

Supplementary Material

Air Pollutants and Their Impact on Chronic Diseases— A Retrospective Study in Bucharest, Romania

Beatrice Mahler ^{1,2}, Dragoș Băiceanu ^{1,*}, Traian Constantin Panciu ¹, Radu Marian Florea ², Ana Luiza Iorga ^{1,2},
Marcin Gnat ³, Cornelia Florina German ⁴, Simona Pârvu ^{2,5}, Dorel Paraschiv ⁶, Daniela Manea ⁷, Mihaela Mihai ^{7,*},
Elmira Ibraim ¹, Bogdan Timar ⁸ and Florin Dumitru Mihălțan ^{1,2}

¹ Marius Nasta Institute of Pneumology, 050159 Bucharest, Romania; beatricemahler@gmail.com (B.M.); panciu.traian@gmail.com (T.C.P.); analuiza_iorga@yahoo.com (A.L.I.); ielmira2000@yahoo.com (E.I.); mihaltan@starmets.ro (F.D.M.)

² Faculty of Medicine, Carol Davila University of Medicine and Pharmacy, 050474 Bucharest, Romania; radu.florea@stud.umfcd.ro (R.M.F.); simona.parvu@umfcd.ro (S.P.)

³ Airly Sp. z o.o., 31-545 Kraków, Poland; m.gnat@airly.org

⁴ The Federation for a Clean Environment, 77962 Chiajna, Romania; cornellia.german@gmail.com

⁵ The National Institute for Public Health, 050463 Bucharest, Romania

⁶ Faculty of International Business and Economics, The Bucharest University of Economic Studies, 010374 Bucharest, Romania; dorel.paraschiv@ase.ro

⁷ Faculty of Economic Cybernetics, Statistics and Informatics, The Bucharest University of Economic Studies, 010552 Bucharest, Romania; daniela.manea@csie.ase.ro

⁸ Faculty of Medicine, Victor Babes University of Medicine and Pharmacy, 300041 Timisoara, Romania; bogdan.timar@umft.ro

* Correspondence: dragos_baiceanu@yahoo.com (D.B.); mihaela.mihai@csie.ase.ro (M.M.)

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Section S1. Evolution of the Number of Sensors and DLV Exceedances in Bucharest during the Period 20.08.2018–01.06.2022

In 2018, for the period included in the analysis (the last 4 months of the year), 10 of the 11 active sensors with more than 50 records recorded exceedances of the DLV in a greater number of days than the maximum allowed (35 times/year) (Table S1).

Table S1. Daily records and number of exceedances of the DLV in Bucharest for 2018 (20.08.2018–31.12.2018).

Sensor ID	Total days of records	Number of days with exceedances	Percentage of days with exceedances in total records
5619	134	51	38%
5628	134	43	32%
5629	133	48	36%
5652	131	51	39%
5718	119	43	36%
6088	106	53	50%
5671	104	29	28%
6139	97	53	55%
9840	96	56	58%
6156	95	50	53%
6509	64	45	70%

In 2019, air quality monitoring in Bucharest was carried out, mainly by 17 sensors (with over 50 measurements/year), and the values for PM10 particles indicated exceedances more than 35 times/year in 10 of them (Table S2).

Table S2. Daily records and number of exceedances of the daily limit value in Bucharest for the year 2019.

Sensor ID	Total days of records	Number of days with exceedances	Percentage of days with exceedances in total records
5619	365	71	19%
5628	365	48	13%
5629	365	72	20%
5652	365	65	18%
6088	365	74	20%
6156	365	75	21%
6509	365	64	18%
6139	342	44	13%
7620	331	28	8%
9840	314	77	25%
7663	303	0	0%
8019	282	42	15%
5718	223	33	15%
8997	175	27	15%
9836	127	30	24%
10046	78	30	38%
87199	54	12	22%

Regarding the year 2020, from forty-eight sensors (with more than 50 measurements/year), about 40% of them having more than three hundred records, we identified thirty-five exceedances of the DLV only in six of them. (Table S3)

Table S3. Daily records and number of exceedances of the daily limit value in Bucharest for the year 2020.

Sensor ID	Total days of records	Number of days with exceedances	Percentage of days with exceedances in total records	Sensor ID	Total days of records	Number of days exceeded	Percentage of days with exceedances in total records
5629	366	43	12%	13214	261	25	10%
5652	366	36	10%	13215	261	10	4%
6088	366	34	9%	13206	259	19	7%
6156	366	37	10%	13253	240	6	3%
7620	366	15	4%	13254	238	15	6%
8019	366	55	15%	15659	198	20	10%
9836	366	34	9%	37982	196	12	6%
9840	366	33	9%	11888	188	7	4%
10046	366	31	8%	18391	185	9	5%
87199	366	23	6%	18392	185	14	8%
6509	365	24	7%	87043	185	4	2%
5619	359	48	13%	11894	176	2	1%
12082	342	20	6%	7663	175	0	0%
11981	341	19	6%	8997	155	27	17%
12083	340	9	3%	12073	153	2	1%
11947	338	37	11%	6139	146	26	18%
11727	334	14	4%	18435	140	0	0%
11734	334	26	8%	23888	92	7	8%
11725	333	26	8%	30455	92	18	20%
11980	323	18	6%	29508	91	0	0%
5628	319	18	6%	32893	64	10	16%
12098	298	27	9%	32894	64	13	20%
13118	289	6	2%	32909	60	9	15%
18797	269	22	8%	32992	53	18	34%

In 2021, 15 out of the 61 sensors (with more than 50 measurements/year), recorded more than 35 exceedances of the DLV (Table S4).

Table S4. Daily records and number of exceedances of the daily limit value in Bucharest for the year 2021.

Sensor ID	Total days of records	Number of days with exceedances	Percentage of days with exceedances in total records	Sensor ID	Total days of records	Number of days with exceedances	Percentage of days with exceedances in total records
5629	365	29	8%	8019	355	50	14%
5652	365	32	9%	29508	339	5	1%
6088	365	40	11%	87043	325	2	1%
6156	365	31	8%	87199	323	8	2%
6509	365	22	6%	13214	315	49	16%
9840	365	29	8%	39805	310	34	11%
10046	365	22	6%	5628	289	10	3%
11725	365	30	8%	9836	289	34	12%
11727	365	9	2%	37982	281	51	18%
11734	365	24	7%	33039	272	14	5%
11947	365	50	14%	40224	248	9	4%
11980	365	44	12%	18797	242	22	9%
11981	365	40	11%	42631	241	7	3%

12082	365	45	12%	6139	239	13	5%
12083	365	18	5%	9836	289	34	12%
12098	365	73	20%	37982	281	51	18%
13118	365	18	5%	33039	272	14	5%
13215	365	30	8%	40224	248	9	4%
13253	365	23	6%	18797	242	22	9%
13254	365	47	13%	42631	241	7	3%
15659	365	41	11%	6139	239	13	5%
18391	365	20	5%	41038	237	3	1%
18392	365	31	8%	32894	181	15	8%
32893	365	32	9%	40642	117	17	15%
32909	365	26	7%	39928	116	0	0%
32992	365	59	16%	40046	113	0	0%
36614	365	32	9%	40310	107	7	7%
36784	365	38	10%	86526	107	4	4%
37504	365	5	1%	42790	90	0	0%
11726	364	19	5%	30455	81	21	26%
11729	364	15	4%	7620	80	0	0%
13206	362	50	14%	23888	76	3	4%
37505	361	7	2%	7663	74	0	0%
11732	360	21	6%	86785	52	11	21%

In the case of 2022, since we did not have records for the entire year, the analysis could not be carried out by reporting to the daily limit value ($50 \mu\text{g}/\text{m}^3$) that must not be exceeded more than 35 times/year. The available data for the first 5 months of 2022 showed that for the sixty-eight sensors (for which there were more than fifty records), the average number of days with exceedances was approximately three, but this value is not representative because there was an increased heterogeneity of the data. Half of the sensors included in the analysis showed a number of days exceeding the daily limit greater than two. There were also outliers for nine sensors which registered a share between 9 to 13% of the days with exceedances. (Table S5, Table S6, Figure S1)

Table S5. Daily records and number of exceedances of the daily limit value in Bucharest for the year 2022 (01.01.2022-01.06.2022) at sensors with more than 50 measurements.

Sensor ID	Total days of records	Number of days with exceedances	Percentage of days with exceedances in total records	Sensor ID	Total days of records	Number of days with exceedances	Percentage of days with exceedances in total records
5629	152	2	1%	87056	152	0	0%
5652	152	1	1%	87199	152	0	0%
6088	152	2	1%	90093	152	2	1%
6156	152	3	2%	90105	152	9	6%
6509	152	0	0%	13254	151	3	2%
8019	152	7	5%	40224	151	20	13%
9840	152	2	1%	86883	150	2	1%
10046	152	1	1%	32992	149	5	3%
11725	152	13	9%	90230	149	2	1%
11726	152	10	7%	15659	147	3	2%
11727	152	4	3%	40642	145	3	2%
11729	152	9	6%	29508	144	0	0%
11732	152	11	7%	37505	139	0	0%
11734	152	9	6%	90336	139	2	1%

11947	152	7	5%	11980	132	2	2%
11981	152	4	3%	13206	129	3	2%
12082	152	3	2%	90553	120	3	3%
12083	152	0	0%	90558	119	3	3%
12098	152	11	7%	90604	113	0	0%
13118	152	0	0%	90606	113	4	4%
13215	152	2	1%	92165	112	0	0%
13253	152	0	0%	91985	107	0	0%
18391	152	0	0%	96190	107	3	3%
18392	152	2	1%	96223	106	1	1%
32893	152	1	1%	96251	105	0	0%
32909	152	1	1%	96344	101	1	1%
36614	152	0	0%	92353	88	0	0%
36784	152	3	2%	5628	85	0	0%
37504	152	0	0%	96895	79	10	13%
37982	152	3	2%	96355	76	8	11%
39805	152	4	3%	97009	72	1	1%
42631	152	0	0%	41038	71	2	3%
86785	152	3	2%	97387	59	0	0%
87043	152	1	1%	97620	50	0	0%

Table S6. Daily records and number of exceedances of the daily limit value in Bucharest for 2022—outliers list.

Sensor ID	Total days of records	Number of days with exceedances	Percentage of days with exceedances in total records
11725	152	13	9%
11726	152	10	7%
11729	152	9	6%
11732	152	11	7%
11734	152	9	6%
12098	152	11	7%
90105	152	9	6%
96895	79	10	13%
40224	151	20	13%

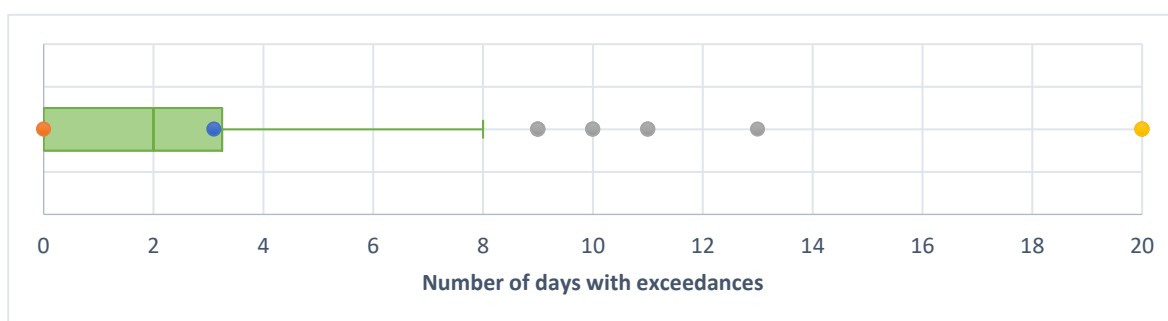


Figure S1. Box-plot diagram for the analysis of the distribution of days with exceedances from the year 2022.

Table S7. Monthly records (PM10) for the eight sensors.

Table S8. Synthesis for all sensors (PM10)—monthly average values for the eight sensors for days with DLV exceedances.

month/year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018										14.28	21.00	22.85
2019	25.71	16.85	6.50	1.85		1.00			1.00	13.37	7.12	19.37
2020	21.75	5.12	2.62	1.00						1.37	11.14	4.37
2021	9.42	7.85	6.28			1.00			1.00	11.50	10.25	2.37
2022	1.66	1.50	1.00									
	No records		min						max			

Table S9. Share of days with exceedances in total records (PM10) for the eight sensors (%).

Year Sensor	2018					2019												2020												2021												2022					
	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
5628	0	0	55	60	68	77	50	10	0	0	0	0	0	3	39	10	48	61	7	3	0	0	0	0	0	3	0	33			0	0	0	0	0	0	3	32	20	0	0	0	3				
5629	0	0	48	57	77	84	57	19	3	0	0	0	0	3	48	17	61	74	17	16	0	0	0	0	0	6	43	19	39	29	23	0	0	0	0	0	0	29	10	0	3	7	3	0	0	0	
5652	0	0	48	70	81	84	57	23	3	0	0	0	0	3	32	20	58	68	17	6	0	0	0	0	0	3	40	16	32	29	26	0	0	0	0	0	0	39	33	3	3	0	3	0	0	0	
6088		0	55	73	71	87	57	26	7	0	0	0	0	3	52	30	68	77	17	6	0	0	0	0	0	3	30	13	29	29	23	0	0	0	0	0	3	42	43	6	6	4	3	0	0	0	
6156		0	55	67	74	81	61	26	3	0	3	0	0	3	42	33	68	68	17	10	0	0	0	0	0	3	43	13	32	29	26	0	0	3	0	0	3	39	37	10	3	4	3	0	0	0	
6509			100	84	71	77	75	29	10	0	0	0	0	3	35	23	55	65	21	3	0	0	0	0	0	3	10	10	16	18	10	0	0	0	0	0	3	39	33	3	0	4	3	0	0	0	
8019							57	10	0	0	0	0	0	3	52	27	77	84	31	16	3	0	0	0	0	10	57	26	39	36	32	0	0	0	0	0	3	52	53	19	13	11	3	0	0	0	
9840		0	55	77	74	90	64	23	7	0	0	0	0	3	45	30	65	65	14	6	0	0	0	0	0	3	37	13	26	29	3	0	0	0	0	0	3	42	43	3	3	4	3	0	0	0	

No records

Exceedances of more than 50% are highlighted in yellow.

Table S10. Monthly records (PM2.5) for the eight sensors.

Year Sensor	2018					2019												2020												2021												2022					
	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
5628	12	30	31	30	31	31	28	31	30	31	30	31	31	30	31	30	31	31	29	31	30	31	30	31	31	30	31	11	3			14	30	31	30	31	31	30	31	30	31	27	28	30			
5629	11	30	31	30	31	31	28	31	30	31	30	31	31	30	31	30	31	31	29	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	1
5652	9	30	31	30	31	31	28	31	30	31	30	31	31	30	31	30	31	31	29	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	1
6088		14	31	30	31	31	28	31	30	31	30	31	31	30	31	30	31	31	29	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	1
6156		3	31	30	31	31	28	31	30	31	30	31	31	30	31	30	31	31	29	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	1
6509			2	31	31	31	28	31	30	31	30	31	31	30	31	30	31	31	29	31	29	31	30	31	31	30	31	30	31	31	28	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	1
8019							7	30	31	30	31	31	30	31	30	31	31	29	31	30	31	30	31	31	30	31	30	31	31	31	28	31	30	31	30	31	31	30	21	30	31	31	28	31	30	31	1
9840		4	31	30	31	31	28	31	28	29	19	9	17	30	31	30	31	31	29	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	1
Max	12	30	31	31	31	31	28	31	30	31	30	31	31	30	31	30	31	31	29	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	1

No records

Incomplete number of daily records per month

Table S11. Synthesis for all sensors (PM2.5)—monthly average values for the eight sensors for days with exceedances of the DLV.

month/year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018								6.33	12.2	22.14	28.71	30.42
2019	31	27	25	20.4	10.3	11.1	15.5	8.75	13.1	26.75	29.25	30.37
2020	30.12	20.87	20.1	11.1	1.57	3.87	1	1.33	1.87	16	23.87	23.62
2021	29.57	25.71	19.3	17.7	1	2.87	12.1	16.4	12.8	25.25	28.75	25
2022	23.62	20.62	25.8	10.4								
	No records			minmax								

Table S12. Share of days with exceedances in total records (PM2.5) for the eight sensors (%).

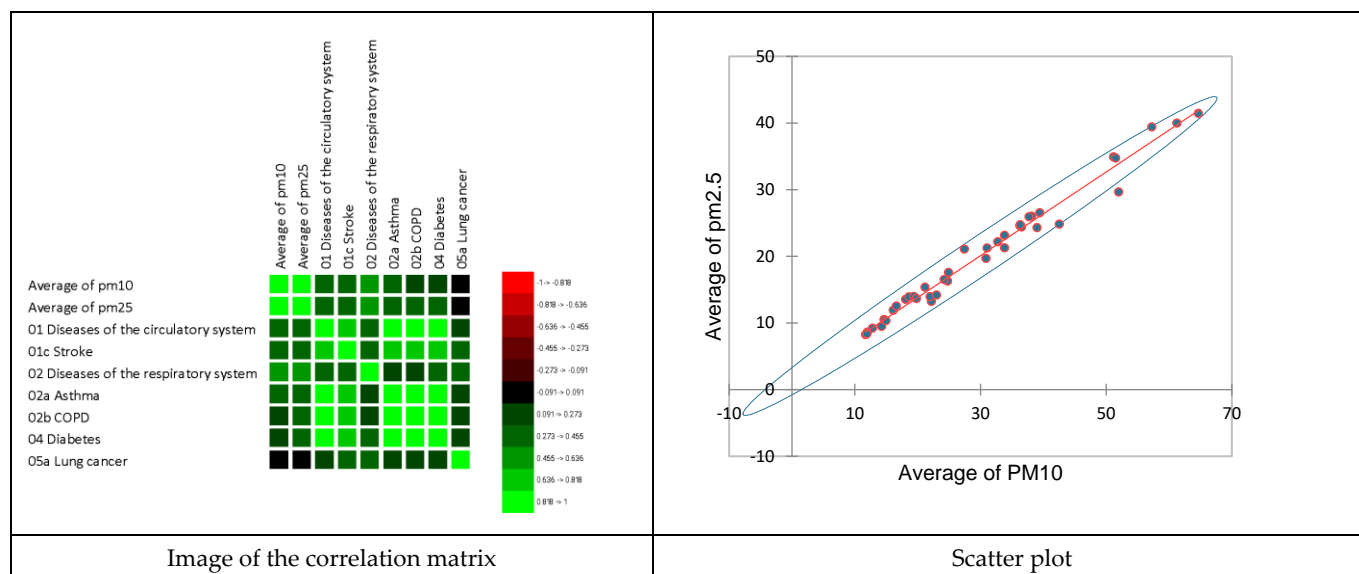
Year	2018					2019												2020												2021												2022						
	Sensor	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
5628	67	73	74	97	94	100	96	77	70	26	37	48	19	40	84	97	90	97	62	58	30	3	13	-	-	3	48	82	100			64	40	-	10	39	48	37	84	93	81	78	71	73				
5629	64	60	77	90	97	100	96	94	63	26	33	48	13	37	90	97	97	97	79	65	40	3	13	-	-	7	52	87	84	97	89	71	50	-	7	19	16	27	71	90	68	58	61	61	23	-	-	
5652	44	70	77	93	100	100	96	84	63	23	27	42	19	27	77	93	97	97	69	68	30	3	10	-	-	3	45	83	87	97	93	74	73	3	10	42	52	37	84	97	84	81	71	81	30	-	-	
6088		50	87	97	100	100	96	90	70	39	40	65	32	50	87	100	100	97	69	68	37	-	13	3	-	3	55	87	90	97	93	84	77	-	10	45	55	50	90	97	81	84	79	87	37	-	-	
6156		67	81	93	97	100	96	90	67	35	47	61	45	43	87	97	100	97	76	65	40	6	17	3	6	13	55	83	84	97	89	65	57	-	10	48	65	43	87	100	81	84	75	90	37	-	-	
6509			100	100	100	100	96	100	80	45	50	61	42	50	87	97	100	100	72	65	38	3	10	-	-	3	45	80	77	87	86	65	50	-	10	39	71	43	87	93	84	68	75	94	40	-	-	
8019								100	63	45	40	55	32	53	87	100	100	97	79	71	43	10	10	3	3	10	52	97	87	97	100	84	67	-	10	35	52	60	95	100	87	90	82	94	40	-	-	
9840		75	97	97	100	100	96	87	71	28	37	67	41	50	90	100	100	97	69	61	40	6	17	-	3	7	61	90	90	97	93	26	-	3	10	45	65	43	84	97	81	77	75	87	37	-	-	
		No records			Exceedances of more than 50% are highlighted in yellow																																											

Section S3. Correlation analysis between chronic pathologies and PM concentrations.

Table S13. *p*-values (Spearman).

Variables	Average of PM10	Average of PM2.5	Diseases of the cardiovascular system	Stroke	Diseases of the respiratory system	Asthma	COPD	Diabetes	Lung cancer
Average of PM10	0	<0.0001	0.036	0.018	0.001	0.069	0.090	0.118	0.670
Average of PM2.5	<0.0001	0	0.036	0.020	0.001	0.066	0.088	0.085	0.781
Diseases of the cardiovascular system	0.036	0.036	0	<0.0001	0.020	<0.0001	<0.0001	<0.0001	0.106
Stroke	0.018	0.020	<0.0001	0	0.006	<0.0001	<0.0001	<0.0001	0.060
Diseases of the respiratory system	0.001	0.001	0.020	0.006	0	0.166	0.221	0.019	0.031
Asthma	0.069	0.066	<0.0001	<0.0001	0.166	0	<0.0001	<0.0001	0.569
COPD	0.090	0.088	<0.0001	<0.0001	0.221	<0.0001	0	<0.0001	0.525
Diabetes	0.118	0.085	<0.0001	<0.0001	0.019	<0.0001	<0.0001	0	0.498
Lung cancer	0.670	0.781	0.106	0.060	0.031	0.569	0.525	0.498	0

Values in bold are different from 0 with a significance level $\alpha=0.05$.



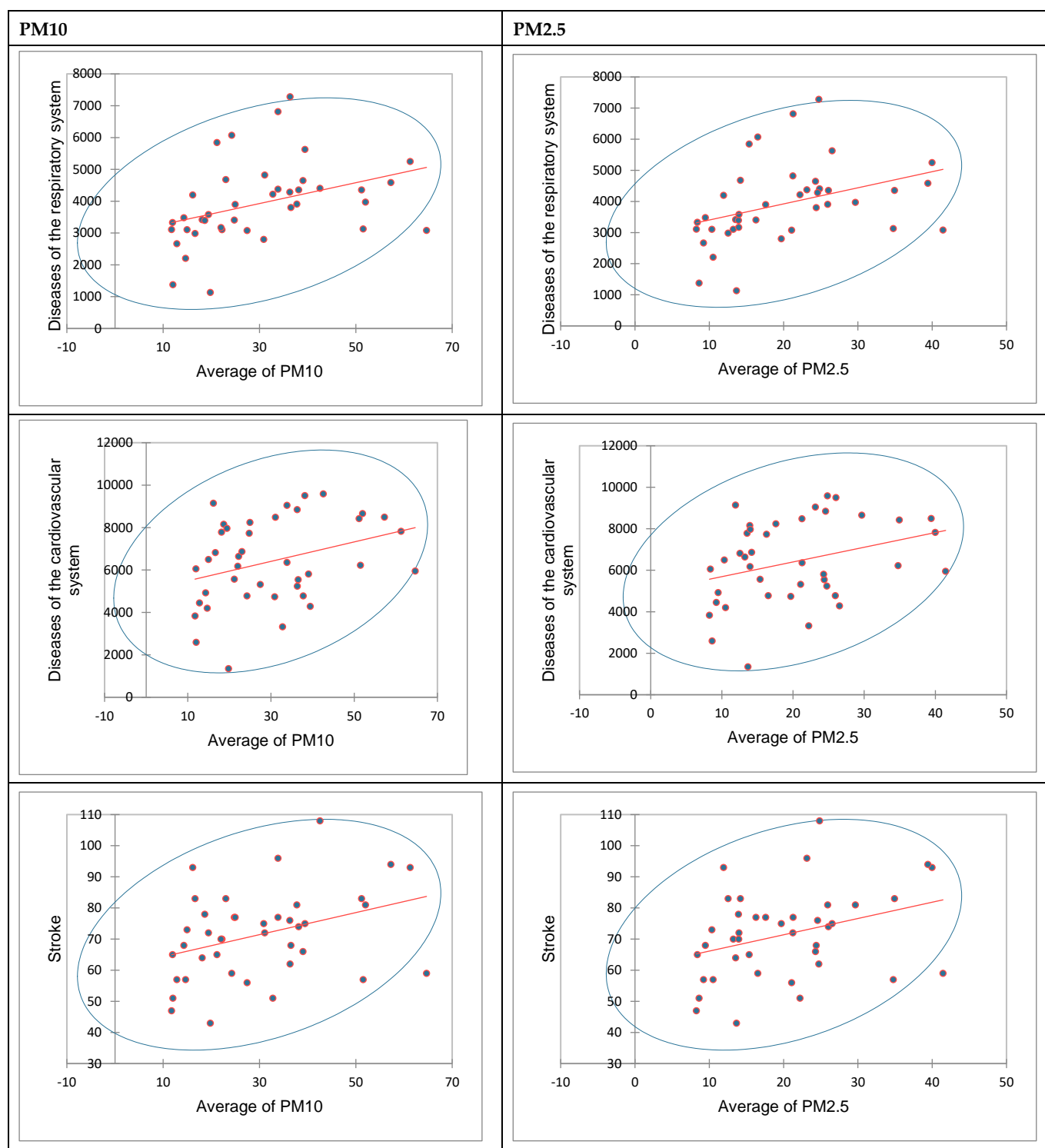


Figure S2. Correlogram.

Section S4. Analysis of variance (ANOVA) for PM concentrations.

Table S14. ANOVA—PM2.5.

ANOVA						
Source of Variation	SS	df	THX	F	P-values	F crit
Between groups	2586.485982	11	235.1350893	9.695248232	6.51964E-07	2.151197456
Within groups	679.0731236	28	24.25261156			
Total	3265.559106	39				

Table S15. ANOVA—PM10.

ANOVA						
Source of Variation	SS	df	THX	F	P-values	F crit
Between groups	6143.203854	11	558.4730777	7.891591922	5.02118E-06	2.151197456
Within groups	1981.507195	28	70.76811411			
Total	8124.711049	39				

Section S5. Descriptive analysis of daily values (PM10 and PM2.5).

Table S16. Descriptive statistics—PM10 and PM2.5.

Statistic	No. of observations	Minimum	Maximum	1st Quartile	Median	3rd Quartile	Mean	Variance (n-1)	Standard deviation (n-1)	Variation coefficient (n-1)	Skewness (Fisher)
PM10	10408	0.710	216.150	15.270	24.060	38.463	29.506	411.884	20.295	0.688	1.893
PM2.5	10408	0.480	129.350	11.170	16.905	25.600	20.060	168.318	12.974	0.647	1.955

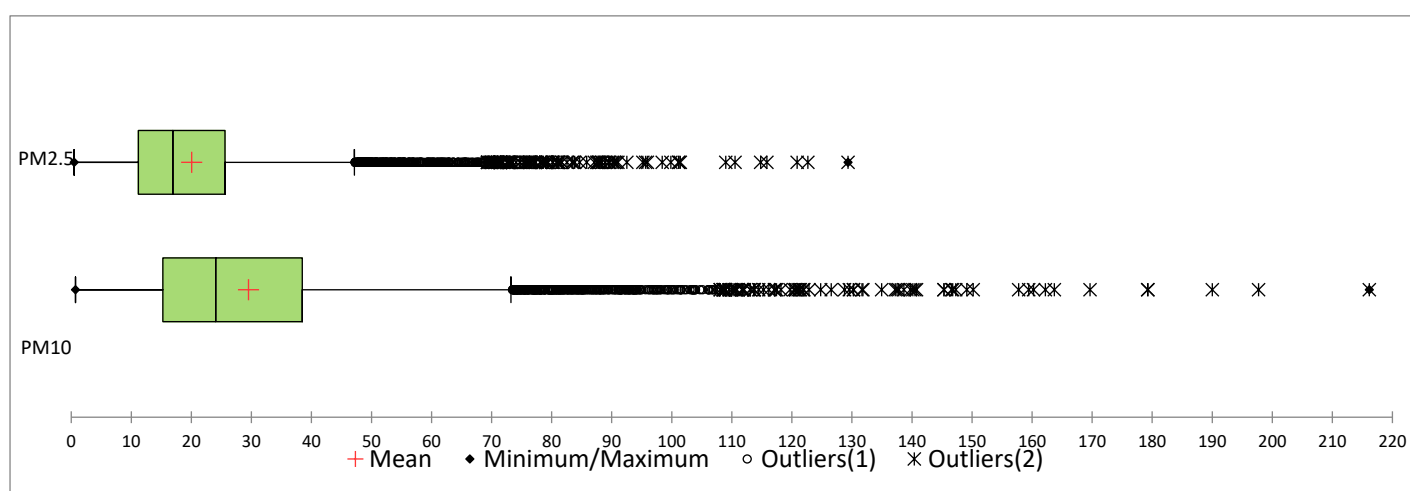


Figure S3. Box-plot.