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Determining Critical Air Pollution Areas and their Ecological Impacts on the Cognitive Functions of 8-10 Years Old Girls, Using GIS

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Abstract

Air pollution is considered as a destructive toxin of the nerves and ecosystems. Many schools are located in high-traffic streets in Tehran metropolitan, Iran. This study aimed at determining air pollution critical areas and impacts of this pollution on ecosystem and mental function of children at sensitive period of brain development. This was a descriptive-applied research in terms of methodology. According to data obtained from 22 stations for air quality monitoring in Tehran and average annual concentration of AQI pollutants, Tehran air pollution zoning has done in 2017 using Spline interpolation method through Arc GIS-10 and map of critical and healthy areas was drawn. Second step was undertaken using Wechsler test for 90 female students at age of 8-10 living in two areas. In the first area, air pollution was critical and the second area had a healthy air. Cognitive and depression disorders scored based on Wechsler and N-Back tests, respectively. Personal health indices obtained from health record of students to analyse their relation with cognitive disorder using ANOVA tests. Regions 22 and 20 were the most healthy and polluted areas, respectively. Girl children had different verbal, functional and general intelligence in these areas; there was a significant relationship between pollution or cleanness of each area and children's IQ. In addition, there was a direct and significant relation between air pollution and ecological effects. Thus, required actions should be taken to prevent the pollution of air and the impairment complications in cognitive functions.

Keywords: critical air, zoning, geographic map, intelligence, Wechsler test, ecological effects

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INTRODUCTION

Air pollution is a major environmental concern. It is an acknowledged widespread problem, it is rarely considered in conservation planning or management. In this synthesis, the state of scientific knowledge on the effects of air pollution on ecology in Iran is presented. Increasing population, unsustainable development regardless of environmental principles, ignoring ecological capacity and physical texture of cities when using natural resources and urban development, manufacturing machines, consuming fuel, and expanding pollution resources and contaminating industries can be named as anthropogenic factors leading to air pollution and disorder in human health. Tehran metropolitan is one of the most polluted cities in the world. Air pollution is a factor that creates brain disorder and reduces cognitive functions of human especially children and elder people. To control pollution rate and reduce impacts of air pollution on human health, air pollutants in this megacity should be accurately detected and polluted zones also should be identified.

Mind is the subject of cognitive sciences. Air pollutants may affect the brain at any age, but in lower

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ages, the growing brain is more vulnerable due to high-rate neuron proliferation, immature and incomplete metabolism of blood-brain barrier. Impaired brain activities can lead to permanent disorders. Oxidants like ozone, sulfur dioxide and dust can directly affect cell components leading to impaired cognitive functions. Various studies have proved that pregnant women, children, elders, and athletes are the most important groups vulnerable to air pollution. Children breathe more air than their weight per unit of time in other words children inhale more air in proportion to their weight so the small surface of respiratory ways directs more air into the lungs. On the other hand, high activities of children and spending much time in school and open spaces compared to adults can exposure them to pollutants leading to more respiratory failure among children. Followed by respiratory failure and blood oxygen shortage, cardiovascular problems, nervous system disorders, and cognitive dysfunction occur in children.

Jordi Sunyer and colleagues (2017) carried out a study entitled "Traffic-related Air Pollution and Attention in Primary School Children" under the support of Pompeu Fabra University cooperating with Epidemiology Research Departments of other universities in Barcelona Catalonia State, Spain. They tested cognitive functions using N-back test and Attention Network Test (ANT); they also used two-back diagnostic test for active memory, three-back test for prior active memory and standard error of hit reaction time for inattention. Results indicated that growing brain of children is vulnerable to specific types of air-related pollutants such as NO_2, CO, particulate matter <2.5 µm (PM2.5), elemental carbon (EC). The results of this research indicated daily ambient levels of both NO2 and EC were negatively associated with all attention processes. They found that both NO2 and EC had acute associations with inattentiveness. They selected EC and NO2 as indicators of traffic pollution because of their link with vehicle exhaust emissions in the city of Barcelona. In addition, the relation between short-term traffic-related air pollution exposure and fluctuating attention indicates potential harmful effects of air pollution on nervous system evolution.

Ailshire et al. (2017) conducted a study under the title of "Neighborhood social stressors, fine particulate matter air pollution, and cognitive function among older U.S. adults" in Gerontology Southern California University of Los Angeles. This study addressed cognitive function and effect of air pollution on it. Their findings showed a strong relation between PM2.5

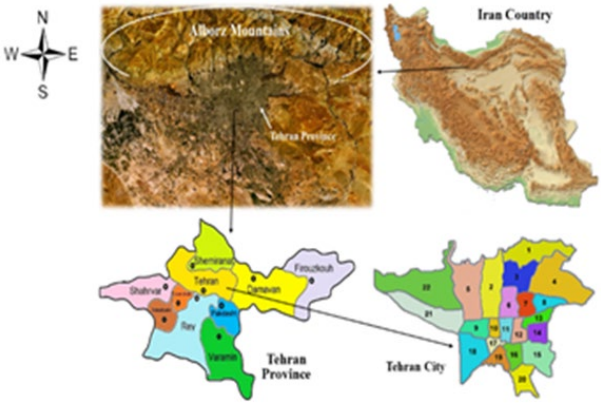


Fig. 1. Geographical location of Alborz Mountains, Tehran Province and 22 districts of Tehran City

particulates and cognitive mistakes among older adults living in stressful areas so that they are more sensitive to dangerous environmental factors and stressful factors. They found that the association between $PM_{2.5}$ and cognitive errors was stronger among older adults living in high stress neighborhoods. Their research results indicated those living in socioeconomically disadvantaged neighborhoods, where social stressors and environmental hazards are more common, may be particularly susceptible to adverse health effects of social and physical environmental exposures.

The extant study were conducted to determine critical air pollution zones in Tehran metropolitan, Iran examining effect of this pollution on cognitive function (executive and memory functions) in female elementary students at age of 8-10 living in Tehran.

Geographical Location of Studied Area

Tehran is geographically located in 51°, 17'-51 °, 33' eastern longitude, 35°, 49' northern latitude. Tehran area is about 733km. In accordance with census report (2016), population of Tehran is more than 8 million people (8.693.706).

Tehran is located in a zone between mountain and desert, surface waters of Alborz Mountain flows southwards. Alborz Mountain is like crescent form (**Fig. 1**).

Location of mountain ranges around Tehran within crescent form of mountains is an effective barrier against western winds blowing into the city leading to more stable weather of Tehran compared to surrounding plains. Air stability in particular in winter during inversion leads to severe accumulation of pollutions in tight spaces of mountains particularly in eastern part of Tehran preventing the natural ascent of hot air and discharge of pollutants. This phenomenon

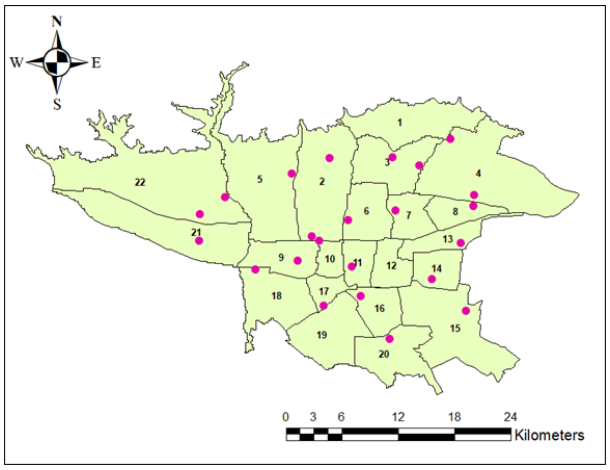


Fig. 2. Location of Tehran Air Quality Monitoring Stations in 22 geographical districts of Tehran City

in morning creates photochemical smog. One another issue in Tehran is uneven distribution of green space in this city. According to studies conducted by Tehran Planning Council, largest green space is seen in districts 3, 6, 15, 16 and smallest green space in districts 13, 5, 10, 18. One of requirements for green space development in Tehran is necessity of pollution reduction through green space expanding (oxygen production and carbon monoxide absorption). Large forest green spaces and regional parks with large areas contribute to Tehran air pollution purification.

METHODOLOGY

At first step of study, the map of most critical and healthiest zones of Tehran, capital of Iran in terms of air pollution illustrated after collecting data from 22 air quality monitoring stations using Arc GIS software and Spline interpolation method.

At second step, Wechsler intelligence scale for children and N-Back tests implemented for all of selected students using Software packages in order to determine impacts of air pollution on children's cognitive function. Finally, data inserted into the SPSS version20 software and analysed using Tukey test and analysis of variance. P-values lower than 0.05 considered as significance level ($P \leq 0.05$) in all of statistical tests. Next section describes implementation process of both steps.

Methodology of First Step

In first step, regarding zoning Tehran metropolitan air pollution, data related to pollutants were obtained from Tehran Air Quality Control Company and Environment Preservation Organization for 22 air pollution monitoring stations based on AQI (**Fig. 2**).

Then, data related to 4 seasons in 2017 was examined in terms of quality and quantity using Excel-2010 software based on standards designed by U.S Environmental Protection Agency (EPA). To determine air quality, mean of air pollution index's parameters like SO2, NO2, PM2.5, PM10, O3, CO were used. Considering inversion phenomenon and severe air pollution in Tehran during November, December, January, and February, these months were selected for examination at second step. To analyze air pollution distribution in Tehran Metropolitan, air distribution in city was illustrated without considering height using Arc GIS-10.5 Software. Pollution values of above-mentioned parameters besides latitude and longitude of selected stations were recorded in Excel table and then Tin map was prepared using Spline interpolation method within Arc GIS-10.5 environment.

Methodology of Second Step

Mental function encompasses a wide range of scopes including judgment, decision-making, visual search, alertness, and memory recall that can be affected when exposure to environmental stresses such as air and noise pollution as well as time pressure resulted by activity (Staal 2004).

After zoning Tehran's air and determining highly polluted geographical areas of Tehran and healthier regions, second step of study was implemented. First, two districts were selected and Wechsler test was done for girl children living there; first area was "Shahr Ray" in south part of Tehran (district 20) that was more polluted compared to other areas and second zone was "VardAvard and Chitgar" areas (district 22) in north west of Tehran with more healthier air during 2017.

Determining critical air pollution areas in Tehran Metropolitan and zoning air pollution of this city in second step, female elementary students in two areas located in south and northwest of Tehran were selected as statistical society in order to examine impacts of air pollution on their cognitive functions. All of female elementary students in two districts 20 and 22 of Tehran Metropolitan as Statistical population of this study filled the personal health questionnaires out; of them, 190 members were selected as qualified members for Wechsler tests.

Average age of studied students was 9 ± 1 that were girl children at age of 8-10 living in most critical (south) and healthiest (northwest) areas of Tehran.

All of studied girl children were selected based on their health information and completed personal health questionnaires by them during interviews with students, their teachers and parents. These members had no mental or physical disease, without using any specific medicines. Sample members were assigned to similar groups in terms of family economic status, height, weight, and nutrition situation. Girl children who refused to take tests at any step were remover for research.

One of cognitive assessment methods is using cognitive function tests. In this regard, Wechsler Memory Scale (W.M.S) and N-Back tests were implemented for all of girl children in order to identify their brain cognitive function level; Girl children were asked to do some tasks based on their cognitive skills. Mentioned evaluation was done in various cognitive parts including reasoning, decision-making, learning, memory, attention, intelligence, linguistic skills etc.

The Revised Wechsler Intelligence Scale for Children (WISC-R) was used to match students in terms of IQ. WISC is divided to two parts; first part comprised verbal test and 6 subtests and second part consisted of non-verbal (functional) tests and 6 subtests (Shahim 2006).

Six subsets of verbal scale included general information, numerical memory, vocabularies, calculating, comprehension, and similarities, and 6 functional subsets included picture span, picture concept, visual puzzles, block design, coding and symbol search. Validity of this test reported to 0.97, 0.97, and 0.93 for total IQ, verbal IQ and functional IQ, respectively using split off method. Validity and reliability of this scale was also tested in Shiraz University, Iran and its correlation with academic achievement and retest reported to 0.88 and 0.85, respectively.

IQ score ≤70 indicates mental retardation and scores >130 indicate ingenuity level. Full-Scale IQ shows relative situation of person compared to his peers presenting a general estimation of person's mental abilities. Verbal IQ is an index indicating understanding, comprehension and verbal abilities; Performance IQ is an index showing perceptual organizing abilities. In case of scoring relevant tests, the difference equal to 9-15 rate should be taken into account so that 15 rate difference and above should be addressed (child is LD possibly). Each of Wechsler subtests determines IQ, memory type or cognitive functions of individuals' brain.

WISC subscales were implemented based on the relevant instruction in this research. For instance, numbers are gradually increases from 3 to 9 in each row in direct memory span test; in this sense, a series of numbers with a specific order was repeated for respondents and they were asked to repeat numbers as had heard it. In reserve memory span's test, figures are gradually increased from two to 8 figures in each row and respondents were asked to repeat figures reversely. Each part has two scores since there are two rows of numbers in each part. High score of direct and reverse tests indicates high capacity of working memory. At next step, data were analyzed at two descriptive and inferential parts using Tukey and ANOVA tests through SPSS-20 Software ($P \leq 0.05$).

RESULTS

Ecological Effects

Iran forest ecosystems have naturally evolved cross-tolerance to deal with harsh environmental conditions (Matesanz and Valladares 2014, Paoletti 2006). However, climate change, N deposition and O3 are currently threatening forests in unprecedented and complex manners, with consistent stoichiometric responses to increased N deposition (higher leaf N: Pratios; Sardans et al. 2016), but with physiological and growth-related consequences forecasted to vary among the three main tree functional types (i.e., conifers, evergreen broadleaf trees, and deciduous broadleaf trees). As deposition increases, photosynthesis, water use efficiency, and thus growth, often increase in conifers (Leonardi et al. 2012), although under chronic N deposition, other nutrients such as P can become more limiting, counteracting the initial benefits of more N availability (Blaneset al. 2013). Nitrogen deposition could also increase pine mortality rates in response to drought due to a decline of ectomycorrhizal colonization rates, a phenomenon of widespread occurrence in US dryland woodlands (Allen et al. 2010). On the other hand, their low stomatal conductance and their high stomatal sensitivity to vapour pressure deficit and water availability might limit the diffusion of O3 to the mesophyll (Flexas et al. 2014). Similarly, conservative strategies of water and nutrient-use may also play a key role in allowing conifers to keep a positive balance between assimilation and respiration in response to climate change (Way and Oren 2010). However, O3 exposure might be impairing their ability to withstand other environmental stresses such as those triggered by drought, high temperature and solar radiation.

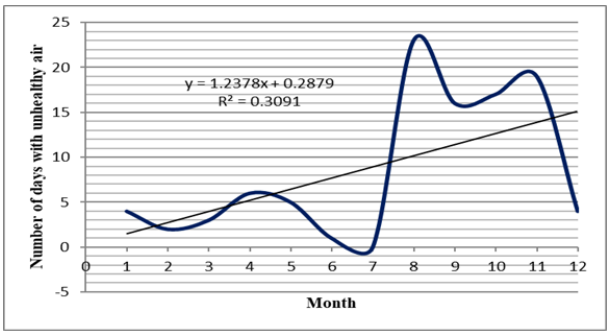


Fig. 3. Comparing days with unhealthy Air for sensitive groups in Tehran during different months -2017

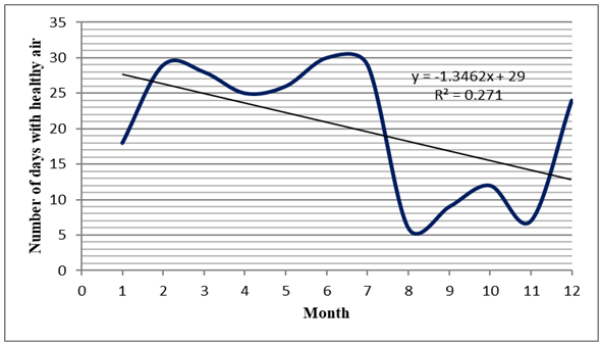
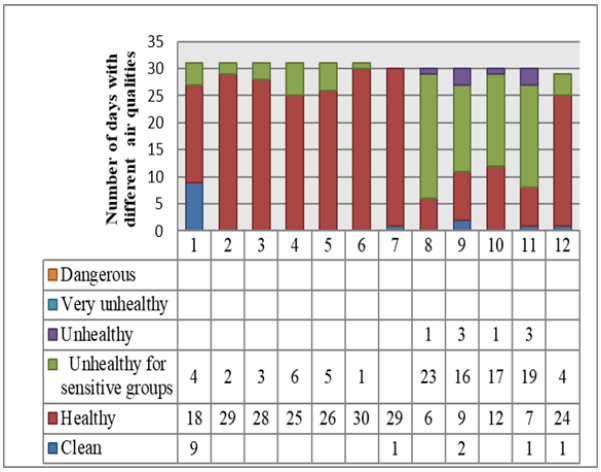


Fig. 4. Comparing days with healthy Air in Tehran during different months- 2017

Findings of the First Step

Considering the wind direction in Tehran, that blows from west to east and southwest, polluted zones are seen in southern and central areas. According to illustrated maps, it was found that wind speed and direction have been effective in the majority of the air pollution displacement cases in Tehran. In fall, dominant wind direction plays a vital role in increased pollution. During mid-December 2017, wind direction was toward south and southwest without adequate speed for pollutants displacement; hence, polluted air in central and north areas of city could not exit due to low-speed wind and mountains located in northern part. Therefore, unhealthy and very unhealthy zones have been expanded within west-east area involving majority stations and regions. Since Shahr Ray-located in district 20 of Tehran Metropolitan geographical divisions- is located in southern west of Tehran and there is no dominant wind direction, this zone has unhealthy air most days of the year. Moreover, presence of small and large industrial units like Cement Factory and Oil Refinery besides thousands of heavy vehicles related to these industries can be named as main reasons for pollutant accumulation in district 20. Accordingly, 250 unhealthy days in Shahr Ray were recorded during 2017.



	1	2	3	4	5	6	7	8	9	10	11	12
Dangerous												
Very unhealthy												
Unhealthy								1	3	1	3	
Unhealthy for sensitive groups	4	2	3	6	5	1		23	16	17	19	4
Healthy	18	29	28	25	26	30	29	6	9	12	7	24
Clean	9						1		2		1	1

Fig. 5. Tehran AQI during different months, 2017

According to the statistics recorded in air pollutant monitoring station until the end of fall 2017 in Shahr Ray governorate, %75 days in this district are unhealthy in terms of particulate matter emissions (**Figs. 3** and **4**).

In general, illustrated maps and data indicate that many days of the year in areas around the Shahr Ray, Azadi, Bazar, and Fatemi stations have been unhealthy or extremely unhealthy.

In some cases, stations located in Gholhak and Aghdasiyeh reported unhealthy or extremely unhealthy air. It should be noted that this pollution intensified in fall and winter 2017 due to inversion. Particulate matters with diameter lower than 2.5-micron (PM2.5) and particulate matters with diameter lower than 10-micron (PM10) had unfavorable conditions in Tehran during 2017 and polluted days of the year associated with increasing concentration of these two pollutants, in particular PM2.5.

Although all of months in 2017 (except for October) have been unhealthy for sensitive groups in Tehran, the data obtained from different air quality monitoring stations in city indicated more unhealthy days in fall and early days of winter. Hence, in **Fig. 3**, Tehran AQI depicted by bar graph and the number of each month days displayed according to the types of Air Quality (**Fig. 5**).

Besides natural factors affecting pollution in mentioned regions, human activities like concentration of industries and commerce, density of motor vehicles, excessive consumption of fossil fuels and density of population, play a crucial role in making air pollution in studied districts.

Table 1. Number of polluted days based on particulate parameters of AQI index- Tehran Metropolitan-2017

Number of received information days	AQI	Air pollutant index parameters						Total number of air quality monitoring stations
		$PM_{2.5}$	PM_{10}	SO2	NO2	O3	CO	
		Number of days						
365	108	101	7	0	3	7	0	23

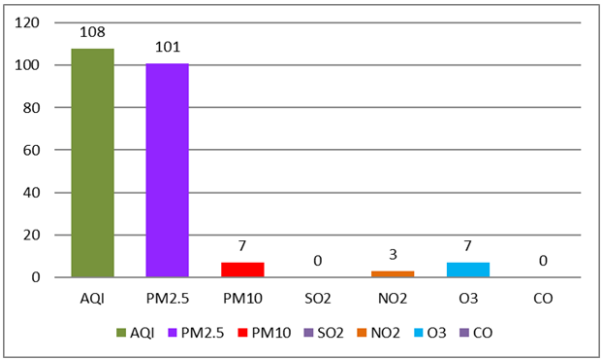


Fig. 6. Comparing pollutant parameters of AQI during polluted days in Tehran-2017

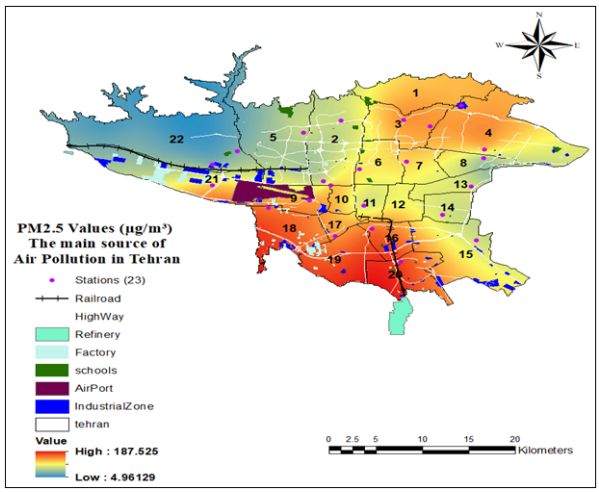


Fig. 7. Zoning air of different districts in Tehran based on mean of PM2.5 parameter -2017

According to the statistics published by Tehran Air Quality Control Company, there has been a descending concentration rate of PM10, CO, SO2, and O3 in recent years.

These data showed unfavorable conditions of particulate matter pollutants with diameter lower than 2.5micron (PM2.5) so that concentration of these particulate matters has been higher than the standard level in all days of the year. Obviously, climate conditions have a significant role in highly complicated behaviors of pollutants.

According to data gathered from various Tehran Air Quality Monitoring Stations during 2017, mean of pollutant parameter PM2.5 was higher than other parameters of AQI index so that these particulate matters have the highest contribution is Tehran air pollution (**Table 1**, **Fig. 6**).

Considering higher PM2.5 rate compared to other air pollutant parameters in Tehran during 2017 and damaging effects of this particulate matter on human cognitive function, zoning of air in various districts of Tehran was done concentrating on PM2.5 distribution level (**Fig. 7**).

It should be explained that Vardavard and Chitgar areas (district 22) in northwest of Tehran had healthier and cleaner air in 2017. Restrict 22 of Tehran municipality is located in downstream basin of Kan and Vardij Rivers. This area reaches to Central Alborz Mountain in north, to Kan Riverside in east, to Tehran-Karaj freeway in south and to Vardavard Planting Forests in west. Existence of forest parks like Chitgar, Vardavard, Khargoush Dareh, Letmal Kan and because of wind direction in Tehran blowing from west to east, this area of Tehran has cleaner air compared to other regions.

On the other hand, district 20 of Tehran (Shahr Ray) is located in southernmost part of this city with highly polluted area during 2017. Shahr Ray is limited to Varamin and Pakdasht counties in east, to Islamshahr, Robatkarim and Zarandiyeh in west. Ray County is located in plain with low-height Mountain. Long and Saline River called Fashapouyeh passes through the Ray County with northwest-southeast direction. Shahr Ray has semi-arid weather with moderate and dry air, there is no natural forest in this area but is active in terms of hand planting agriculture. Shahr Ray is adjacent to Tehran Railway and Imam Khomeini International Airport. Existence of Kahrizak landfill of waste disposal and recycling center in southern area of district 20 besides industrial and manufacturing factories like Tehran Refinery, Ray Gas Power Plant, mines, and Tehran Cement Factory in this area can be named as factors affecting air pollution in this region. Most times, visible dust existing from chimneys enters to the air in this area.

Findings of Second Step

After implementing verbal and non-verbal Wechsler subtests for all of 8-10 year old girl children studying in schools located in districts 20 and 22, Tehran City, Iran,

Table 2. Mean, Sd., ANOVA of Wechsler subtests' scores in two groups of girl students (age of 8-10) in districts 20 and 22, Tehran

Variable	District 22		District 20		P
	Min	SD	Min	SD	
Information	8.22	3.14	8.18	1.81	0.015
Similarities	10.09	2.41	9.95	3.3	0.091
Arithmetic	9.02	2.3	9.15	3.01	0.17
Vocabulary	10.17	2.56	6.05	2.6	<0.001
Comprehension	10.03	2.4	7.85	3.4	<0.001
Verbal Test	47.53	9.8	41.18	9.71	0.04
Picture Completion	9.90	2.8	9.84	3.4	0.19
Matrix Reasoning	12.10	4.0	12.09	4.17	0.16
Block Design	11.24	2.9	11.01	3.01	0.083
Symbol Search	14.05	2.79	13.88	2.9	0.095
Digit Coding	9.89	2.81	9.95	3.3	0.088
Performance Test	57.18	10.2	56.77	10	0.18
Verbal IQ (VIQ)	96	13.2	87	13	<0.01
Performance IQ (PIQ)	108	13.4	108	13.4	0.97
Full Scale IQ (FSIQ)	102	12.9	101	12.8	0.90

Table 3. Comparing means of VIQ, PIQ and FIQ Between two districts 20 and 22, Tehran in each group of girl students (age of 8-10)

Age group	Variables	District 22	District 20
		Min	Min
8	VIQ	87	77
	PIQ	98	98
	FIQ	92	90
9	VIQ	95	95
	PIQ	113	113
	FIQ	105	105
10	VIQ	106	93
	PIQ	113	113
	FIQ	108	109

scores of each subtest for each age group were recorded in Excel tables; then data were inserted into the SPSS Software and mean, standard deviation and ANOVA were prepared and extracted (**Table 2**).

Table 2 indicates significant difference between all of Wechsler subtests particularly for vocabulary and comprehension tests in 8-10 year old girl students living in two studied areas ($P<0.05$). There was a significant difference between verbal IQs of girl children living in two studied areas, and there was a significant difference between performance IQ and full IQ of girl students in these two areas ($P<0.05$).

Numerous studies have shown that exposure to air pollution leads to olfaction impairment, immune system disorder and cognitive disorders making these girl children susceptible to Alzheimer and Parkinson (Gorciduenas et al. 2013). Frontal lobe and posterior area of brain are the main places for executive functions in human brain (Zook et al. 2004).

Arffa (2007) conducted a study on executive functions in normal and gifted children and found a relationship between intelligence and executive functions so that intelligence can affect executive functions.

All of mean scores of verbal scale or performance subtests were calculated after completing performance and verbal tests. Calculating mean scores, verbal and performance differences between age groups were examined based on the pre-determined standards. To compare FIQ, PIQ and VIQ of girl children at age groups 8, 9 and 10 in two studied areas, the mean data obtained from Wechsler test were classified in a table then relevant Figures were illustrated (**Table 3**, **Figs. 8-11**).

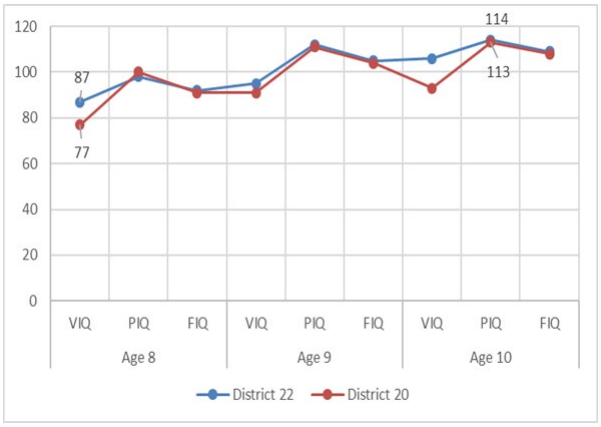


Fig. 8. Comparing means of VIQ, PIQ and FIQ Between two districts 20 and 22 Tehran - in each group of girl students (age of 8-10)

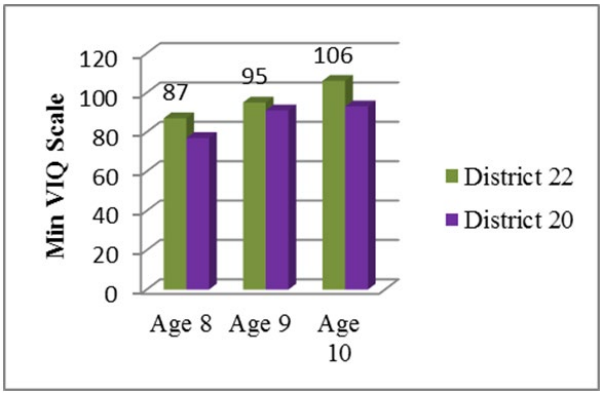


Fig. 9. Comparing VIQ means of 8-10 year old girl children in districts 20 and 22, Tehran, fall 2017

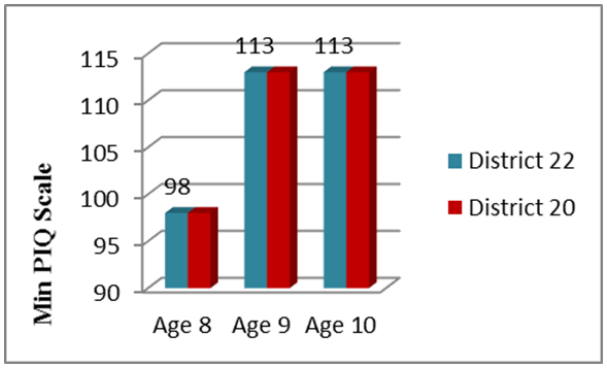


Fig. 10. Comparing PIQ means of 8-10 year old girl children in districts 20 and 22, Tehran, fall 2017

In case of comparing mean of groups using ANOVA, variance used to test following hypotheses. This is similar to T test (**Tables 4-6**). According to H0 hypothesis of this research, there was not any difference between IQs of three age groups (μ) in studied districts. H1: there is a difference between IQs of three age groups (μ) in studied districts. ANOVA was used to tests of research hypotheses.

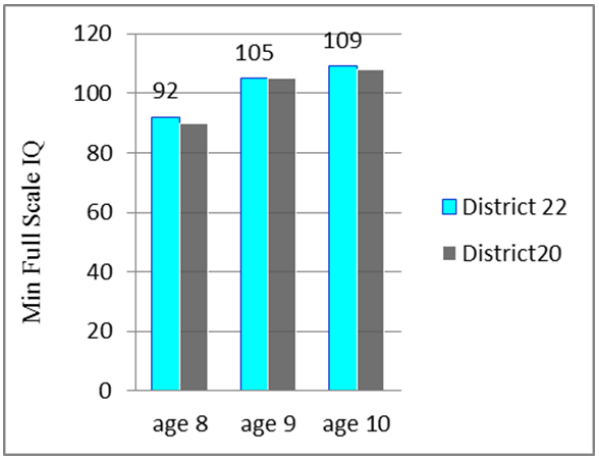


Fig. 11. Comparing FSIQ means of 8-10 year old girl children in districts 20 and 22, Tehran, fall 2017

Table 4. ANOVA of VIQ, PIQ and FSIQ between two groups of girl students in districts 20 and 22, Tehran

ANOVA					
IQ					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	50	1	50.000	.426	.023
Within Groups	1880	16	117.500		
Total	1930	17			

Table 5. Test of Homogeneity of Variances of VIQ, PIQ and FSIQ in three age groups (8-9-10) in districts 20 and 22, Tehran

IQ			
Levene Statistic	**df1**	**df2**	**Sig.**
.299	2	15	.046

H0: $\mu1=\mu2=\mu3$

H1: $\mu1\neq\mu\,2\neq\mu3$

According to **Table 4**, Sig level obtained to 0.023 that is less than 0.05; hence, H1 was confirmed indicating a significant difference ($P<0.05$) between IQs of age groups in two studied districts (20 and 22). Variance homogeneity examined at next step to compare IQs of age groups in two studied areas (**Table 5**).

According to **Table 5**, significance level obtained less than 0.05 (Sig=0.046); hence, H1 is confirmed indicating heterogeneity of variances of IQs in all of three age groups in two studied areas. Besides heterogeneity of variances, ANOVA was used to compare three age groups 8, 9 and 10 year old, and results in **Table 6** indicated Sig<0.05; hence, H0 was rejected and H1 was accepted indicating significant

Table 6. ANOVA of VIQ, PIQ and FSIQ in three age groups (8-9-10)

ANOVA					
IQ					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	933	2	466.667	7.023	0.007
Within Groups	996	15	66.444		
Total	1930	17			

Table 7. Multiple Comparisons test for VIQ, PIQ, and FSIQ in three age groups (8-9-10) in studied areas

IQ Tukey HSD						
(I) Age	**(J) Age**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
8	9	-13.33333*	4.70618	.032	-25.5575	-1.1092
	10	-16.66667*	4.70618	.008	-28.8908	-4.4425
9	8	13.33333*	4.70618	.032	1.1092	25.5575
	10	-3.33333	4.70618	.762	-15.5575	8.8908
10	8	16.66667*	4.70618	.008	4.4425	28.8908
	9	3.33333	4.70618	.762	-8.8908	15.5575

*. The mean difference is significant at the 0.05 level

Table 8. Classification of homogeneous age groups in districts 20 and 22-Tukey Test

Age	**N**	**Subset for alpha = 0.05**	
		1	**2**
8	6	90.3333	
9	6		103.6667
10	6		107.0000
Sig.		1.000	0.762

difference between studied groups in terms of IQ (Sig.=0.007).

Considering heterogeneity of variances and difference between IQs of girl children in two studied areas, next step was undertaken to study difference between girl children at different ages in terms of IQ. For this purpose, Tukey Multiple Comparisons Test was done and Post Hoc table was extracted (**Table 7**).

According to Multiple Comparisons between IQs of girl children in three age groups, there was a significant difference between IQs of girl children at age of 8 and 9 and 10-year-old; In this regard, Sig. value obtained to 0.032 in comparison between 8 and 9 year old girl children and this value obtained to 0.008 in case of comparison between 8 and 10 year old children; since these significance values were lower than 0.05, Therefore, there was a significant difference between the intelligence of the 8-year-olds and the other two groups. Significance level obtained above 0.05 for 9 and 10 year old girl children indicating lack of significant difference between IQs of these girl children (Sig=0.762). Tukey test was used in ANOVA and a suitable suggestion obtained to classify studied groups (**Table 8**).

For this purpose, two categories were formed. Then 8-10-year-old girl children studying in districts 20 and 22 of Tehran to classify them and test their IQs.

According to **Table 8** and recommendation of Tukey test, it would be better to classify homogenous groups in same class in order to test IQ of studied girl children in this research. Therefore, age group of 8 assigned to first class and other groups (9 and 10) assigned to second class then were compared with each other.

Figs. 5-7 are indicated the difference between VIQ, PIQ and FSIQ of studied students in three age groups in two Tehran's districts. According to data extracted from presented tables and figures, children's IQ has increased from age 8 to 10 and their verbal IQs fewer than performance IQs, in addition ANOVA indicates that this difference has been significant in studied districts.

Hence, it can be stated that there was significant difference between VIQ, PIQ and FSIQ means in three age groups living in districts 20 and 22. In addition, ANOVA proved a significant difference between IQ of girl children at age of 8 and girl children at ages 9 and 10 within groups of each separate studied district.

CONCLUSION

This study was conducted to determine critical and healthy air zones in Tehran Metropolitan in order to investigate ecological effects and possible difference between cognitive functions like memory, concentration, learning ability and consciousness among girls who live in most polluted and health districts of Tehran.

According to the results obtained from first section of study, illustrated maps indicated that two districts 20 and 22 had the most polluted and the healthiest air, respectively as compared to other areas during 2017. District 22 was healthier and district 20 was more polluted compared to other areas. Weather conditions in Tehran had been unhealthy more than one third of the year during recent years. Annual average concentration of some pollutants in Tehran has been at unhealthy level several times greater than standards dictated by World Health Organization (WHO).

According to the obtained results, PM2.5 is the major air pollutant in Tehran. This particulate matter can harm human health in particular among children, pregnant women, older people and other vulnerable groups. GIS maps drawn in Spline interpolation method indicated high concentration of prominent pollutants in central and especially south areas of the city showing the impact of western winds on pollution displacement in Tehran. On the other hand, concentration density and heights in Tehran demonstrates that these heights prevent from pollution outflow and displacement so that blowing west winds lead to concentration density in southern areas of Tehran. As can be seen in **Figs. 1** and **2**, maximum concentration in fall is higher than other seasons due to low air temperature and impact of inversion on concentration density of pollutant factors during cold seasons. Besides climate and natural conditions, human activities also play a vital role in creating pollution and pollution concentration density in southern, central and other zones of Tehran. Some of these activities include existence of pollutant industries such as Shahr Ray Refinery and Cement factories, waste disposal center of Kahrizak Landfill, commercial centers, population dense, high traffic, long hours of traffic, high fuel consumption, old clean technologies and transportation fleet in Tehran.

According to the results obtained from second section of study, a significant relationship between cognitive function and age of girl children was proved in this paper so that ANOVA results in case of cognitive performance of 8-10 year old girl children indicated that lower age of girl children plays a moderating role in relationship between executive functions and mental performance. In this sense, 10-year-old girl children with higher education level had higher cognitive function compared to 8-year-old girl children with lower education regardless of other factors.

Among girl children at age of 8, there was a significant relationship between their IQ and pollution or clean air of the living area. Wechsler cognitive test was abnormal among girl children living in district 20 of Tehran with more air pollution compared to girl children living in district 22 with healthier air, and there was a significant difference between mental performances of girl children living in districts 20 and 22 of Tehran so there was a differences between subtests mean scores of students living in these districts. It should be explained that the difference between PIQ, VIQ and FSIQ scores was significant statistically.

Therefore the difference between two studied areas was statistically significant in terms of IQ among three age groups of girl students; in addition data and Figures associated with comparison between cognitive functions of 8-10 year old girls in each district indicated weaker cognitive function of girl children at age of 8 compared to other two age groups and next ranks assigned to 9 and 10 year old children, respectively.

Figs. 5-7 show that with increase in age of respondents, their mental performance was developed and girl students ate ages 9 and 10 obtained higher scores; the reason for such mental performance promotion may be related to the difference between fluid intelligence and crystalized intelligence of children.

Fluid intelligence is a factor affecting general intelligence and defined as internal or inherent learning capacity in person. This intelligence does not depend on the education level, teachings and experiences (Spearman 1923).

In contrary, crystallized intelligence comprises learned and stored skills during life time of person that are gained through studying and doing daily activities. Crystalized intelligence is not memory but is used for data processing through long-term memory. Like fluid intelligence, crystallized intelligence grows during childhood. Contrary to fluid intelligence, crystalized promotes until adulthood then deteriorates after 65. These two types of intelligence are correlated. Wechsler also measures person's intelligence score based on the combination of two fluid and crystalized intelligences (Jensen et al. 1994).

Findings obtained from this study are in line with above-mentioned theories confirming that cognitive function is significantly related to education level and age of persons. The lower the education level, the higher the cognitive disorder will be. According to the

results obtained from other studies on period after mental growth and nervous system completion, higher age is along with higher cognitive disorder (Kurella et al. 2010, Odagiri et al. 2011). Growing cognitive function observed in 8-10 year old girls that are at the age of childhood and nervous system maturity.

Furthermore, results of this study showed higher cognitive impairments in girl children who had depression.

Other studies found depression symptoms with more possible cognitive disorder. Two brain areas, Hippocampus and Frontal Lobe, play a vital role in memory so that Frontal Lobe plays role in decision-making, problem solving and planning. Long-term exposure to high-level cortisol in depression leads to reduced Hippocampus volume that has negative effect on verbal memory (Schiepers et al. 2005).

Another results of this study showed higher VIQ of girl children who live in district 22 compared to VIQ of girl children living in district 20. Analyses showed significance of this difference and moderating role of PIQ in calculating FSIQ led to average IQ level in two studied districts. In addition to the findings of this research, for as much as the negative effects of air pollution on Hippocampus and verbal memory indicate need for further studies in this field considering the difference between VIQ of girl children living in two healthy and polluted areas of Tehran. Considering the fact that cognitive skills of children not only are subjected to environmental conditions but also depend on heredity and age changes; ultimately it can be confirmed that optimal cognitive function is a crucial factor for academic achievement of students leading to promotion of their mental health and quality of life. Accordingly, it is recommended to allocate time in schools regarding promotion of mental performance of students who suffer from cognitive impairment.

It is recommended to conduct further studies on different age ranges and genders among different societies to make best decisions on higher levels.

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