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Independent and combined interaction of fine particulate matter in atmospheric air and the frequency of acute myocardial infarction hospitalizations in Varna, Bulgaria

Research Article

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Abstract: Aim: To explore the relationship between atmospheric particulate matter concentrations and the frequency of acute myocardial infarction (AMI) hospitalizations. Materials and methods: The relationship between air quality and the frequency of AMI admissions at the Intensive Cardiologic Clinic of St. Marina University Hospital, Varna was determined in the period between October 2004 and December 2005. The samples were taken at four points of the Regional Inspectorate of Protection and Control of Public Health, Varna. Pollutants such as general and fine particulate matter with particle diameters up to 10 μg/m3 (FPM10), ozone, nitrogen oxide, dioxide and total general nitrogen oxides, and mean 24-hour values of meteorological parameters were monitored. Results: The independent influence of FPM10 on frequency of AMI hospitalizations is described using a linear regression model. In all combined methods, the standardized Beta coefficients are higher than that of isolated FPM action. In combination with the meteorological parameters model, the influence of FPM is increased, and air movement velocity is a protector. The combination of FPMs with the other pollutants-ozone, non-methane hydrocarbons, nitrogen dioxide, total hydrocarbons and carbon oxide is connected with the highest risk for AMI.

Keywords: *Fine particulate matter • Meteorological parameters • Acute myocardial infarction*

1. Introduction

A number of studies have revealed the relationship between early and late effects of atmospheric pollution in cities with high level of urbanization and an increased risk of cardio-vascular diseases [1-3]. Some Bulgarian researchers have indicated that hydrogen sulphide, lead and nitrogen oxide are cardiotoxic air pollutants [4,5].

Recent studies have focused on the concentration of carbon oxide, nitrogen oxides, sulphur dioxide, ozone, lead aerosols and particulate matter – inhalable and respirable fraction in the atmospheric air – as factors influencing hospital admissions and mortality from acute myocardial infarction (AMI) [1,6-8].

The number of studies on the cardiotoxic effect of arsenic and fine particulate matter (FPM) is increasing, although no available study is comparable to the

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Bulgarian studies. Further research on the influence of particulate matter in both an isolated and a combined model is necessary.

The aim of the present study is to investigate the possible relationship between atmospheric particulate matter concentration and the frequency of AMI by controlling environmental factors that determine different individual sensitivity (professional exposition, presence of risk factors such as sex, age, risky habits, accompanying chronic diseases, and heredity

2. Materials and methods

The relationship between air quality and the frequency of AMI hospitalizations between October 2004 and December 2005 was explored. We analyzed data from the Regional Inspectorate of Environment and Water (RIEW) and the Regional Inspectorate of Protection and Control of Public Health (RIPCPH) in Varna, for the mean daily values of atmospheric pollutants and data from the Intensive Cardiologic Clinic (ICC) of St Marina University Hospital in Varna, including newly registered patients for each day. Samples were taken at four stationary points in the city of Varna (three manually and one automatically) as part of an air quality monitoring system. The permanent monitoring points of RIEW are localized in the localities of “Ian Palach St.” (automatic analysis) and “Batac St.”, and those of RIPCPH are in the region of “Black Sea Hotel” and “Vladislav Varnenchik” quarter. The following atmospheric pollutants were monitored: general particulate matter and FPM with particle diameters up to 10 μg/m^3 (FPM$_{10}$), ozone, nitrogen oxide, dioxide and total general nitrogen oxides, sulphur dioxide, carbon oxide, lead, methane, non-methane and total hydrocarbons, ammonium and hydrogen sulphide. The mean 24-hour values of the meteorological parameters of the local air were determined: temperature, relative humidity, air movement velocity and direction, sun radiation, atmospheric pressure. In all, 5257 mean 24-hour samples were analyzed and grouped as follows: 506 (9.10%) samples for FPM, 529 (9.51%) for general particulate matter, 409 (7.36%) for ozone, 350 (6.29%) for nitrogen oxide, 1013 (18.22%) for nitrogen dioxide, 218 (3.92%) for total nitrogen oxides, 842 (15.14%) for sulphur dioxide, 83 (1.49%) for lead aerosols, 296 (5.32%) for carbon oxide, 59 (1.06) for methane hydrocarbons, 375 (6.74%) non methane hydrocarbons, 344 (6.19%) for total hydrocarbons, 251 (4.51%) for ammonia, 233 (4.19%) for hydrogen sulphide and 52 (0.94%) for benzol. The methods for gas analysis used are based on unified firm methods in the country. Only hospitalized citizens of the city of Varna were included in the analysis.

All statistical analysis was performed using SPSS version 17.0 k (SPSS Inc., Chicago, IL, USA). Data were presented as mean ± standard deviation (SD) or as the number of patients (as a percentage of the entire cohort). Because the distributions of continuous data were skewed, nonparametric methods were used for group comparison and correlation analyses. Differences between groups were analyzed with the independent samples T test or the Mann-Whitney U-test, where appropriate. We used linear regression analysis to predict the values of quantitative variables, and logistic regression analysis for quantitative assessment of the probability of developing of a disease (y) in relation to the exposure to the risk factor under examination (x). Independent risk factors were identified using the multivariate logistic regression analysis. A result was deemed statistically significant when $p < 0.05$.

3. Results

In the study period from 01.10.2004 to 31.12.2005, 591 patients were admitted at ICC and diagnosed with AMI; 397 (67.2%) men and 194 (32.8%) women (Table 1). Mean age was 63.93 ± 0.49 years (from 18 to 93 years). The mean age of the men was significantly lower than that of the women and was in the range of the work capability age for men according to normative basis of the Republic of Bulgaria.

3.1. Baseline characteristics of the analyzed pollutants in the study period

The baseline characteristics of the monitored atmospheric pollutants and the values of the meteorological parameters in the study period are presented in Table 2. The mean concentrations of FPM10 are within referent range. The values are higher at the “Batac St” point,

Table 1. Sex and age of AMI hospitalized patients in the period between 01.10.2004 and 31.12.2005.

Age	Number of patients	Lowest value	Highest value	Mean age	SD	Mann-Whitney Test	
						U	Sig.
Total number of cases	591	18	93	63,93	0,4846		
Women	194	35	93	67,77	0,8540	27186,5	0,000
Men	397	18	92	62,05	0,5657		

probably because of the more intense traffic in the central part of the city. In this part of the city, the maximal registered value of atmospheric respirable particulate matter exceeds two times the normatively determined safe values.

3.2. Influence of FPM_{10} on the AMI hospitalization frequency in the presence of conventional risk factors

The independent influence of FPM_{10} on AMI hospitalization frequency is best described by a linear regression model. The equation revealing the dependence of mean 24-hour frequency of AMI of mean 24-hour concentration of FPM_{10} is

$$Y = 0.888 + 0.01596 \times FPM_{10}\ (\mu g/m^3)$$

The influence of the atmospheric FPM_{10} concentrations on AMI hospitalization frequency of the citizens of Varna varies according to a combined interaction with meteorological parameters and with the other atmospheric pollutants. The highest regression coefficients are determined by the combined action with the meteorological parameters; FPM and air movement velocity yield statistically significant regression coefficients.

In other controlled air pollutants, the effect of FPM pollution on the frequency of AMI is influenced by ozone, nitrogen oxide, carbon oxide, non-methane and total hydrocarbons, together and separately (Figure 1). In all combined models, the standardized coefficient Beta, which describes the regression correlation, is higher than that of the independent action of FPM on AMI hospitalizations. In the model that accounts for meteorological parameters, the power of FPM is increased

Table 2. Characteristics of the atmospheric pollutants and the meteorological parameters in the study period (October 2004 - December 2005).

		Number of mean daily samples	Mean	SD	Minimum	Maximum	Percentiles				
							10th	25th	50th	75th	90th
1.Manual sample taking-"Black Sea" point	General particulate matter, $\mu g/m^3$	129	0,2513±0,023	0,266	0,02	1,89	0,02	0,08	0,19	0,335	0,52
	SO_2, $\mu g/m^3$	129	33,944±6,866	77,99	0,00	443	0,00	0,00	0,00	16,375	126
	NO_2, $\mu g/m^3$	129	29,015±3,399	38,6	0,00	308,25	5,5	12,25	19,75	31,375	64
2. Manual sample taking-"Vl.Varnenchik"	General dust $\mu g/m^3$	130	0,1013±0,0098	0,112	0,02	0,74	0,02	0,02	0,06	0,1225	0,229
	SO_2, $\mu g/m^3$	130	12,006±5,29	60,35	0,00	578	0,00	0,00	0,00	0,00	15,975
	NO_2, $\mu g/m^3$	130	12,9377±1,35	15,39	0,00	64	0,00	1,5	7,5	20,62	35,92
3. Manual sample taking-"Batac"point	General dust,$\mu g/m^3$	270	0,0998 ±0,003	0,0447	0,0070	0,3430	0,048	0,07	0,094	0,122	0,154
	PM_{10}, $\mu g/m^3$	268	55,7826 ±1,53	24,98	3,4	147	30,95	40,475	52,8	67,92	87,54
	SO_2, $\mu g/m^3$	306	15,1956 ±1,12	19,68	0	102,15	0	0	6,6	23,65	45,34
	NO_2, $\mu g/m^3$	306	7,759 ±0,596	10,43	0	58,15	0	0	2,675	14,45	23,45
	Pb	83	0,02 ±0,009	0,082	0	0	0	0	0	0	0,04
4. Automatic sample taking "Ian Palach" point	O_3, $\mu g/m^3$	409	38,4939 ±1,4	28,43	3,18	117,8	8,56	15,165	28,83	60,765	82,82
	NO, $\mu g/m^3$	350	18,80 ±0,99	18,85	0,03	111,7	3,361	6,132	13,44	21,97	47,93
	NO_2, $\mu g/m^3$	448	21,268 ±0,54	11,55	0,26	96,9	9,717	13,817	19	25,585	34,48
	NO_x, pm	218	24,7 ±0,989	14,6	0,52	94,04	12,52	15,98	20,54	28,22	42,64
	SO_2, $\mu g/m^3$	277	32,34 ±0,91	15,227	2,19	67,46	4,61	33,2	36,96	40,8	46,98
	CO, mg/m^3	296	1,014 ±0,03	0,587	0,13	4,1	0,46	0,64	0,9	1,27	1,53
	PM_{10} , $\mu g/m^3$	238	4,67 ±0,76	11,73	0,00	87,58	0,000	0,000	0,010	0,175	18,92
	NMHC, mg/m^3	375	1,0629 ±0,07	1,3	0	8,12	0,17	0,34	0,59	1,09	2,78
	CH_4, μg-C/m^3	59	1,4456 ±0,1	0,773	0,1	3,16	0,4	0,8	1,47	2,03	2,54
	THC, mg/m^3	344	4,15 ±0,055	1,01	0	8,6	3,43	3,86	4,05	4,475	5,22
	H_2S, mg/m^3	233	0,0028 ±0,00	0,0025	0,00	0,01	0,0002	0,0009	0,0017	0,0055	0,0069
	NH_3, mg/m^3	251	0,0252 ±0,00	0,014	0,00	0,09	0,0075	0,0117	0,0234	0,0354	0,0447
	Benzol, $\mu g/m^3$	52	1,3965 ±0,2	1,42	0,00	5,14	0,000	0,04	1,15	2,525	3,462
Meteorological parameters	Temperature, °C	457	12,179±0,37	7,943	-9	27,297	1,825	5,847	12,84	18,226	22,98
	Humidity, %	449	74,82±0,46	9,695	44,91	96	61,45	67,73	75,59	82,53	87,47
	Atmospheric pressure, mbar	457	1010,6±0,34	7,354	987,5	1032,72	1001	1006	1009	1015	1020
	Sun radiation,W/m	293	301,487±16,6	284,4	20,52	713,7	57,52	78,5	99,33	661,98	695,34
	Velocity of air movement, m/s	457	1,718±0,025	0,536	0,73	4,62	1,178	1,347	1,615	1,953	2,328

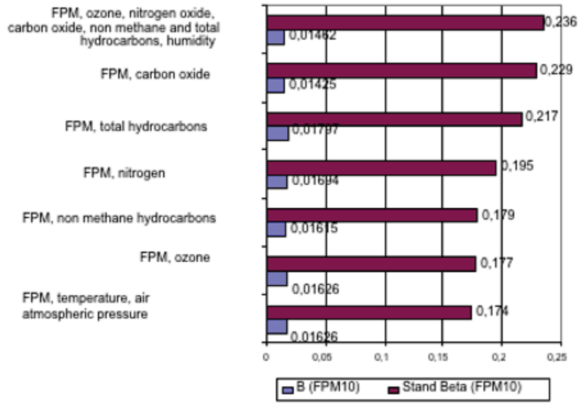


Figure 1. Regression coefficients of the linear correlation between AMI frequency hospitalizations in the citizens of Varna and fine particulate matter concentration at the point of "Ian Palach St." (mean 24-hour values) in different models of combined action.

(B 0.01626 Beta 0.174 p<0.01) and the air movement velocity shows protective action (B -0.2323 Beta -0.127 p<0.047). Analysis of the combined action of FPM with the other atmospheric pollutants increases the significance of the particulate matter pollution in the following gradation: ozone (Beta 0.177 p<0.01), non-methane hydrocarbons (Beta 0.179 p<0.01), nitrogen dioxide (Beta 0.195 p<0.01), total hydrocarbons (Beta 0.217 p<0.01), and carbon oxide (Beta 0.229 p<0.01).

In a multivariate AMI prognostic model including ozone, nitrogen dioxide, carbon oxide, non-methane and total hydrocarbons, relative humidity and air movement velocity, FPM_{10} has the greatest effect (Beta 0.236 p<0,01).

The correlation between particulate matter atmospheric pollution and the frequency of AMI hospitalizations is influenced not only by its interaction with meteorological parameters and with the atmospheric pollutants, but also by individual sensitivity of the person exposed. We determined different regression coefficients according to the age- and sex-related characteristics of the patients with AMI, the presence of conventional risk factors (hypertension, diabetes, hypercholesterolemia, overweight, smoking) (Table 3), and also according to the characteristics of the work environment (Table 4).

We found the highest regression coefficients of the influence of atmospheric FPM concentration on AMI hospitalizations in men over 65 years old (B 0.011 Beta 0.247 p<0.001) (Figure 2). Another research group has also reported increased sensitivity of this population group [9]. Significant linear regression correlations were established not only in the AMI patients at retirement age, but also in the younger group of patients – those under 35 years (B 0.001 Beta 0.163 p<0.01). The correlation between FPM 10 concentrations and AMI hospitalizations is linear in nondiabetic patients (B 0.010 Beta 0,132 p<0.05), in pensioners with normal levels of cholesterol (B 0.006 Beta 0,170 p<0.01), triglycerides (B 0.007 Beta 0,156 p<0.01) and in smokers (B 0.00655 Beta 0.128 p<0.05).

The potential toxicity of ozone and sulfur dioxide in combination with particular matter exposure has also been an object of active research. The presence of these two pollutants is regarded to be an important determinant of the described correlations between the hospitalizations for respiratory and cardiac diseases in

Table 3. Regression coefficients of the linear correlation between the frequency of AMI hospitalizations in people with conventional risk factors, and FPM atmospheric concentration at the point of "Ian Palach St." (mean 24-hour values).

AMI hospitalizations in the presence of conventional risk factors		Unstandardized Coefficients		Stand Coeff. Beta	t	Sig.	95% CI	
		B	SE				Lower	Upper
Men over 65 years old in Varna	(Constant)	**0,250**	0,036		6,871	0,000	0,178	0,321
FPM automatic point	PM10_ug/m³	**0,011**	0,003	0,247	3,913	0,000	0,006	0,017
Participants with normal cholesterol over 65 years old from Varna	(Constant)	**0,149**	0,028		5,366	0,000	0,094	0,204
FPM automatic point	PM10_ug/m³	**0,006**	0,002	0,170	2,642	0,009	0,001	0,10
People< 35 years old from Varna	(Constant)	**0,002**	0,006		0,392	0,695	-0,010	0,015
FPM automatic point	PM10_ug/m³	**0,001**	0,001	0,163	2,534	0,012	0,000	0,002
People with normal triglycerides over 65 years from Varna	(Constant)	**0,241**	0,036		6,637	0,000	0,169	0,312
FPM automatic point	PM10_ug/m³	**0,007**	0,003	0,156	2,424	0,016	0,001	0,013
People between 65-75 years old from Varna	(Constant)	**0,307**	0,043		7,214	0,000	0,223	0,391
FPM automatic point	PM10_ug/m³	**0,007**	0,003	0,136	2,113	0,036	0,000	0,014
People without diabetes from Varna	(Constant)	**0,585**	0,060		9,748	0,000	0,467	0,703
FPM automatic point	PM10_ug/m³	**0,010**	0,005	0,132	2,047	0,042	0,000	0,019
Smokers	(Constant)	**0,259**	0,042		6,243	,000	0,177	0,341
FPM automatic point	PM10_ug/m³	**0,00655**	0,003	0,128	1,989	0,048	0,000	0,013

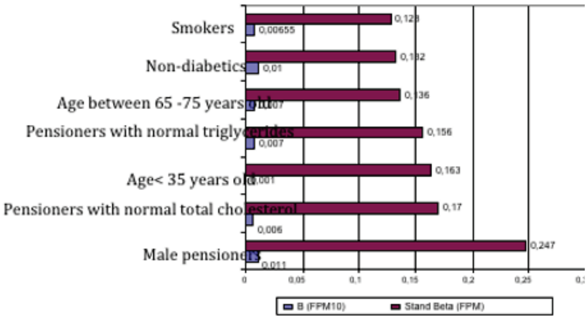
Table 4. Regression coefficients of the linear correlation between the frequency of AMI hospitalizations in people, working in hypokinetic state, and FPM concentrations at the point of "Ian Palach St." (mean 24-hours values) in different models of combined action.

AMI hospitalizations in people working in hypokinetic state		Unstandardized Coefficients		Stand. Coefficients	t	Sig.	95% CI B	
		B	SE	Beta			Lower	Upper
FPM automatic point	(Constant)	**0,897**	0,074		12,149	0,000	0,752	1,043
	PM10_ug/m^3	**0,01387**	0,006	0,152	2,368	0,019	0,002	0,025
FPM automatic point and humidity	(Constant)	**0,898**	0,076		11,807	0,000	0,748	1,048
	PM10_ug/m^3	**0,01398**	0,006	0,153	2,351	0,020	0,002	0,026
FPM automatic point and atmospheric pressure	(Constant)	**0,897**	0,074		12,149	0,000	0,752	1,043
	PM10_ug/m^3	**0,01387**	0,006	0,152	2,368	0,019	0,002	0,025
FPM automatic point and temperature	(Constant)	**0,897**	0,074		12,149	0,000	0,752	1,043
	PM10_ug/m^3	**0,01387**	0,006	0,152	2,368	0,019	0,002	0,025
FPM automatic point, temperature, humidity, air movement velocity, atmospheric pressure	(Constant)	**0,898**	0,076		11,807	0,000	0,748	1,048
	PM10_ug/m^3	**0,01398**	0,006	0,153	2,351	0,020	0,002	0,026
FPM automatic point and ozone	(Constant)	**0,892**	0,074		12,049	0,000	0,746	1,038
	PM10_ug/m^3	**0,01403**	0,006	0,154	2,394	0,017	0,002	0,026
FPM automatic point sulphur dioxide	(Constant)	**0,989**	0,095		10,364	0,000	0,800	1,177
	PM10_ug/m^3	**0,016**	0,008	0,160	2,017	0,045	0,000	0,032
FPM automatic point, nitrogen oxide and dioxide	(Constant)	**0,848**	0,097		8,706	0,000	0,655	1,041
	PM10_ug/m^3	**0,01675**	0,007	0,189	2,281	0,024	0,002	0,031
FPM automatic point and nitrogen oxide	(Constant)	**0,850**	0,097		8,810	0,000	0,660	1,041
	PM10_ug/m^3	**0,01667**	0,007	0,188	2,275	0,024	0,002	0,031
FPM automatic point and nitrogen dioxide	(Constant)	**0,989**	0,095		10,364	0,000	0,800	1,177
	PM10_ug/m^3	**0,016**	0,008	0,160	2,017	0,045	0,000	0,032
FPM automatic point and non-methane hydrocarbons	(Constant)	**0,883**	0,076		11,621	0,000	0,733	1,032
	PM10_ug/m^3	**0,01439**	0,006	0,160	2,431	0,016	0,003	0,026
FPM automatic point and total hydrocarbons	(Constant)	**0,849**	0,070		12,176	0,000	0,712	0,987
	PM10_ug/m^3	**0,01528**	0,005	0,181	2,799	0,006	0,005	0,026
FPM automatic point and non- methane and total hydrocarbons, nitrogen and sulfur dioxide and ozone	(Constant)	**0,917**	0,091		10,113	0,000	0,738	1,096
	PM10_ug/m^3	**0,01812**	0,007	0,202	2,484	0,017	0,004	0,033
FPM automatic point and non- methane and total hydrocarbons, nitrogen and sulfur dioxide, temperature, humidity , air movement velocity and atmospheric pressure	(Constant)	**0,921**	0,094		9,832	0,000	0,736	1,107
	PM10_ug/m^3	**0,01824**	0,007	0,204	2,461	0,015	0,004	0,033
FPM automatic point and nitrogen dioxide, ozone, temperature and humidity	(Constant)	**0,988**	0,099		9,993	0,000	0,792	1,183
	PM10_ug/m^3	**0,01629**	0,008	2,021	0,045	0,000	0,032	
FPM automatic point, nitrogen dioxide, temperature and humidity	(Constant)	**0,995**	0,098		10,115	0,000	0,801	1,190
	PM10_ug/m^3	**0,01607**	0,008	0,161	1,995	0,048	0,000	0,032

adults and children [11-12]. Experimental studies in rats and rabbits demonstrate complex results, more often with potentiating [13-15] rather than with antagonistic effects. A review of these studies reveals an increase of the frequency of hospitalizations ranging from 0.8% to 3.4% with the increase of FPM $_{10}$ pollution by 10 µg/m^3 [16,17].

Using logistic regression, we found that an increase in the atmospheric concentrations by FPM$_{10}$ by 1 µg/m^3 leads to a higher probability of AMI in people working in low activity occupations with 1.031 (1.002-1.061 p<0.035). The risk increases when humidity is added to the model. In days of increased pollution with respirable particular matter up to 1 µg/m^3, the risk of at least one AMI in persons in hypokinetic professional groups increases to 1.034 (1.004-1.064) (Table 5).

Figure 2. Regression coefficients of the linear correlation between the frequency of AMI hospitalizations in the presence of conventional risk factors, and the atmospheric FPM concentrations at the point of “Ian Palach St.”



By controlling for the concentrations of sulfur dioxide in the atmospheric air, the odds ratio for AMI in people working in hypokinesia is 1.069 (1.012-1.129) when increasing of FPM_{10} pollution by 1 μg/m³. Equalizing the ozone concentrations, the risk in the days with FPM_{10} pollution > 1 μg/m³ is 1.031(1.002-1.061) in comparison to the days with $FPM_{10} \leq 1$ μg/m³ or in comparison to the days with no increase of FPM_{10} concentrations (Table 6).

More abrupt changes in the increase of FPM_{10} atmospheric concentrations by ≥10 μg/m³, can increase the risk up to eight times. Controlled by the concentration of nitrogen oxide, the probability of AMI for at least one person in the hypokinetic group in the days with such dynamics of the PM pollution, is 8.328 (1.025-67.648) compared with other days (Table 7).

In the days with FPM_{10} concentrations between the 25th and 75th percentiles (from 0.01 μg/m³ to 18.92 μg/m³) the risk of AMI in people with professional hypokinesia is increased by up to three times: 2.909 (1.209-7.002) in comparison with the days with FPM_{10} concentrations below the 25th percentile (below 0.01 μg/m³).

Assessing the impact of FPM_{10} according to the season, we found an influence on AMI frequency only for the cold months (from November to February, inclusive) (Beta 0.162, p= 0.028 for the winter half-year, Beta 0.508, p<0.006 for February 2005; Beta 0.696, p= 0.017 for November 2004 and Beta 0.763, p<0.01 for November 2005).

The potential negative effect of episodes of high atmospheric pollution on health has been debated for more than 50 years [4]. In developed countries, cardiovascular diseases are a leading cause of death and are also related to high incidence of morbidity [18,19]. These countries have high levels of pollution. Since 1990, epidemiologic research has revealed the relationship between the level of atmospheric pollution and human health, as assessed by the level of hospitalizations

Table 5. Odds ratio for AMI in people working in hypokinetic state, according to the mean 24-hour value of FPM_{10} at the point of “Ian Palach St.” in an independent, combined with ozone and sulfur dioxide, and with relative humidity action.

Parameters		B	SE	Wald	Df	Sig.	**Exp(B)**	95% C.I. for Exp(B)	
								Lower	Upper
Hypokinesia (137/101)	FPM_{10}	0,031	0,015	4,439	1	0,035	**1,031**	1,002	1,061
Hypokinesia (130/100)	FPM_{10} controlled for relative humidity	0,033	0,015	5,000	1	0,025	**1,034**	1,004	1,064
Hypokinesia (130/100)	FPM_{10} controlled for relative humidity	0,000	0,000	4,883	1	0,027	**1,000**	1,000	1,001
Hypokinesia (93/64)	FPM_{10}, sulfur dioxide	0,067	0,028	5,638	1	0,018	**1,069**	1,012	1,129
Hypokinesia (136/101)	FPM_{10},ozone	0,031	0,015	4,520	1	0,034	**1,031**	1,002	1,061

Table 6. Odds ratio for AMI in people, working in hypokinetic state in the days with increased concentrations of $FPM_{10} \geq 10$ μg/m³ at the point of “Ian Palach St.”, by controlling the concentrations of nitrogen oxide.

		B	SE	Wald	Df	Sig.	Exp(B)	95% C.I. for Exp(B)	
								Lower	Upper
Hypoki-nesia (76/63)	FPM “Ian Palach St.” Increase by 10 μg/m³ controlled by the concentrations of nitrogen oxide	2,120	1,069	3,934	1	0,047	8,328	1,025	67,648

Table 7. Odds ratio for AMI in people working in a hypokinetic state in days with concentrations of FPM_{10} above 0.01 μg/m³ in comparison with the days with FPM10 below 0.01 μg/m³ at the measuring point of “Ian Palach St.”, by controlling the concentrations of nitrogen oxide.

		B	SE	Wald	Df	Sig.	Exp(B)	95% C.I. for Exp(B)	
								Lower	Upper
Hypokinesia (93/64)	Groups PM Auto 2/1, NO2	1,068	0,448	5,681	1	0,017	2,909	1,209	7,002

[5] and the mortality rate, including respiratory [2] and cardiovascular mortality [19]. However, the relationship between atmospheric pollution and short-term risk of AMI is still under discussion. Some studies have found a relationship [1,3,10], others do not [1,17]; in some cases, a relationship is shown only for some of the pollutants [7,8].

AMI can be triggered by several factors, among which atmospheric PM pollution has been considered [21]. However, the relative individual risk is lower than that of well-known risk factors such as physical exhaustion, caffeine, alcohol and cocaine consumption. The risk of PM pollution that is shown by our results is also significant on a population level.

4. Conclusion

Atmospheric PM exposure increases the risk of AMI. The level of risk depends on age- and sex-related differences and also varies according to a combined interaction with the other endogenous and exogenous risk factors. The combined influence of PM with the other physical and chemical risk factors in the work environment is also self-potentiating.

PM exposition and hypercholesterolemia interact to increase risk; the cumulative risk is greater than that of each of the factors taken individually. The odds ratio for AMI in the independent action of PM and varies in combination with lifestyle factors. The impact of the atmospheric FPM concentration on the frequency of AMI hospitalizations in the citizens of Varna varied through combined interaction with meteorological parameters and influence combined with other atmospheric pollutants.

The relationship between atmospheric PM pollution and the frequency of AMI hospitalizations is also influenced by the individual sensitivity of the exposed person, e.g., by the presence of conventional risk factors (hypertension, hypercholesterolemia, overweight, smoking) and the characteristics of the working environment.

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