



Interaction between air pollution and total antioxidant capacity (DTAC) on the managers and teacher's anxiety and memory in two polluted and less polluted areas of Tehran province

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Abstract:

Background: industrialization has increased air pollution in large cities. Due to the association between air pollution and memory impairment , anxiety and the effectiveness of antioxidants in improving these, it was suggested that a high level of antioxidants may have adverse effects of air pollution on brain function, memory, and anxiety.

Objective: This study investigate the interaction between air pollution and total antioxidant capacity (DTAC) on the teacher's anxiety and memory in the two polluted and less polluted areas of Tehran.

Methods: In cross-sectional study . Air Quality Index(IQA) assessed in 200 teachers from two polluted and less polluted areas of Tehran. It include 6 air pollutants substances(CO, SO₂, NO₂, O₃, particulate matter (PM<2.5µm), particulate matter (PM<1.0µm) . the data from DTAC estimated by food frequency questionnaire(FFQ). Wechsler and Spielberger tests was used for memory and anxiety measurement, respectively.

Results: A mean of anxiety and memory in two areas did not show statistically significant differences. Relationship between dietary TAC and air pollution in determining memory benefit and anxiety levels was non significant.

Conclusions: there was no significant relationship between dietary TAC and air pollution in determining memory benefit and anxiety levels.

Keywords: “air pollution”, “total antioxidant capacity”, “DTAC”, “brain function”, “memory”, “anxiety”



Introduction

Air pollution has noxious effects on public health and it is responsible for high health expenditures linked to the development of chronic diseases, and their associated disability and mortality (Segalowitz 2008). Some literature has shown a clear association between air pollution and respiratory (Kelly and Fussell 2015), while the effects of air pollutants on the central nervous system (CNS) are demonstrated. Some research studies have mentioned that highly air polluted environments are responsible for an increased risk of cognitive decline (Power, Weisskopf et al. 2010, Tallon, Manjourides et al. 2017). Different agents have been repeat to be toxic for CNS including fine airborne particulate matters (PM_{2.5}, PM₅, PM₁₀), carbon monoxide (CO), benzene and ozone (O₃) nitrogen, sulfur oxides (Lam, Li et al. 2016). The procedure and mechanisms of neurotoxicity of air particulate pollutions are not clarified, but systematic inflammation and brain oxidative stress seem to play a role in CNS structural and functional changes that are associated with mental disorders (Buoli, Grassi et al. 2018). studies show that increased inflammation in part of brain areas such as the hippocampus has been affirmed in animals that exposure to air pollution (Fonken, Xu et al. 2011); Mental health disorders accounted for over 140 million disability-adjusted life-years worldwide in 2010 (Spencer 2013).

Studies have shown that inflammation, oxidative stress, and vascular diseases interfere with the risk of mental disorders (Vogelzangs, Beekman et al. 2013, Kim, Lim et al. 2016). Anxiety disorders are the most common class of psychiatric disorders in the US⁴ and many other countries. In Iran, the prevalence of mental disorders is 23.4% (27.5% in women and 19.2% in men), with the prevalence of depression being 10.3% (11.4% in women and 9.3% in men) (Noorbala, Faghihzadeh et al. 2017). Oxidative stress (Gholizadeh, Farajzadeh et al. 2009, Hassan, Noreen et al. 2016) and inflammation (Gyllenborg, Skakkebaek et al. 1999). are directly associated with the chance of depression. Fruit and Vegetables (FV) is rich in antioxidants and anti-inflammatory components, which may have beneficial effects in the prevention of depression. A higher intake of total FV and some of its specific subgroups might be associated with depression (Baharzadeh, Siassi et al. 2018).

It is assumed that dietary antioxidants might reduce oxidative stress induced by air pollution. Besides, there is no comprehensive study available on the relationship between dietary total antioxidant capacity and memory. Given these reasons, we aimed to investigate the interactions of air pollution and dietary total antioxidant capacity (DTAC) on short term memory and anxiety of teachers in two regions in Tehran.

MATERIAL and METHODS

Study population and regions: This cross-sectional study was conducted in 200 teachers from schools in Tehran. Study participants were selected from polluted and less polluted areas by using a simple random sampling method. The statistical sample was calculated based on Pedozi formula, using the prevalence of anxiety = 30.2%, considering the first type error of 0.05 and a power of 80%. We selected polluted and less polluted regions based on information available at the pollution register stations. In each school, a sample of 100 teachers was randomly recruited from a list of schools. A total of 200 subjects (120 males and 80 females) were included in the study.

Inclusion and exclusion criteria:



The teachers who are healthy and lived in the selected region in Tehran. those who had thyroid or cardiovascular diseases or suffered from thyroid disease, respiratory disease, and anemia were not included.

Regions:

The polluted area is the area with the highest air pollution reported, and the less polluted area is the region where the air pollution is lower than in other areas of Tehran according to the report of air and weather organization of Tehran province.

Ethical consideration

After discussing the study's aims, informed consent was signed by the students' parents. The study has been approved by the Bioethics Committee of Tehran University of Medical Sciences, Tehran, Ira. (IR.TUMS.VCR.REC.۱۳۹۶,۳۶۷۲).

Assessment of dietary intakes:

At first, from all teachers, a food frequency questionnaire (FFQ) was completed by a nutritionist. The questionnaire contains 147 items for determining dietary intake on a daily, weekly, monthly or annual basis. teachers were asked to report their food intake during the last year based on daily, weekly and monthly measures. In this study, all food reported was converted to daily intake. Then, the frequency of intakes for each food was converted to grams per day (Poljšak and Fink 2014).

The validity and reliability of the questionnaire have been confirmed in Tehran Lipid and Glucose Study (TLGS) (Hosseini-Esfahani, Hosseinpour-Niazi et al. 2018).

Assessment of antioxidant activity:

DTAC, as a measure of antioxidant intake, may also be a potential marker of diet quality in healthy subjects (Romieu, Castro-Giner et al. 2008).

Dietary intake was assessed by a validated food-frequency questionnaire, which was also used to calculate the dietary Total Antioxidant Capacity (18). Then, each person was coded and the total amount of antioxidant activity of the diet was expressed as the equivalent of Rolex micromole, based on 100 g of each diet (Haytowitz and Bhagwat 2010).

Assessment of anxiety:

The steady-state of anxiety was measured by using the Spielberger test. The assessment of memory: Short-term memory was assessed by the Wechsler test (20). Wechsler memory is capable of measuring the forward and reverse memory of short-term memory and can be used to measure the memory of children and adults. Based on the number of correct answers and errors, each person's score is given. Then, the average and standard deviation of the total population score are reported.

The difference between the standard deviation of the average is reported normal. Individuals with higher scores than the standard deviation from the average are reported powerful short term memory and scores lower than standard deviations from average are reported week short term memory (Mashhadi Ali km 2014).

The assessment of other variables: information about teachers' age, and education, and the number of family members, menopause condition is provided by completing the demographic questionnaire. teachers' height was measured by the meter and teachers' weight was measured by scales.

Statistical Analysis: Differences in general characteristics across different DTAC status and regions pollution status were searched by using 2-factor (High DTAC versus low DTAC and



polluted region versus less polluted region) analysis of variance (ANOVA), and the main effects of DTAC and region pollution status, as well as the DTAC-pollution status interaction, were tested.

To detect significant differences in the distribution of subjects in terms of categorical variables across different DTAC and pollution statuses, the Chi-square test was used. Energy-adjusted dietary intakes across different DTAC status and region pollution status were also compared by using 2-factor ANOVA.

Besides, differences in scores of Memory and Anxiety across different DTAC and region pollution statuses were also searched by using 2-factor ANOVA before adjustment for confounders and in two models. First, we controlled for energy intake (Kcal). P values less than 0.05 were considered as statistically significant. We used SPSS software (version 16; SPSS Inc, Chicago IL) for all statistical analyses.

Results:

This is a cross-sectional study, which conducted with 200 teachers in both sex,

A total of 200 subjects (sixty-one males and seventy-one females) were included for analysis.

The mean age of the participants was 42 (sd 8.3) years men and 40.4 (sd 6.4) years in women.

The mean energy-adjusted reliability The FFQ developed for the TLGS has reasonable relative validity and reliability for nutrient intakes in Tehranian adults (Hosseini-Esfahani, Hosseinpour-Niazi et al. 2018).

pollution status and TAC:

comparing anxiety score and memory score in two air polluted areas and between total antioxidant capacity tertiles are shown in Table 1. This information was collected by completing the Spielberger test and the Wechsler test. And FFQ Total Antioxidant Capacity (TAC).

Total Antioxidant Capacity (TAC), is the total antioxidant capacity which is divided into three groups (Tertile) of TAC1 and TAC2 and TAC3. Individuals with lower dietary antioxidant status are in the TAC1 group and the TAC3 group has a higher antioxidant capacity in their diet.

As you can see in the table1, teachers in less polluted areas with lower TAC1 have a lower memory score than teachers with a higher antioxidant capacity (TAC3), but this difference was not significant.

There was no significant difference in the number of family members between the two regions and two TAC groups.

The teachers who questioned and completed the frequency of food intake Shows 200 cases. The amounts of dietary intake for energy and Findings related to food groups intake (fruits, corn, vegetables, cereals, nuts Dairy products, meat) are given in Table 2.

The results showed that teachers in the TAC3 group compare to the TAC1 group intake more amount of vegetables, corn, cereals, fruits, nuts, meat.

Findings related to nutrient intake by Dietary Tertiles. linoleic acid, vitamin C, D, B1, B2, B3, B6, folate, B12, Selenium, and Zinc In polluted and less polluted areas are presented in Table 3.



Table 1-Pollution status and DTAC: comparing anxiety score and memory score in two air polluted areas and between total antioxidant capacity tertiles.

Dietary tertiles (DTAC)	TAC 1	TAC 2	TAC 3	P(value)	Less polluted region(Tehran)	Polluted region(reycity)	P(value)
Age	41.3±7.0	41.1±7.2	42.2±8.0	۰,۴۳	41.4±7.4	41.7±8.0	۰,۲۸
Anxiety	77.4±16.1	76.8±16.8	73.5±16.3	۰,۳۳	75.4±16.2	76.4±16.6	۰,۶۱
Memory score	117.1±9.1	115.2±1.8	119.0±3.2	۰,۱۷	116.8±12.0	117.5±11.1	۰,۳۳
Sex(female)	%۵۳	%۳۴	%۳۳	۰,۰۳	%۳۷	%۴۳	۰,۴۷

*ANOVA test for quantitative variables

\$ Chi-square test for qualitative variables

Table 2: Dietary intake information and pollution status* TAC: interaction air pollution and total antioxidant capacity.

Dietary Tertiles	TAC ^۱	TAC ^۲	TAC ^۳	P value	Less polluted region(Tehran)	Polluted region(reycity)	P value
fruits	260.4±58.7	313.7±107.1	445.4±332.0	<0.001	348.4±237.4	332.0±197.8	۰,۵۹
corns	530.0±161.6	578.3±178.0	649.2±271.0	<0.001	603.5±223.9	598.9±216.2	۰,۸۸
vegetables	200.8±69.9	238.9±109.2	323.3±171.0	<0.001	248.3±113.3	260.9±151.7	۰,۵۰
cereals	44.6±32.2	46.1±32.5	64.1±47.6	0.005	49.6±37.4	53.7±40.6	۰,۴۶
nuts	14.9±10.3	22.2±13.8	41.9±57.9	<0.001	24.9±24.0	27.9±45.9	۰,۵۷
Dairy products	280.3±113.3	355.8±237.7	381.8±181.9	0.005	347.9±212.2	331.2±163.4	۰,۵۳
meat	86.3±49.1	88.3±48.8	114.4±66.7	0.006	93.9±51.1	98.9±62.0	۰,۵۳

*ANOVA test for quantitative variables

Table 4. The interaction between air pollution ,DTAC , memory and anxiety

DTAC Tertiles	TAC 1	TAC 2	TAC 3	P(value)
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Memory				
Less polluted region	116.3±2.0	115.0±2.0	116.3±2.0	NS
Polluted region	117.9±1.9	114.6±1.9	117.9±1.9	NS
Anxiety				
Less polluted region	73.6±2.9	79.8±2.8	73.6±2.9	NS
Polluted region	80.8±2.7	73.9±2.8	80.8±2.7	NS

Table 3. Nutrient intake by Dietary Tertiles .linoleic acid, vitamin C,D, B1·B2· B3·B6 ·folate,B12, Selenium and Zinc. In polluted areas.

Dietary Tertiles (DTAC)	TAC ¹	TAC ²	TAC ³	P value	Less polluted region(Tehran)	Polluted region(rey city)	P value
Linoleic Acid	0.8±0.4	1.0±0.7	1.2±0.8	0.002	1.0±0.5	1.1±0.8	0.26
C	124.4±33.8	151.7±64.9	203.3±125.7	0.001	153.8±70.7	166.2±105.7	0.33
Fe	37.8±21.8	45.1±29.1	53.5±28.9	0.004	41.9±22.1	49.2±31.6	0.05
E	20.3±13.0	19.6±7.2	22.4±7.4	0.20	21.5±8.1	20.1±10.9	0.33
B1	1.9±0.5	2.2±0.5	2.7±0.9	0.001	2.2±0.7	2.3±0.8	0.50
B2	2.1±0.6	2.4±0.8	2.9±1.2	0.001	2.3±0.8	2.5±1.0	0.18
B3	24.1±6.3	26.4±6.7	33.7±12.2	0.001	27.2±8.88	28.9±10.6	0.19
B6	1.9±0.4	2.1±0.5	2.4±0.9	0.001	2.2±0.6	2.3±0.8	0.25
folate	559.6±156.2	628.8±152.4	770.1±204.4	0.001	642.1±186.2	664.5±221.4	0.44
D	617.8±167.5	689.4±171.2	827.5±242.9	0.001	699.9±197.6	724.1±230.9	0.42
B12	4.1±2.0	4.5±2.1	6.7±9.4	0.001	4.7±2.5	5.6±7.9	0.27
selenium	133.2±43.4	141.3±39.0	179.5±91.2	0.001	147.8±65.3	155.1±65.9	0.42



There was no statistically significant between in vitamin E intake of teachers between tertiles. Teachers who live in polluted area intake more Fe compare to those in less polluted areas. p value < 0.05 .

There was no statistical significant between other dietary food groups or nutrients in polluted and less polluted areas. Findings which is related to interaction among air pollution and DTAC with memory score and anxiety are shown in table 4. In the case of memory, there was no significant relationship between memory and air pollution before. Also, There was no significant relationship between memory and diet.

Discussion

The present study was conducted on teachers in Tehran and interactions between air pollution and total antioxidant capacity of the diet focused on the memory and anxiety of teachers.

The results of this study showed that teachers who live in polluted area consume more fruit, vegetables, vitamin D, vitamin C, vitamin B12, B1, B2, B3, B6, Folate, zinc, iron, selenium, and carbohydrates but there are no significant differences between two regions. Teachers in polluted area intake more Fe p value < 0.05 . The interaction of air pollution and dietary total antioxidant capacity on memory was not significant (0.66), and the interaction of air pollution and dietary total antioxidant capacity on anxiety was not significant ($p=0.66$), too.

According to the results of this study, the difference between anxiety in the two polluted and less polluted areas was not meaningful ($p=0.66$), which means that our hypothesis has been rejected on the relationship between air pollution and teachers' anxiety. Mehta and his colleagues in longitudinal analysis on 987 older men shows that Air pollution was associated with higher levels of perceived stress in aged men. Specially in colder months for specific pollutants (included ambient particulate matter $\leq 2.5 \mu\text{m}$ in diameter (PM_{2.5}), sulfate particles (SO₄²⁻), black carbon (BC), and particle number counts (PNC). It is a prospective study which is conducted in winter, our study was done in winter and spring but not only the duration was shorter but also the sample size was more little than Mehta's study (Mehta, Kubzansky et al. 2015).

The results of this study showed that teachers in the less polluted areas received more memory scores, but p -value was not significant neither in one region (before compare to after study) nor in two regions. Therefore, air pollution is not related to teachers' memory. So, our hypothesis is rejected. According to previous studies, the effect of air pollution on memory was expected to be significant. Possible causes are aggregated of pollutants in our study.

The results of the Maria study were not in line with our study. This cohort study was conducted on 1000 pairs of children and mothers exposed to PM_{2.5} and carbon black. The scores for IQ cognitive assessments, nonverbal memory, design memory, and video memory were less than normal among participants who lived 50 meters from the main road (Harris, Gold et al. 2015).



Probably the reason for the significance of the relationship in this study was assessment a type of pollutant, PM_{2.5} and high sample volume. The other reason might be the type of study, we did a cross-sectional study with less time than Maria's cohort study.

The study of Aungudornpukdee et al., which was about the influence of petrochemical agents on children's memory, used a digit span test, and the memory rating of residents near the refinery was reported to be lower (Aungudornpukdee, Vichit-Vadakan et al. 2010). likewise, in Carmen's study, there was a reduction in children's working memory. In this study, an air pollution marker (NO₂) was investigated and a memory evaluation tool (MSCA) was used (Freire, Ramos et al. 2010), It should be said that the differences in the type of pollutants, as well as the memory test, are responsible to see such different results in these two studies.

Cramer observed the reduction in working memory in children (Cramer 2002). he used The memory evaluation tool (MSCA) (Freire, Ramos et al. 2010). Moreover, an air pollution marker (NO₂) was evaluated (Freire, Ramos et al. 2010).

The difference in the type of pollutants, as well as the memory test, is a charge for the difference in results. We used the Wechsler test in our study.

According to the results of this study, the interaction between total antioxidant capacity and anxiety was not significant. Thus, it isn't in line with our hypothesize "anxiety is related to the total antioxidant capacity of the diet"

In our study, people with a higher TAC level scored that life in the less polluted area have not more anxiety than those in lower TAC that live in the polluted area.

Power investigated the effect of PM_{2.5} exposure on anxiety prevalence in women with age 57-85 in cohort study. there is a significant difference between PM_{2.5} exposure group and anxiety prevalence (Power, Kioumourtzoglou et al. 2015). this study isn't in the line with our study.

In this study they use the Crown-Crisp index for estimated anxiety. this test was different from the (CPT) which is used in our study.

The results of the Vert study were consistent in consist of our study. they assessed the exposure to pollutant particles (PM₁₀, NO₂, PM_{2.5}) in people with age 45-84 during one year on anxiety. there are no significant differences (Vert, Sánchez-Benavides et al. 2017).

Mahash in cohort study approved that people who have lower DTAC and were exposed to air pollution (SO₂, CO, NO) have higher anxiety score. the result off this study isn't in consist of our study. it might be related to the type of study and the sample size (Mahesh, Lokesh et al. 2018).

Limitations

We could not consider significant differences between the score of information and memory in teachers of two regions. so it is might be related to population sample which is more lower power to show the difference.

This is a cross-sectional study that is related to study time limitation. Because the duration of exposure to pollution was so limited.



There is an investigation about the situation of openness or closure of doors and windows of cases at their houses or workplaces.

Conclusion:

This is the first study which is simultaneously examined these three variables. Previously, Other studies have examined two factors, and the researches have been investigated either food groups or types of food. The validity and reliability of memory and focus tests were high. The CPT test has a roughness of 90%.

According to the results of the study, Dr. Hadianfard and his colleagues found that the Farsi version of the CPT Continuous Performance Test has appropriate validity and reliability. In their study, the test-retest reliability test was between 52% and 93%.

In sum up, teachers with better scores have antioxidant-rich diets but the difference between the two areas was not significant. Also, teachers who have a higher intake of food have more consume vegetables, corn, cereals, fruits, nuts, meat, linoleic acid, vitamin C, D, B1·B2· B3·B6 ·folate, B12, Selenium and Zinc and they are in TAC3.

may be antioxidant are effective to interact with air pollution and decrease the decline in anxiety and memory score, but we couldn't show this relationships because of some limitations which is mentioned.

We recommend that ,if this study will be conducted by higher sample size and in longer duration or different design, the results might be different.

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