districts, spatial analysis was performed and maps of noise level differences were created. Results show that equivalent noise level increased from 2001 to 2006 approximately 0,5-3 dB(A), in some places – more than 3 dB(A). Noise level differences were evaluated in 24 hours period as well as in the night period. Higher noise level increase was found near the main streets to the first line of houses and lower in the yards of living houses. Night time noise level have increased more (0,5-4 dB(A) and more) than 24 hours noise since 2001 to 2006.

Modeling of residents' number in 3 districts in 2001 revealed that in 55 dB(A) and higher noise zone noise annoyance was experienced by 34% of residents from Dainava district, 20,5 % from Eiguliai and 12,6 % from Šilainiai district. 65 dB(A) and higher noise was experienced by 0,2 % Dainava, 0,025 % Eiguliai and 0,08 % Šilainiai districts residents. The biggest part of residents in Šilainiai (28,9 %) and Eiguliai (29,8 %) districts experienced 40-45 dB(A) noise, in Dainava district (24,9 %) – experienced 45-50 dB(A) noise. In 2005-2006 the majority number of residents (28,8 %) in Kaunas city lived in the noise zone of 50-55 dB(A). In Dainava and Eiguliai districts the biggest part of residents was affected by 50-55 dB(A) (28,8 % and 28,1 % respectively), and in Šilainiai (35,3 %) – by 45-50 dB(A) noise level.

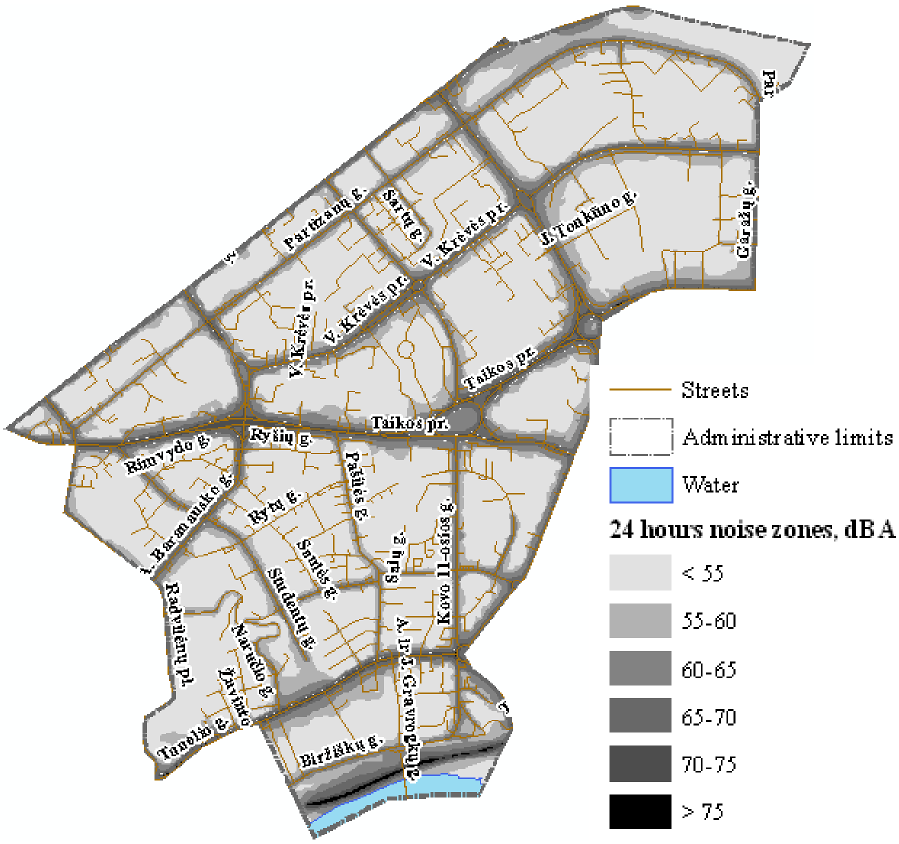


Figure 3. Noise dispersion map of 24 hours period in Dainava district in 2001

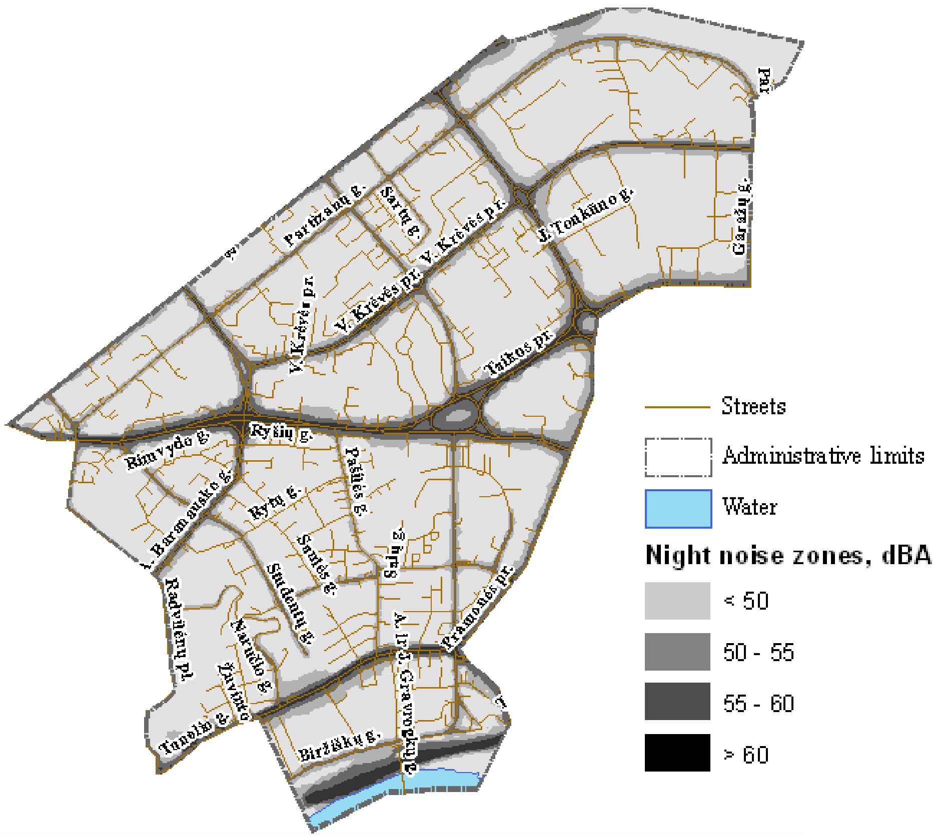
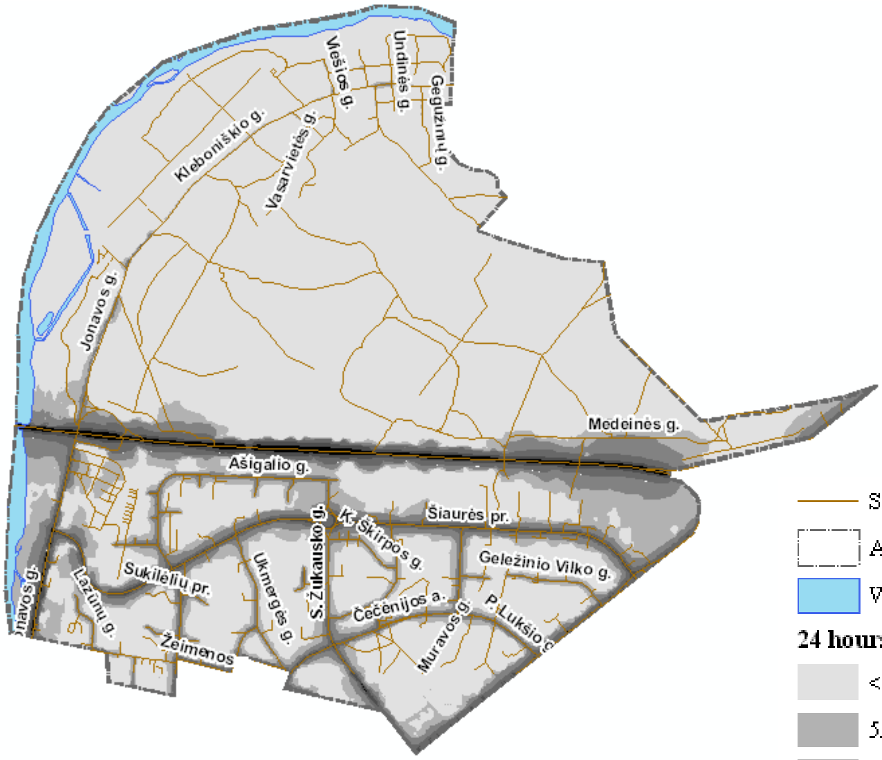


Figure 4. Noise dispersion map of night period in Dainava district in 2001



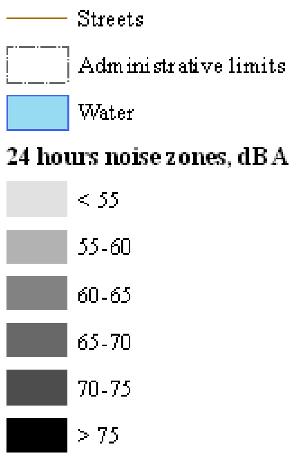
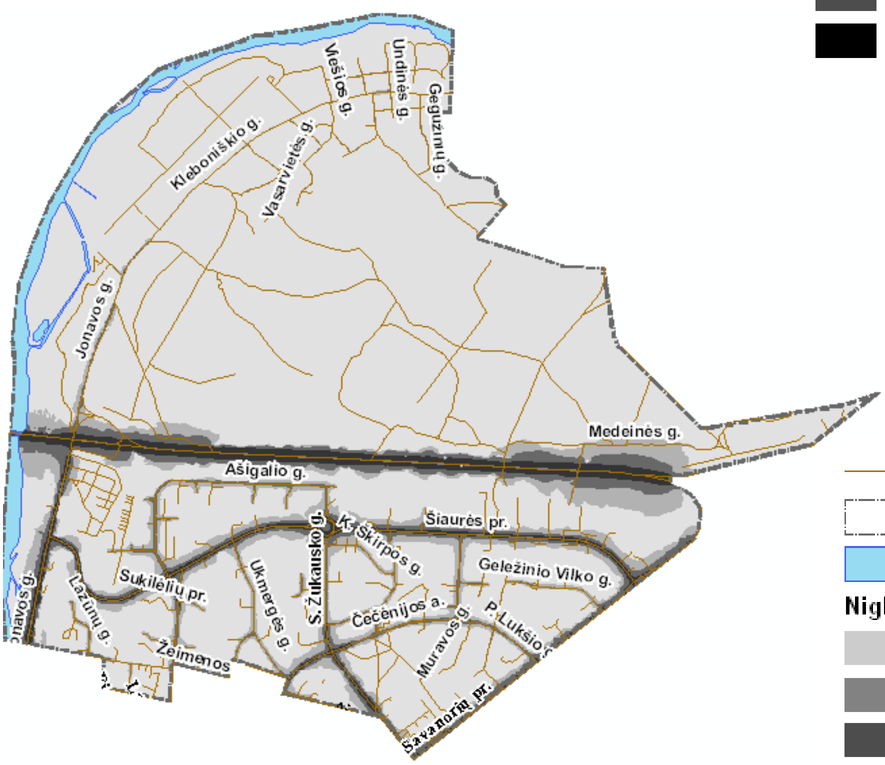


Figure 5. Noise dispersion map of 24 hours period in Eiguliai district in 2001



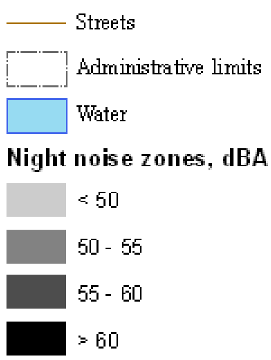


Figure 6. Noise dispersion map of night period in Eiguliai district in 2001

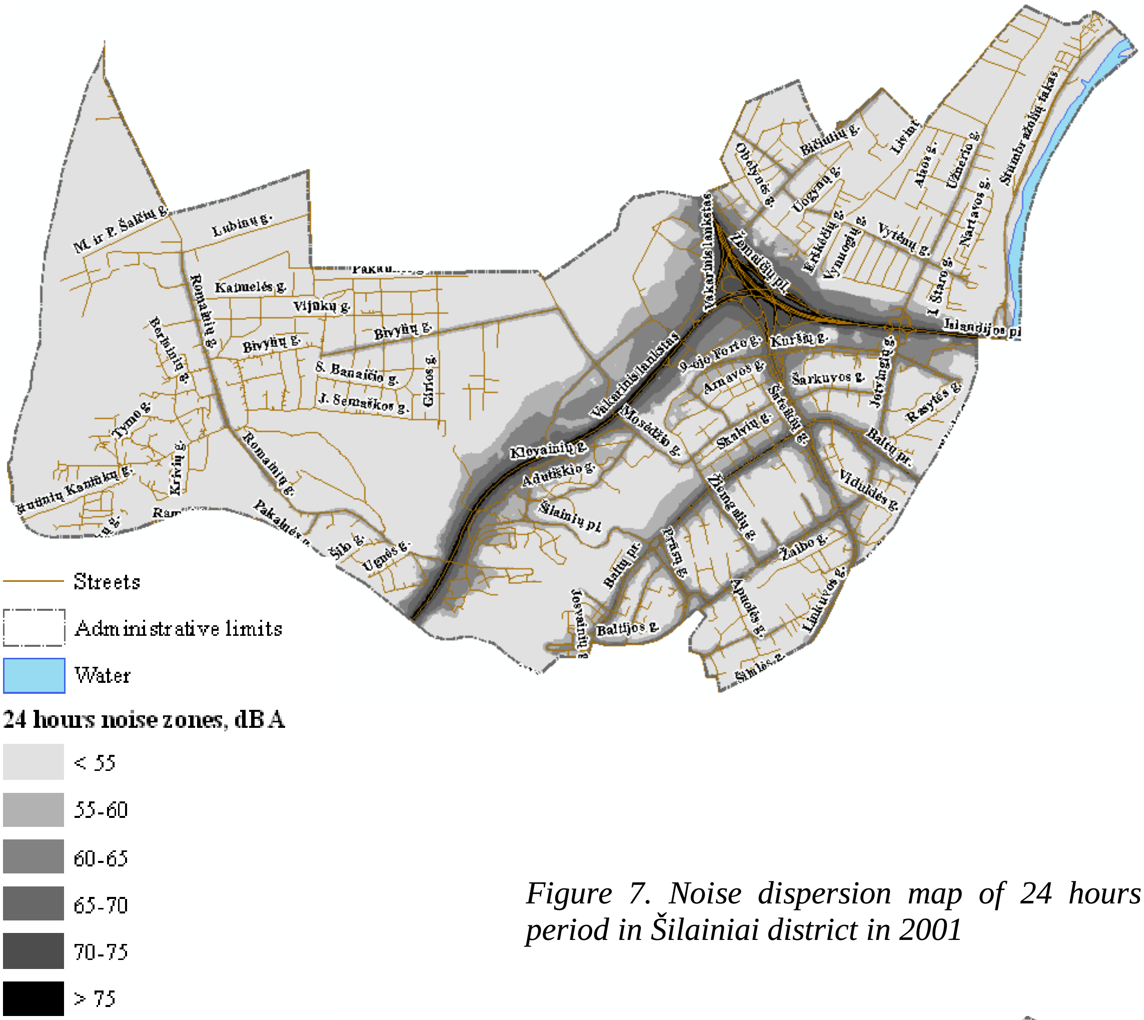


Figure 7. Noise dispersion map of 24 hours period in Šilainiai district in 2001

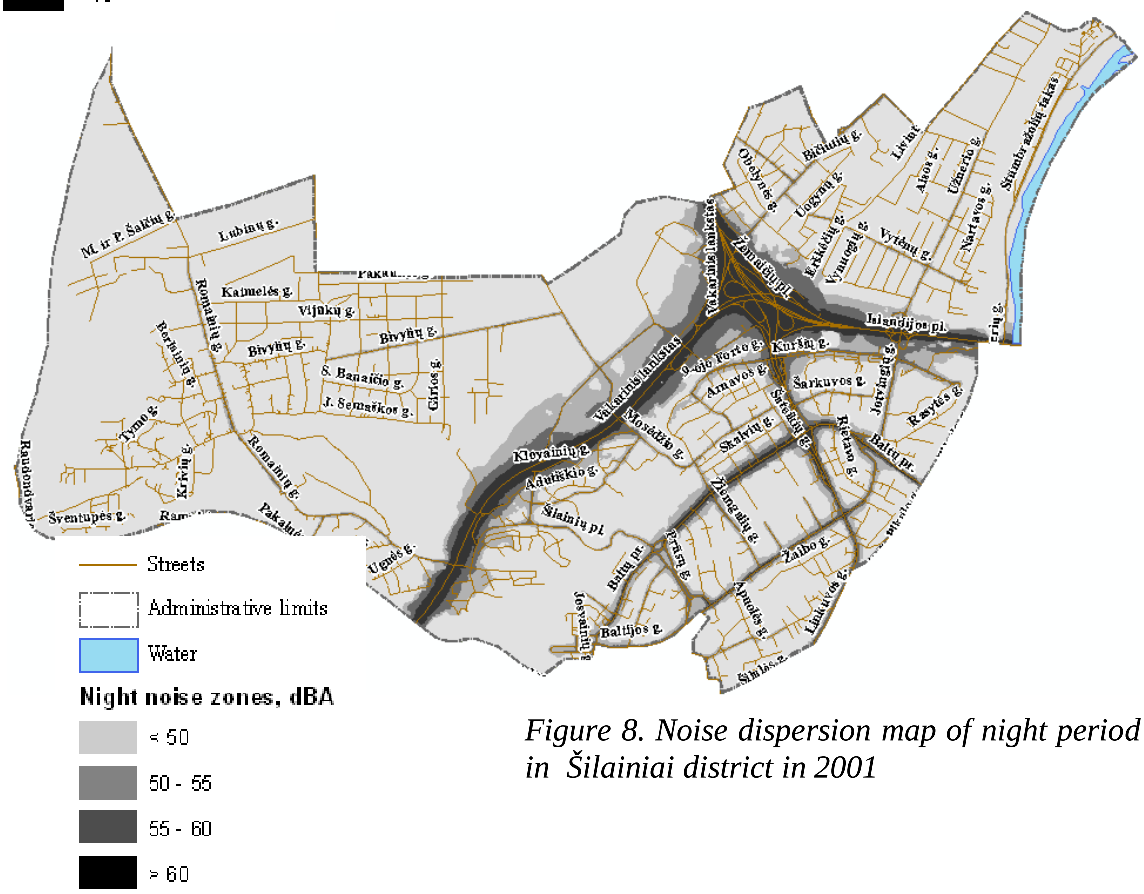


Figure 8. Noise dispersion map of night period in Šilainiai district in 2001

Analysis of changes of noise exposition near the streets and inside the living blocs in 10 years (in 1995-2005) was executed while using noise measurements data from Kaunas city ecological monitoring. The results revealed tendency of noise level increase near the main streets and inside the living blocs of Kaunas city. The measurements were taken in warm and cold periods. The tendency of higher noise level increase during the cold period near the streets was noticed. As there are no trees, noise is absorbed less.

Noise level increase is dependent on the increase of traffic flows in the period of 10 years(in 1995-2005). Results of analysis of correlation between number of individual motor vehicles (data from department of Statistics) and noise pollution (data from ecological monitoring) disclosed, that noise level is highly correlated with number of individual motor vehicles (correlation coefficient $r = 0{,}892$, $p=0{,}000$). Noise level increased along with increasing number of individual motor vehicles.

To assess individual exposure, geocoding of all addresses in Kaunas city was performed; the addresses of subjects were linked with Kaunas addresses database. The results received from geocoding are presented in Figure 9. Later, geocoded subjects were linked with their living houses using spatial GIS analysis. By applying GIS overlays functions, noise dispersion data and living buildings were joined to define noise level to every living house, where subjects from 3 districts of Kaunas lived. Using zonal statistics maximal noise level to every subject in his living place was received. Individual noise exposure in the living place for each subject was used for case-control-study.

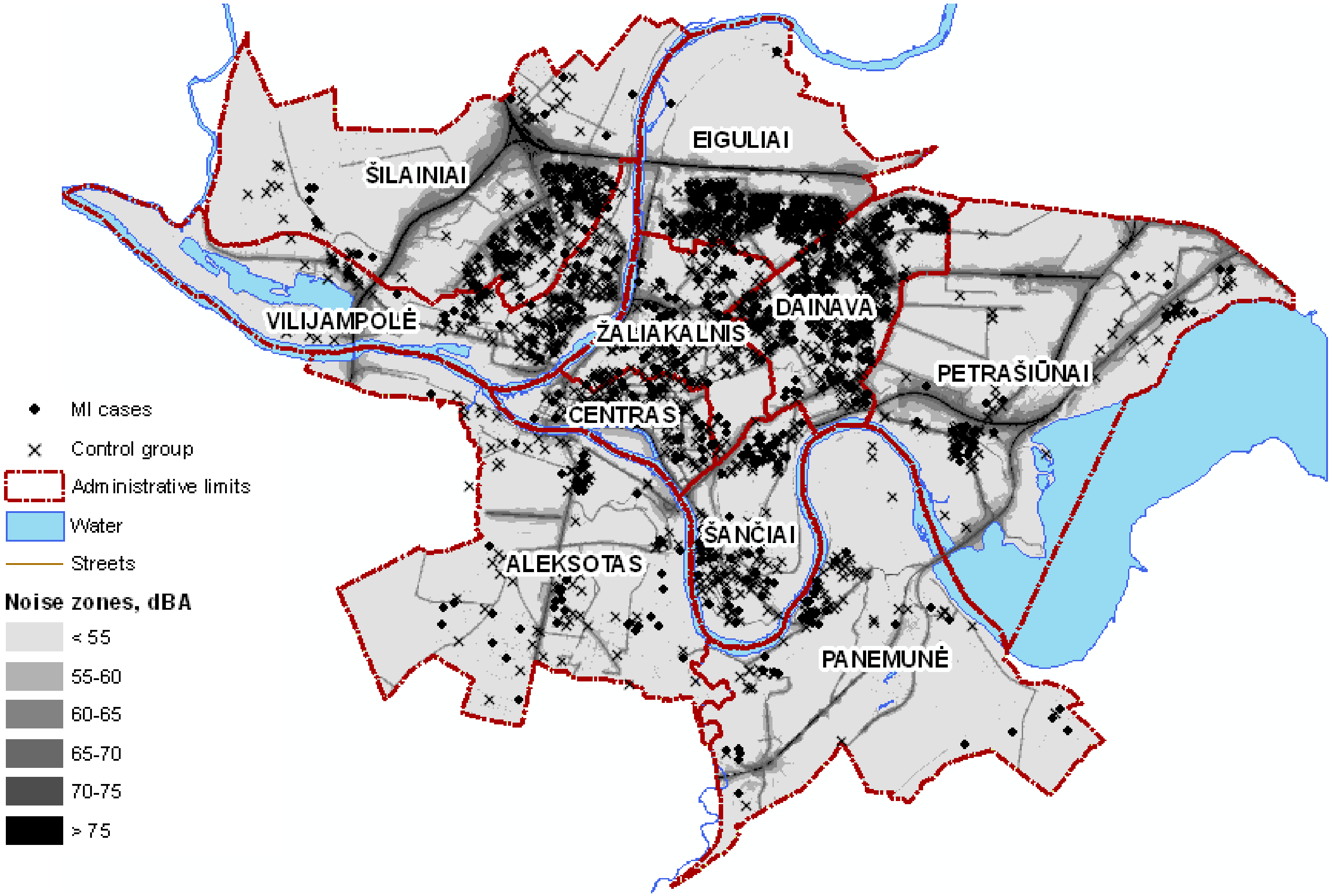


Figure 9. 24 hours period noise dispersion map (2005-2006) and distribution of MI cases and control group subjects in Kaunas districts

Evaluation of the relation between noise pollution and myocardial infarction risk based on ecological study

The relation between noise pollution and myocardial infarction incidence in three noise zones was established, when study object was population groups in the districts. Study units were districts of Kaunas city, 25-64 years old men and subjects, involved in register of myocardial infarction in 1999-2004.

Noise zones were classified according to factual noise level in districts during day, night and 24 hours period (measurements of 2005-2006) and under measured noise level near the main streets (in 2001-2002). Three areas of different exposure were determined. The districts with the highest exposure level clearly distinguished by all time periods in 2005-2006, the highest noise level was in the same districts: Dainava, Eiguliai and Žaliakalnis. To the second noise exposure zone – a medium exposure area – Aleksotas, Centras, Petrasiunai and Vilijampolė districts were attributed. The first exposure zone involved districts with lowest average noise levels: Panemunė, Šančiai and Šilainiai (Table 3). Centras and Vilijampolė districts had limit values, thus another criterion for attribution of these 2 districts was used: percentage (%) of the surface of noise zone exceeding 65 dB(A) in the district.

Table 3. Districts in three different exposure noise zones

Districts	Average noise level, day time, dB(A)	Average noise level, night time, dB(A)	Average noise in 24 hours period, dB(A)	Average noise in day time, dB(A) (2001-2002)
1 zone. Low exposure				
Panemunė	64,9	55,5	65,9	68,0
Šančiai	66,4	57,1	67,5	68,2
Šilainiai	66,6	57,3	67,7	66,6
2 zone. Medium exposure				
Centras	66,8	57,0	67,0	75,0
Vilijampolė	67,1	57,8	68,1	72,5
Petrašiūnai	67,4	57,9	68,4	69,7
Aleksotas	67,5	58,2	68,6	68,8
3 zone. High exposure				
Žaliakalnis	69,5	59,4	69,5	75,9
Dainava	69,9	60,3	70,8	71,3
Eiguliai	70,5	61,1	71,5	71,7

During the study period, 994 first time myocardial infarction cases among men aged 25-64 were registered. The age distribution of MI cases and risk population is presented in Table 4. Most of MI cases were in the third – high noise exposure zone, but it must be pointed out that almost double number of population lived in this zone. The age standardized incidence of myocardial infarction in three noise zones was assessed (Table 4). In the first zone of low noise exposure, the incidence of myocardial infarction was 1,97, it slightly increased in the medium noise exposure zone – 2,01/1000; and in the third noise exposure zone it increased to 2,16/1000 among 25-64-year-old men. The relative risk in the second noise zone was quite low and statistically insignificant – 1,04 (95 % PI 0,87 – 1,25); in the high noise exposure zone the relative risk increased to 23 % (95 % PI 1,05 – 1,43, χ^2=7,9; p<0,0005) in comparison with the first noise exposure zone. The results revealed that the higher noise exposure level was, the more frequent myocardial infarction incidences occurred.

Table 4. Distribution of 25-64-year-old men population and first-time cases of myocardial infarction (MI) across noise exposure zones

Noise exposure zones	MI	Population at risk	MI incidence		Relative risk	
			1000	95 % PI	RR	95 % PI
1. Low exposure	235	142224	1,97	1,71 – 2,23	1,00	
2. Medium exposure	218	126930	2,01	1,73 – 2,28	1,04	0,87 – 1,25
3.Hgh exposure	541	267024	2,16	1,98 – 2,35	1,23	1,05 – 1,43

To find out whether the effect of noise exposure increased with age, the age standardized myocardial infarction incidence in age groups of 25-64, 25-44, 45-54 and 55-64 among men was calculated. The results disclosed that myocardial infarction incidence between 25-64 year-old men in Kaunas city was 2,08 (95% PI 1,94-2,21). The myocardial infarction incidence increased along with increasing noise exposure level except age group of 44-54-year-old men (Figure 10). Impact of traffic noise pollution was major for 55-64 year-old men, with the highest number of myocardial infarction cases.

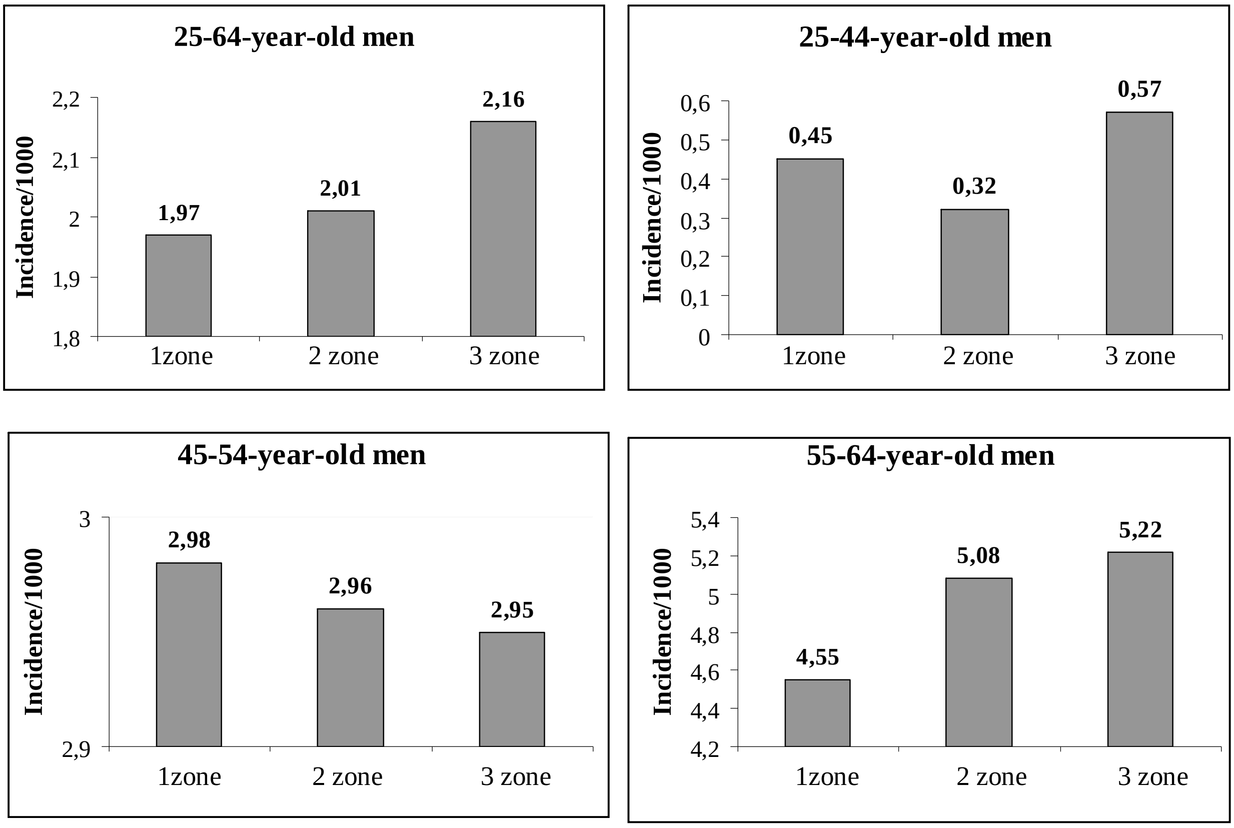


Figure 10. Traffic noise pollution zones and age standardized myocardial infarction incidence per 1000 residents in age groups

Evaluation of the relation between noise pollution and myocardial infarction risk based on case-control study

To define potential confounding factors to exposure of noise on myocardial infarction risk, analysis of individual data selected by questionnaires was performed. Case-control study comprised 496 men in age group of 25-64 as cases and 1099 – in control group, to whom data about confounding factors were selected.

To investigate whether the characteristics of the myocardial infarction cases and controls differed, the distribution of potential myocardial infarction risk factors in these two groups was compared.

Age, smoking, high blood pressure, body mass index, stress, place of living for more than 10 years and subjective noise annoyance increased myocardial infarction risk from 1,48 to 6,33 times among 25-64-year-old men.

To remove the effect of differences in the prevalence of independent variables, the crude odds ratios for the following identified predictors of first time myocardial infarction were adjusted: blood pressure, body mass index, psychological status, smoking, current living place for more than 10 years, subjective noise annoyance, estimated noise in 24 hours and in night periods. Multivariate logistic regression analysis for two age groups: 25-64 year-old men (Table 5) and 55-64 year-old men (Table 6) was performed.

Table 5. Crude and adjusted odds ratios (OR) for myocardial infarction among the men aged 25-64

Risk factors	25-64-year-old men					
	Crude		Adjusted		Adjusted	
	OR	95 % CI	OR*	95 % CI	OR**	95 % CI
Noise annoyance at home						
no						
yes	1,90	1,53-2,37	1,99	1,56-2,53	1,92	1,51-2,45
24 hours noise						
< 60 dB(A)						
60 – 65 dB(A)	0,83	0,64 - 1,09	0,71	0,53 – 0,96		
> 65 dB(A)	1,26	0,57 - 2,78	1,29	0,55 – 3,04		
Night noise						
< 50 dB(A)						
50 – 55 dB(A)	0,91	0,72 - 1,16			0,84	0,64–1,1
> 55 dB(A)	1,42	0,73 - 2,76			1,36	0,65–2,84

* - Odds ratios adjusted for blood pressure, body mass index, psychological status, smoking, current living place for more than 10 years, subjective noise annoyance, estimated noise in 24 hours period.

** - Odds ratios adjusted for blood pressure, body mass index, psychological status, smoking, current living place for more than 10 years, subjective noise annoyance, estimated noise in night period.

Effect of noise of 24 hours period and night period was evaluated separately and it was figured out that the results of multivariate logistic regression did not differ a lot. After adjustment in 25-64 year-old men group the myocardial risk increased with an increase of noise exposure level. Odds ratios for 24 hours period were found to be higher in the third noise exposure zone – in 24 hours period (OR 1,29; 95% CI 0,55 – 3,04) and in night period (OR 1,36; 95% CI 0,65–2,84). Noise annoyance at home, after adjustment, increased MI risk to two times (OR 1,99; 95% CI 1,56-2,53) for 24-64-year-old men group, and to 86% (OR=1,86; 95% PI 1,33-2,61) for 55-64-year-old men for 24 hours period.

Table 6. Crude and adjusted odds ratios (OR) for myocardial infarction among the men aged 55-64

Risk factors	55-64-year-old men					
	Crude		Adjusted		Adjusted	
	OR	95 % CI	OR*	95 % CI	OR**	95 %CI
Noise annoyance at home						
no						
yes	1,74	1,29-2,37	1,86	1,33-2,61	1,83	1,3-2,56
24 hours noise						
< 60 dB(A)						
60 – 65 dB(A)	0,83	0,57 - 1,21	0,71	0,47 – 1,08		
> 65 dB(A)	1,00	0,29 - 3,44	1,17	0,31 – 4,45		
Night noise						
< 50 dB(A)						
50 – 55 dB(A)	0,79	0,57 - 1,11			0,74	0,51–1,07
> 55 dB(A)	1,52	0,58 - 4,02			1,5	0,51–4,46

* - Odds ratios adjusted for blood pressure, body mass index, psychological status, smoking, current living place for more than 10 years, subjective noise annoyance, estimated noise in 24 hours period.
** - Odds ratios adjusted for blood pressure, body mass index, psychological status, smoking, current living place for more than 10 years, subjective noise annoyance, estimated noise in night period.

In 55-64 year-old men group the myocardial risk also increased with an increase of noise exposure level after adjustment. Odds ratios for 24 hours period were found to be higher in the third noise exposure zone in 24 hours period (OR 1,17, 95% CI 0, 31 – 4,45) and in night period (OR 1,5, 95% CI 0,51–4,46) as well. Adjusted results for both age groups are presented in Figure 11. The results showed that effect of 24 hours noise exposure has increased in both age groups after adjustment. However, these results are statistically insignificant. Received results could be influenced by small numbers of subjects in the case and control groups in the highest noise exposure category.

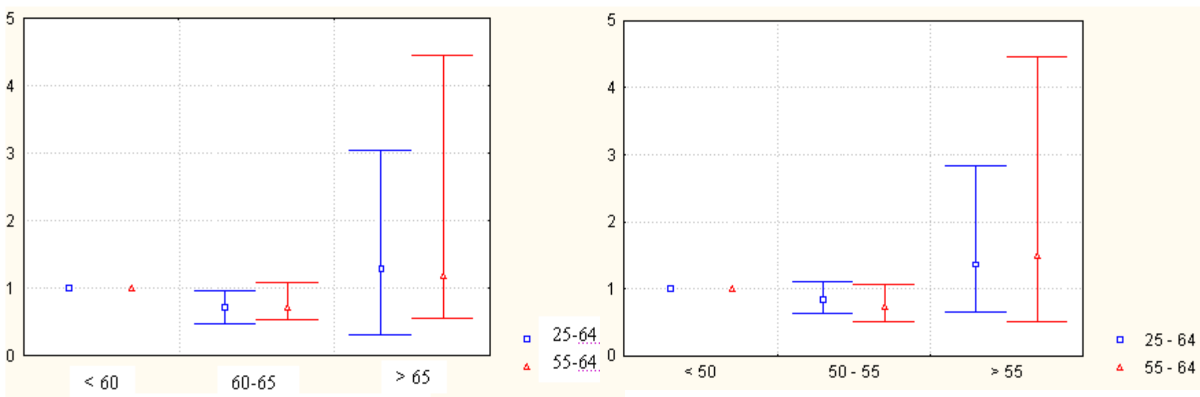


Figure 11. Adjusted odds ratios for myocardial infarction in 24 hours period and in night period in different exposure level noise zones in 25-64 and 55-64 year age groups

Conclusions

1. Results of noise dispersion modeling and spatial geographical analysis show that average equivalent noise level in 24 hours period has increased approximately 0,5-3 dB(A) and more in the districts of Kaunas city – Dainava, Eiguliai and Šilainiai since 2001 to 2006. In the night period noise level increase was higher (4 dB(A) and higher) than in 24 hours period. Higher increase of noise level was observed near the streets in comparison with the noise level inside the living blocs.
2. According to modeling results, in 2001 55 dB(A) and higher noise was experienced by 34 % of residents from Dainava district, 20,5 % from Eiguliai district and 12,6 % from Šilainiai district. The biggest part of residents in Šilainiai (28,9 %) and Eiguliai (29,8 %) districts experienced 40-45 dB(A) noise, in Dainava district (24,9 %) – experienced 45-50 dB(A) noise. In 2005-2006 the majority number of residents (28,8 %) in Kaunas city lived in the noise zone of 50-55 dB(A). In Dainava and Eiguliai districts the biggest part of residents was affected by 50-55 dB(A) (28,8 % and 28,1 % respectively), and in Šilainiai (35,3 %) – by 45-50 dB(A) noise level.
3. Noise level in Kaunas city in 2001-2002 during the rush hour near the main streets ranged from 58 dB(A) to 82 dB(A). In 2005-2006 the average equivalent noise level in day period was 67,5 dB(A), in night period – 60 dB(A), and in 24 hours period – 68,3 dB(A). The highest noise level was in Eiguliai district (71,5 dB(A)), and the lowest – in Panemunė district (65,9 dB(A)).
4. According to analysis data of ecological monitoring, determined strong relation between noise level and number of individual motor vehicles ($r = 0,892$, $p=0,000$) indicates influence of road traffic on the increase of noise level in Kaunas city.
5. Standardized myocardial infarction incidence for men in Kaunas has increased with increasing noise level. Relative risk for incidence of myocardial infarction in the medium exposure noise zone did not differ from first (low noise exposure) zone (1,04 (95 % CI 0,87 – 1,25); and in the high noise exposure zone the relative risk has increased statistically significantly to 23 % (95 % CI 1,05 – 1,43).
6. Among the men aged 25-64, standardized myocardial infarction incidence for 1000 residents was 2,08 (95 % CI 1,94-2,21). The rate of myocardial infarction incidence among the men aged 55-64 fluctuated from 4,55/1000 in the low noise exposure zone to 5,22/1000 in the high noise exposure zone.
7. Using GIS analysis functions (addresses geocoding, spatial analysis, spatial modeling), individual exposure by noise was determined. After adjustment, controlling blood pressure, body mass index, psychological status, smoking, time of living in the current place and subjective noise annoyance, estimated noise of individual living place in 24 hours period tended to increase myocardial infarction risk to 29 % (OR 1,29; 95% PI 0,55-3,04) in the highest noise exposure zone (> 65 dB(A)). Noise in night period (>55 dB(A)) tended to increase myocardial risk to 36 % (OR=1,36; 95% PI 0,65-2,84).
8. Subjective noise annoyance in the living place must be considered as important factor to MI incidence. 57,1 % of subjects have complained about noise. While controlling influence of confounding factors, subjective noise annoyance like tiring has increased MI risk to 2 times (OR=1,99; 1,56-2,53).
9. To improve life quality of biggest part of Kaunas population, traffic noise in 24 hours period has to be reduced to 50 dB(A).

List of publications

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1. Grazuleviciene R., Lekaviciute J., Mozgeris G., Merkevicius S., Deikus J. "Urban traffic noise and myocardial infarction risk", *The 6th international conference "Environmental engineering"*, ISI Proceedings, Selected papers. Vilnius Gediminas Technical University Press "Technika" ISBN 9986-05-858-9, 2005; p. 84-88.

2. Grazuleviciene R., Lekaviciute J., Mozgeris G., Merkevicius S., Deikus J. *Traffic noise emissions and myocardial infarction risk.* Polish Journal of Environmental Studies. 2004; 13(6), p. 737-741. ISSN 1230-1485.

3. Gražulevičienė R., Lekavičiūtė J., Mozgeris G., Merkevičius S. Traffic noise emission and myocardial infarction incidence in Kaunas city. Environmental research, engineering and management (Aplinkos tyrimai, inžinerija ir vadyba). 2003; 1(23). p. 70-75. ISSN 1392-1649. (in Lithuanian with sumarry in English).

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1. Lekaviciute J., Grazuleviciene R. Miesto transporto taršos įtaka miokardo infarkto rizikai. Žmogaus ir gamtos sauga. Tarptautinės mokslinės - praktinės konferencijos medžiaga. 2007 m. gegužės 16-19 d., Akademija, Kaunas. 2007; p. 252-254.

2. Grazuleviciene R., Lekaviciute J., Dulskiene V. The association between noise exposure and myocardial infarction risk. The IEA-EEF European Congress of Epidemiology 2006 „Epidemiology and Health Care Practice". June 28 – July 1, Utrecht, The Netherlands, *European Journal of Epidemiology.* 2006; Vol. 21. Suppl. p. 98.

3. Gražulevičienė R., Lekavičiūtė J. Autotransporto srautų keliamas triukšmas ir 55-64 metų vyų miokardo infarkto rizika. Žmogaus ir gamtos sauga. Respublikinės mokslinės konferencijos medžiaga. 2004 m. gegužės 20-22 d. Akademija, Kaunas. 2004; p. 186-188.

4. Lekavičiūtė J., Gražulevičienė R., Mozgeris G., Merkevičius S. Aplinkos triukšmas ir sergamumas miokardo infarktu Kaune. Žmogaus ir gamtos sauga. Respublikinės mokslinės konferencijos medžiaga. 2003 m. gegužės 22, 23 d. Akademija, Kaunas. 2003; p. 156-158.

Participation in seminars:

1. "Noise monitoring and noise mapping in cities and around airports", Brüel & Kjær Environmental Noise Seminar, March 21-22, Riga, Latvia. 2005.

2. Mozgeris G., Lekavičiūtė J. "GIS teaching for forestry and environmental science students at two universities in Kaunas, Lithuania" The 4-th European GIS education seminar "EUGISES" , 2-5 September,Villach, Austria, 2004.

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REZIUMĖ

1992 metais Rio de Žaneire surengtos Jungtinių Tautų konferencijos globaliame veiksmų plane Darbotvarkė 21 (UN, 1993) buvo apibūdintos prioritetinės su sveikata susijusios problemos. Tarp jų patenka ir aplinkos triukšmas: veiklos programoje numatyta sveikatos rizikos, susijusios su aplinka, sumažinimas, sveikatos problemų miestuose išaiškinimas ir jautrių visuomenės grupių apsauga (Schwenk, 2000). Veiksmų planai, skirti sumažinti kenksmingą triukšmo poveikį, yra išdėstyti Europos direktyvoje, skirtoje aplinkos triukšmo įvertinimui ir valdymui (Europos Parlamento ir Komisijos Direktyva 2002/49/EB, 2002) . Tačiau iki šiol kiekybiniai sveikatos rizikos, susijusios su triukšmu, vertinimo kriterijai dar nėra nustatyti, todėl jiems skiriamas prioritetinis dėmesys Europos Komisijos mokslo programose BP6 ir BP7.

Aplinkos taršai apibūdinti ir sklaidai modeliuoti pastaraisiais dešimtmečiais naudojamos geografinės informacinės sistemos (GIS). GIS vis dažniau naudojama aplinkos epidemiologiniuose tyrimuose. Dažniausiai GIS naudojama atliekant tyrimuose dalyvaujančių asmenų adresų geokodavimą, teršalų iš taršos šaltinio sklaidos modeliavimą ir aplinkos monitoringo duomenų integravimą į sveikatos rizikos analizę. GIS naudojimas epidemiologiuose tyrimuose aplinkos taršos poveikiui nustatyti apima geoerdvinį mokslą, aplinkos mokslą ir epidemiologiją. GIS gali būti naudojamas nustatant ekspozicija – atsakas ryšį įvairuose etapuose. (Nuckols et al., 2004).

Mokslinių tyrimų duomenimis, triukšmas gali sukelti klausos sutrikimus, susierzinimą, hipertenziją, skatinti išeminės širdies ligos raidą (van Kempen et al., 2002; Babisch 2001; 2002; Schwela, 2000). Neigiamas triukšmo poveikis žmonių sveikatai buvo nustatytas 1960-aisiais metais, remiantis profesinės ekspozicijos pasekmėmis, tačiau triukšmo valdymo politika iki šiol nėra moksliškai pagrįsta dėl to, kad nėra nuoseklių epidemiologinių tyrimų populiacijos mastu. Didžiausia kliūtis yra individualios ekspozicijos nustatymo sunkumai atliekant aplinkos epidemiologinius tyrimus. Sprendimų priėmimas ir rizikos valdymas priklauso nuo kiekybinio sveikatos rizikos įvertinimo ir priežastinio ryšio nustatymo (Gražulevičienė, 2005). Kadangi dauguma rizikos veiksnių, tirtų sąrišyje su triukšmu, didina širdies ir kraujagyslių ligų riziką triukšmo veikiamiems asmenims, tad pagrindinis dėmesys triukšmo epidemiologijoje yra skiriamas labiausiai paplitusiai išeminei širdies ligai (IŠL). IŠL yra viena iš pagrindinių priešlaikinės mirties priežasčių ekonomiškai išsivysčiusiose šalyse ir Lietuvoje (Doll, 1992; WHO, 1999; Domarkienė ir kt., 2003).

Ši liga dažniausiai pakerta vidutinio amžiaus asmenis, todėl skiriamas didelis dėmesys ligos priežastims išaiškinti ir paieškai rizikos veiksnių, skatinančių ligos atsiradimą ir progresavimą. Pastaruoju metu ypatingas dėmesys skiriamas kenksmingiems aplinkos veiksniams išaiškinti bei ištirti galimybes juos kontroliuoti. Visapusiškas situacijos įvertinimas leidžia teigti, kad prevencijos priemonės, taikomos kai kuriose Europos šalyse, gali penkeriais metais pailginti sveiko žmogaus gyvenimo trukmę (WHO, 2000b). Dėl tos priežasties aplinkos triukšmo poveikio miokardo infarkto rizikai tyrimas yra aktualus tiek kuriant šiuolaikinę aplinkos stebėsenos sistemą Europos Sąjungoje, tiek ir siūlant sveikatos profilaktikos priemones.

Aplinkos triukšmo matavimai ir standartizuoti epidemiologiniai tyrimai sudaro galimybę nustatyti kokia dalis ligų populiacijoje gali kilti dėl triukšmo poveikio ir kaip kinta rizika, kai keičiasi vienas iš kelių įtakojančių veiksnių. Moksliškai įrodyta, kad nuolatinis triukšmas darbe padidina riziką susirgti išemine širdies liga bei miokardo infarktu, tačiau aplinkos triukšmo poveikio sveikatai skirtų tyrimų yra nedaug, jų rezultatai nevienareikšmiai, dažnai statistiškai nereikšmingi. Siekiant nustatyti transporto keliamo triukšmo įtaką miokardo infarkto rizikai, būtina kuo tiksliau nustatyti individualią ekspoziciją triukšmu ir turėti tinkamą duomenų apie naujai kylančius miokardo infarkto atvejus surinkimo sistemą. Ypač svarbu parinkti tinkamiausius tyrimo metodus siekiant pasiūlyti moksliškai pagrįstas priemones rizikai mažinti.

Šiame darbe, siekiant nustatyti transporto keliamo triukšmo poveikį gyventojų sveikatai, naudojome aplinkos epidemiologinį tyrimą. Tyrimo metu buvo atliktas transporto keliamo triukšmo Kauno mieste modeliavimas, naudojant GIS, kiekvienam tiriamajam asmeniui buvo priskirta atitinkama individuali ekspozicija ir buvo nustatytas ryšys tarp ekspozicijos triukšmu ir miokardo infarkto rizikos.

Darbo tikslas - nustatyti kelių transporto keliamą triukšmą Kauno mieste ir ištirti jo ryšį su miokardo infarkto rizika. Darbe tyrėme hipotezę, kad transporto keliamas triukšmas didina 25-64 metų amžiaus vyrų sergamumo miokardo infarktu riziką.

Pagrindiniai uždaviniai :

1. Nustatyti aplinkos taršą triukšmu Kauno miesto seniūnijose ir įvertinti triukšmo lygio kitimą 2001 – 2006 metais.
2. Įvertinti gyventojų ekspozicijos triukšmu dydį, naudojant GIS
3. Nustatyti veiksnius, galinčius turėti įtakos ryšiui tarp ekspozicijos triukšmu ir miokardo infarkto rizikos.
4. Sukurti ir aprobuoti metodus triukšmo ekspozicijai ir sveikatos duomenims integruoti, siekiant įvertinti miokardo infarkto rizikos kitimą skirtingose triukšmo zonose.
5. Nustatyti priklausomybę tarp ekspozicijos triukšmu ir miokardo infarkto rizikos.
6. Pateikti pasiūlymus gyvenimo kokybei, susijusiai su aplinkos triukšmu, gerinti.

IŠVADOS

1. Atlikto triukšmo sklaidos modeliavimo ir erdvinės geografinės analizės rezultatai rodo, kad vidutinis ekvivalentinis paros triukšmo lygis Kauno miesto Dainavos, Eigulių ir Šilainių senūnijose nuo 2001 metų iki 2006 metų vidutiniškai padidėjo 0,5 – 3 dB(A) ir daugiau. Nakties metu gautas didesnis triukšmo lygio padidėjimas nei paros metu – iki 4 dB(A) ir daugiau. Stebėtas didesnis triukšmo lygio padidėjimas prie gatvių nei gyvenamųjų kvartalų viduje.
2. Modeliavimo duomenimis, 55 dB(A) ir didesnį triukšmą 2001 metais Dainavos seniūnijoje patyrė 34 proc., Eigulių seniūnijoje – 20,5 proc., Šilainių seniūnijoje - 12,6 proc. gyventojų. Didžiausia gyventojų dalis Šilainių (28,9 proc.) ir Eigulių (29,8 proc.) seniūnijose patyrė 40-45 dB(A) triukšmą, o Dainavos seniūnijoje – 45-50 dB(A) triukšmą (24,9 proc. gyventojų). 2006 m. Kauno mieste daugiausia gyventojų gyveno 50-55 dB(A) zonoje (28,8 proc.). Dainavos ir Eigulių seniūnijose daugiausia gyventojų buvo veikiami 50-55 dB(A) (28,8 proc. ir 28,1 proc. atitinkamai), o Šilainiuose - 45-50 dB(A) (35,3 proc.) triukšmo lygio.
3. 2001-2002 metais Kauno mieste piko valandomis šalia pagrindinių gatvių triukšmo lygis svyravo nuo 58 dB(A) iki 82 dB(A). 2005-2006 metais vidutinis ekvivalentinis triukšmo lygis dienos metu buvo 67,5 dB(A), nakties metu – 60 dB(A), o visos paros laikotarpiu – 68,3 dB(A). Didžiausi paros triukšmo lygiai buvo Eigulių seniūnijoje (71,5 dB(A)), o mažiausi – Panemunės seniūnijoje (65,9 dB(A)).
4. Ekologinio monitoringo analizės duomenimis, nustatytas stiprus ryšys tarp triukšmo lygio ir automobilių skaičiaus ($r = 0,892$; $p=0,000$) rodo kelių transporto įtaką triukšmo lygio didėjimui Kauno mieste.
5. Didėjant triukšmo lygiui, didėjo Kauno miesto vyrų hospitalinis sergamumas pirmuoju miokardo infarktu. Santykinė rizika gyvenantiems vidutinio triukšmo poveikio zonoje, lyginant su mažo poveikio zona, iš esmės nesiskyrė (1,04; 95 proc. PI 0,86 – 1,25), o didelio poveikio zonoje rizika statistiškai reikšmingai padidėjo iki 23 proc. (1,23; 95 proc. PI 1,05 – 1,43).
6. Kaune 25-64 metų amžiaus vyrų standartizuotas sergamumas 1000 gyventojų buvo 2,08 (95 proc. PI 1,94-2,21). 55-64 metų vyrų sergamumo miokardo infarktu rodiklis kito nuo 4,55 1000-čiui gyventojų mažo poveikio triukšmo zonoje, iki 5,22 1000-čiui gyventojų didelio poveikio triukšmo zonoje.
7. Naudojant GIS analizės funkcijas (adresų geokodavimas, erdvinė analizė, erdvinis modeliavimas), buvo nustatyta individuali ekspozicija triukšmu. Daugiaveiksnės analizės duomenimis, kontroliuojant arterinį kraujospūdį, kūno masės indeksą, psichologinę būseną, rūkymą, gyvenimo trukmę esamu adresu bei subjektyvų triukšmo vertinimą namuose nustatyta, kad paros triukšmas didžiausios ekspozicijos zonoje (> 65 dB(A)) miokardo infarkto riziką 25-64 metų amžiaus vyrams turėjo tendenciją didinti iki 29 proc. (GS 1,29; 95 proc. PI 0,55-3,04), o nakties triukšmas (>55 dB(A)) - iki 36 proc. (GS=1,36; 95 proc. PI 0,65-2,84).
8. Subjektyvų triukšmo vertinimą gyvenamojoje vietoje reikia laikyti svarbiu veiksniu, turinčiu įtakos miokardo infarkto rizikai. Kaune 57,1 proc. tirtųjų skundėsi triukšmu. Kontroliuojant trukdančiųjų veiksnių įtaką, subjektyvus triukšmo vertinimas, kaip ‘varginantis’, iki 2 kartų padidino miokardo infarkto riziką (SGS=1,99; 95 proc. PI 1,56-2,53).
9. Norint pagerinti daugumos gyventojų gyvenimo kokybę, reikia mažinti miesto transporto paros triukšmo lygį iki 50 dB(A).