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Research Paper

Review of recent researches on air pollution effects on human cognitive functions

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Abstract

Air pollution is of factors leading to disturbance in nervous system while its acute neurological effects have not been completely studied. In metropolis, communities experience various social problems caused by air pollution such as retardate, academic disability, and increasing crime rate due to disturbed cognitive functions of children and vulnerable generation without being aware of the effect of air pollution on perception power of human. In this research, the published researches in 2017 available in database and publishers of valid scientific publications such as PubMed and Elsevier were reviewed then 11 related papers were selected to check and criticize their methodology, research instruments and results.

Results indicated that the review researches employed various tests and instruments to assess cognitive functions, but most of them obtained similar results introducing disturbing and preventive effect of air pollution on mental functions; however, these studies did not determine the prominent effect of each air pollutant factor on specific area of brain and effect of genetic and environmental background of individuals. Moreover, valid and authentic tests were not employed in many of these papers to assess cognitive function and perception power, while validity and reliability of each of cognitive function tests have been determined and proved to assess the function of specific part of brain.

Keywords: *Air Pollution; Cognitive Function; Executive Functions; Wechsler Intelligence and Memory Test; Neurological Disorder.*

1. Introduction

Exposure to air pollution is in relation with nervous inflammation and neuropathology in citizens. One of the most significant effects of air pollution in particular fine particles on brain is injuries in the forehead, temporal and lacrimal lobes of the brain. Researches indicate that individuals, who have been exposed to fine particles for long time, suffer from injuries in forehead and lacrimal lobes. These injuries lead to decreased cognitive functions including attention deficit, short-term memory loss, poor performance in picture completion (video memory), and lower general intelligence especially in children [1].

Cognitive function (mind performance) consists of a wide range of judgment scopes and decision-making, visual search, consciousness, and memory reminder so that this function will be affected when facing environmental stresses such as air pollution, noise and pressure caused by activity. Cognitive appraisal is done to determine cognitive function level of brain; the person is asked in this process to do some tasks that require cognitive skills. One of methods for cognitive appraisal is using valid tests [2].

According to study of Victoria Anne Dietz et al., 1599 psychologists in governmental schools of New Jersey were surveyed about the most applied children and adults' neuropsychology tests. Accordingly, the most popular test for cognitive function was Wechsler Intelligence Scale for Adults; moreover, the most applied methods of educational appraisal included Wechsler individual achievement test-version 3 (WIAT-III) and Woodcock-Johnson Tests of Achievement (WJ-III Ach). The most common appraisal method for social-emotional assessment was Behavioral Assessment System for Children (BASC-II) and second version of this test and third version of Conners test (Conners III) were the most applied systems [3].

To investigate the applied methods in researches on cognitive function evaluation of individuals when exposure to air pollution in this research, 91 journals of valid databases and publishers of Elsevier Academic, PubMed (PubMed) and some other authenticate publishers were searched.

Of published papers published mentioned scientific and authenticate journals in 2017, 11 papers related to effects of air pollution on human cognitive functions were received. All of these papers were selected and studied then results of them were reviewed by 4 professors. Table 1 indicates properties of mentioned papers.

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Table 1: Papers Received From Scientific Databases. 2017

Row	Title	Publisher's database-Release year- Journal address
1	Traffic-related Air Pollution and Attention in Primary School Children	Epidemiology • Volume 28, Number 2, March 2017 Inc. PubMed https://ehjournal.biomedcentral.com/articles/10.1186/s12940-017-0210-z www.epidem.com
2	Particulate air pollutants, APOE alleles and their contributions to cognitive impairment in older women and to amyloidogenesis in experimental models	Translational Psychiatry (2017) 7,e1022;doi:10.1038/tp.2016.280 PubMed www.nature.com/tp
3	Using machine learning to identify air pollution exposure profiles associated with early cognitive skills among U.S. children	Environmental Pollution 230 (2017) 730-740 http://dx.doi.org/10.1016/j.envpol.2017.07.023 www.elsevier.com
4	Neighborhood social stressors, fine particulate matter air pollution, and cognitive function among older U.S. adults	J. Ailshire et al. / Social Science & Medicine 172 (2017) 56e63 www.elsevier.com
5	Particulate matter air pollution associated with hospital admissions for mental disorders: A time-series study in Beijing,China	European Psychiatry 44 (2017). http://www.europsy-journal.com www.elsevier.com
6	Smog in Our Brains: Gender Differences in the Impact of Exposure to Air Pollution on Cognitive Performance	IZA – Institute of Labor Economics .March (2017) IZA DP No. 10628 www.iza.org
7	Exposure to air pollution as a potential contributor to cognitive function, cognitive decline, brain imaging, and dementia: A systematic review of epidemiologic research	NeuroToxicology Volume 56, September 2016, Pages 235-253 https://doi.org/10.1016/j.neuro.-2016 ,.published(2017) https://www.sciencedirect.com
8	Cognitive deficits due to thermal stress: An exploratory study on soldiers in deserts	Air Vice Marshal R.C. Das DOI: (2017) http://dx.doi.org/10.1016/j.mjafi.2017.07.011 www.elsevier.com
9	Effects of low-level prenatal lead exposure on child IQ at 4 and 8years in a UK birth cohort study	NeuroToxicology 62 (2017) 162–169 http://dx.doi.org/10.1016/j.neuro.2017.07.003 www.elsevier.com
10	Methylmercury exposure and cognitive abilities and behavior at 10years of age	Environment International 102 (2017) 97–105 http://dx.doi.org/10.1016/j.envint.2017.02.004 www.elsevier.com
11	Early-life exposure to air pollution and greater use of academic support services in childhood: a population-based cohort study of urban children	Environmental Health (2017) 16:2 DOI 10.1186/s12940-017-0210-z https://www.researchgate.net/publication/312503607

This study aimed at comparing methodology or released papers in past year besides comparing cognitive function assessment tools when exposing to air pollution reviewing results of these studies.

2. Researches results

The summary of methodology, comparison between cognitive function assessment tools in exposure to air pollution and important achievements of 11 researches obtained from valid scientific databases are as follows:

A study was conducted entitled “traffic-related air pollution and attention in primary school children short-term association” by Jordi Sunyer and colleagues [4].

It is explained in this research that although short-term effects of air pollution are recognizable and preventable, it seems that acute psychological-neurological effects of this pollution have not been studied yet. The objective of this study was to investigate the relationship between various rates of daily traffic-related pollution and attention level of individuals. The methodology of this study was assessment of cognitive growth of children changing their attention and performance of working memory. For this purpose, of 2687 schools, 265 classes in 39 schools in Barcelona were studied during January 2012-March 2013. Schools were selected based on the modeled amounts of NO2 related to traffic and combination of schools in places with high and low NO2 was done based on the social vulnerability index and type of school (governmental or non-profitable). Participants were not different in terms of gender and age (7-10 years old) but have good or excellent academic achievement.

The authors evaluated 4 domains of children attention process every three months through more than 4 revisits and totally, 10.002 computer test were prepared during 177 days using attention network test (ANT) of children. In this research daily levels of NO2 and element carbon (EC) in particles filters>2.5μm (2.5PM) were measured in air quality monitoring station and schools. The selected validation tests for attention appraisal was the main ANT and N-back was selected to evaluate children’s working memory. The model of average concentration of NO2 and EC was prepared for each class. Research data were calculated using computer program of psychology test (E-Prime) and statistical analysis was done through Stata Software. Results of this study showed that daily environmental level of NO2 and EC has negative relationship with all of attention processes. For instance, those children who were in contact with lower level of NO2 daily had 14.8 seconds faster response compared to those who had daily contact with upper level of this gas and this was equal to 1.1 months retardation in natural growth and response

rate with increasing age. Similar findings observed after implementing tests for internal environment (class) and pollutants' level. Results of EC gas also were similar to results of NO2 gas. Achievement of this study expresses that the relationship between short-term effect of traffic-related air pollutants and attention fluctuations imply that air pollution have destructive effects on neurological growth. However, the hypothesis that air pollution is the factor affecting neurological development has not been accurately tested due to limits in public population. Researchers did not observe any relationship between short-term connection and working memory of people. In contrary, exposure to NO2 was accompanied with reduced attention and working memory processes. In addition, results of this study showed a strong relationship between traffic-related air pollution and child's attention within long-term contact with air pollution compared to short-term contact [4].

Another study was conducted by M Cacciottolo and his colleagues under the title of "particulate air pollutants, APOE alleles and their contributions to cognitive impairment in older women and to amyloidogenesis in experimental models" [5].

Authors of this research have expressed that exposure to air particulates (PM) and its interaction with APOE alleles may contribute to aging brain and Pathogenesis of Alzheimer's Disease (AD). Therefore, neurogenic effects of air particles pollutions on a group of older women belonged to Women's Health Initiative Memory Study were examined using prepared models for experimental mice. Exposure of Neuroblastoma cells (N2a-APP / swe) to Nanosize particles (PMn) increases Pro-Amyloidogenic processing. This substance is the Amyloid Precursor Protein (APP). According to methodology of this study, participants in WHIMS association were local houses (95% in urban areas) in 48 states; they were 65-79 years old individuals without any dementia at the time of participation in study. Authors of this study prepared spatial and temporal models to estimate PM2.5 concentration in all of residential places of WHIMS during 1999-2010 using Bayesian Maximum Entropy Method. This method collects data monitoring of the country in US. EPA air quality system (AQS) and output of chemical transportation models were used to define spatial dependence on time of environmental data in order to estimate the model of mean and covariance process of air pollution fields with PM2.5 particulates in time and place. In this regard, annual time series of exposure to PM2.5 was prepared then it was combined with living duration and their relocation in order to calculate average exposure of individuals to PM2.5 during three years. Statistical analysis of this study was done using SAS system for windows. Results obtained from this study showed that living in places consisting of PM levels higher than EPA standards increases the risk of cognitive disorder and dementia equal to 81% and 92%, respectively so that such pollution has destructive effects on APOE 4.4 carriers. Infrastructural mechanisms may include increased brain Aβ production and changed CA1 hippocampal neurons and glutamate receptor subunits [5].

Another study was conducted by Jeanette A.Stingone and colleagues under the title of "using machine learning to identify air pollution exposure profiles associated with early cognitive skills among U.S. children"; this study was conducted in medical department of social health and environment in Sinai School of Medicine in New york [6].

Machine learning methods using data create an opportunity for simultaneous evaluation of effect of several air pollutants on health. This study aimed at using a two-phase data-centered approach to identify relationships between exposure profiles to air pollutant and children's cognitive skills. Methodology of this research was longitudinal study on 6900 children born in 2001 among kindergartens exposure to more than 104 toxic air pollutants; situation of these children had been recorded since 9 months of age. Multivariate linear regression was also prepared to design relevant models and estimate enlargement of effects then statistical method of ANOVA was used. Air pollutant factors were adopted from EPA. Results showed that those children who were exposure to lower amounts of Chloroethylene (common pollutant in urban area air) gained considerably lower scores in mathematics; such relationship was not observed for children living in urban communities. Therefore, confusion should be considered at first step in case of urbanism. Limiting analysis to populations living in urban areas and overpopulated regions in cities exposure to high levels of Isophorone, lower mathematics score were anticipated. Various standard tests were implemented in every kindergarten to evaluated mathematical and verbal skills of children required for entering school. Instruments of this test consisted of initial mathematical abilities. Children who live in regions with higher Isophorone had lower math scores, while exposure to Trichloroethylene indicated no relation with math scores [6].

Jennifer Ailshire and colleagues conducted a study entitled "neighborhood social stressors, fine particulate matter air pollution, and cognitive function among older U.S. adults" in USC Leonard Davis School of Gerontology, University of Southern California, Los Angeles to investigate the cognitive function and effect of air pollution [7].

There have been numerous studies on the relationship between environmental air pollution and adults' cognitive function. Seemingly, social-mental stress is the most identified factor that indicates vulnerability and differential sensitivity of old individuals livening in stressful neighborhoods to dangerous environmental substances; this factor also determines destructive health consequences caused by exposure to air pollution. This study aims finding whether social stresses in a neighborhood can approve the relationship between air pollutant particulates (PM 2.5) and adults' poor cognitive function or not. Methodology of this study included selecting 779 American citizens older than 55 and calculating annual average of PM 2.5 in their living place within 60 Km; these data were obtained from EPA identifiers. Cognitive function of these individuals was tested calculating number of errors in Short Portable Mental Status Questionnaire (SPMSQ) or phone and interview. Items of this questionnaire consisted of subitems about remembering date, weekday, name of president and his deputy in order to count wrong answers and score them. Two-way regression was used in this study to determine the relationship between various data categories, Chi-square tests were employed to analyze cognitive differences between individuals, and stress level in their living places then the relevant model was illustrated. Research findings indicated more strong relationship between PM2.5 particulates and cognitive mistakes among elders living in stressful areas so that these individuals had higher sensitivity to dangerous environmental factors and stressful factors [7].

Q.Gao and colleagues conducted a study entitled "particulate matter air pollution associated with hospital admissions for mental disorders: A time-series study in Beijing, China" [8].

Authors of this study have expressed that nervous system reacts to the environmental changes first and majority of biological reactions caused by climate show psychological, sensational or behavioral properties; in addition, air pollution have been recently recognized as one of harmful neurological poisons. There are few studies on air pollution and brain disorders in China. Considering changes in concentrations and resources of air pollution during past decade in china, it is required to examine acute effects of air pollution in open space on brain disorders. In this research, a time-series analysis was done to evaluate acute effects of PM on hospitalization of individuals in brain wards of hospitals in Beijing. This study was conducted to evaluate previous hypothesis of researchers about the increasing rate of admission in brain disorders hospitals with increasing PM concentration. This study can provide the field to use whether forecast in order to anticipate some mental responses by individuals that are at higher risk under the changing atmosphere circumstances; this study also presents some preventive actions to prevent from undesirable effects [8].

Another study was conducted by Xi Chen and colleagues (2017) under the title of "Smog in Our Brains: Gender Differences in the Impact of Exposure to Air Pollution on Cognitive Performance" [9].

It has been expressed by authors of this study that although there are numerous published texts about negative effects of air pollu-

tion on health, effects of it on cognitive performance of total population have been ignored. Cumulative exposure effects simultaneously with air pollution effect on cognitive performance have been examined in this research based on the national survey from China society. This national study estimated simultaneous and cumulative effects of air pollution on cognition adjusting scores of verbal and math tests of persons older than 10 with local air quality in accurate date and certain place of interview. Methodology of this study was based on scores of CFPS cognitive test that is a China Family Panel Study during 2010, 2012 and 2014. CFPS included some studies about a wide range of topics related to families and individuals living in 162 cities in 25 provinces of China; this information included their economic activities, education results, family dynamism and their relationships, health, and cognitive abilities. Researchers of this study measured air quality using air pollution index (API) based on the assessment of daily rate of three atmospheric pollution including SO2, NO2, and particulate smaller than 10μm (PM_{10}). According to results of this study, when men exposure to similar doses of air pollution, act worse than women. Researchers combined a longitudinal sample at individual level with local air quality data and considered accurate date and area of interview then found that simultaneous and cumulative exposure to air pollution prevents from verbal scores of two math and theoretical lessons. It should be mentioned that this negative effect is stronger for men compared to women. In particular, gender difference was more obvious among older and less-educated individuals in case of low verbal scores of math and theoretical lessons [9].

MC. Power and colleagues carried out a study under the title of "exposure to air pollution as a potential contributor to cognitive function, cognitive decline, brain imaging, and dementia: a systematic review of epidemiologic research [10].

Authors of this paper have stated that dementia is a destructive disease usually diagnosed with long-period initial symptoms of disease and continues with neuropathology accumulation and accelerating cognitive loss. Numerous epidemiologic studies have examined the relationship between air pollution and consequences related to dementia. Methodology of this study was a systematic method including quality appraisal to interpret collected findings and describe cognitive challenges that may limit study procedure. Articles with certain protocol have determined quality of correlation between air pollution, cognitive function, cognitive decline, brain imaging, and dementia.

According to results of this study obtained from the reviewing 18 articles, quality of most of studies was unique and enough and almost all of them have reported poor relationship between at least one pollutant and one result related to dementia. However, few studies have presented robust evidences and reasons for cognitive or internal pathologic changes in persons. Undoubtedly, most of studies may have bias error in case of protected communities and it seems unlikely that they have considered observed bad communities. In this regard, researchers used formal sensitivity analysis and found that biased or unmeasured findings may have not explained unfavorable communities. Moreover, researchers have identified several common challenges; first, majority of studies related to dementia find cases in health system files. Since dementia is not well diagnosed in society, this may lead to bias in classification. Second, consequences of current air pollution in almost all of studies have been replaced with metrics of exposure to long-term air pollution. Although when the assessed etiologic factors with several years gap are separated from each other, this approach may be reasonable but its validity is unknown in long distances. Third, comparison of community magnification may have not been accurately mentioned; in this case, pollutant factors are considered as possible not imminent agents because the rate of exposure to unclassified pollutions is different for each kind of pollutants. Epidemiologic evidences besides other antecedents obtained from other researches confirm the correlation between air pollution and brain dementia [10].

R Saini conducted a study entitled "cognitive deficits due to thermal stress: an exploratory study on soldiers in deserts" [11].

Researchers of this study believe that environmental factors play a vital role in human performance; in particular, high temperature and humidity lead to reduced mental function with changing mind and brain neurons as well as electrolyte disorders leading to reduction in overall productivity of human. Although physiological responses to environmental heat have been recognized, its effect on cognitive function is not clear. This study aimed at examining the effect of high temperature on cognition. In methodology of this study, 100 healthy 20-30 years old soldiers who had been at least one year in desert conditions before participating in study. Cognitive function and memory of respondents was evaluated twice in February and June months. Average age of individuals was 25.8 and generated data were analyzed through appropriate statistical methods. Results of this study showed a significant reduction in cognitive function in hot weather compared to natural weather in memory scale (PGI) and among educated individuals at MA degree ($P<0.05$). There was a high effect of tests, which require continuous attention, concentration, psychological function, verbal memory, and executive performance test. This was a first study in real desert conditions. Findings of this research indicated harmful effects of thermal stress on cognitive function of soldiers [11].

Another study was conducted by Caroline M. Taylor and colleagues (2017) in Centre for Child and Adolescent Health, School of Social and Community Medicine, University of Bristol, UK under the title of "effects of low-level prenatal lead exposure on child IQ at 4 and 8 years in a UK birth cohort study" [12].

The relationship between exposure to lead (Pb) and cognitive dysfunction has been proved, but this relationship has not been understood well for prenatal; however, it is essential to find its potential side effects. This study aimed at evaluating the relationship between prenatal IQ and exposure to Pb determining whether gender difference exist in this case or not. In addition, the moderating effect of exposure to Pb on prenatal IQ was studied. Methodology of this study consisted of blood test for 4285 pregnant women registered in association and 235 infants at with 30 months age. In this experiment, the relationship between Pb concentration in infants' blood during prenatal period and IQ of them at age of 4-8 years old was analyzed and the relevant model was designed. Blood lead levels of all mothers was measured using IPMS (Inductively coupled plasma mass spectrometry) and blood test was implemented for 10% of 4-8 years old children. Statistical analysis was done through SPSS Software. In case of assessing IQ of children, verbal test of IQ was done by expert psychologists. In addition, Wechsler Intelligence Scale (WISCIII) was implemented for pre-school, primary school, and 4-years old children and Wechsler Intelligence Scale for Children was implemented for 8-years old children. Total scores of verbal intelligence subtests was employed to measure verbal IQ and total scores of executive intelligence subtests was used to measure functional IQ then scores of 10 subtests were employed to obtain score of Total IQ. To analyze difference between groups' data, Chi-square test was used and to compare continuous values and blood lead values (B-Pb), ANOVA method was used. Univariate and multivariate linear regression models were employed to examine the relationship between B-Pb and verbal-functional IQ of 4-8 years old children. Results of this study indicated no relationship between Pb pollution and children's IQ at 4-8 years old age before and after childbirth in adjusted regression models and there was not any relationship between B-Pb level and IQ. However, there was a positive relationship for 8-years old girls' IQ so that anticipation shows that each 1mg/dl increase in Pb leads to 0.71 verbal IQ, 0.57 executive intelligence, and 0.73 total IQ; these coefficients were negative among boys (respectively equal to -0.51, -0.42, -0.29). In addition, results of this study showed the exposure to Pb before birth did not lead to side effects on 4-8 years old children. However, there are some evidences in this study indicating boys are more sensitive than girls are in case of being exposure to Pb during prenatal period [12].

Another study was conducted by Klara Gustin and colleagues in Institute of Environmental Medicine in Stockholm, Sweden enti-

tled "Methylmercury exposure and cognitive abilities and behavior at 10 years of age". This study was conducted to examine effect of MeHg factor as neurotoxin of nervous evolution in fishes on cognitive performance of 10-years old children. This effect has not been clear on children with food poverty. In this study, effect of MeHg was examined in poor villages of Bangladesh [13].

Method of this study was evaluation of MeHg in 1434 10-years old children assessing concentration of this substance in hair through spectrometry. Mental function of children was assessed using Wechsler Intelligence Scale for Children. Research data imply that average Hg existing in hair of children was equal to 674µg/kg while concentration of substance was not changed with distancing from hair scalp. In addition, there was not any modified multivariate relationship between Hg of children's hair and their cognitive ability. Moreover, children with higher Hg in this hair had lower hyperactivity and communicational problems compared to other children. Similar assessments were stronger in children born in families with low economic-social status compared to children born in rich families. The similar calculated values were observed in low-weight children born in poor families. Results of study indicated no relationship between MeHg exposure and cognitive function while there was a relationship between MeHg exposure and specific misbehaviors of children [13].

Jeanette A. Stingone conducted a study entitled "early-life exposure to air pollution and greater use of academic support services in childhood: a population-based cohort study of urban children" [14].

Researchers of this study believe that there is a promoting culture indicates the relationship between air pollution and neurological growth of children before and after birth. However, it is not obvious in epidemiologic studies whether neural growth leads to prominent changes in performance of children. This study aimed at investigating the relationship between initial exposure to toxic pollutants of public air in the city and use of educational supports-before primitive teacher help in specific teaching and children learning- in a group of urban children. In methodology of this study, data of 201.599 children born in 1994-1998 in New York were obtained. These data were related to needs of children to initial educational support and educational backgrounds adopted from Administrative Communication and Birth Information. Consensus was done since birth time and data of using educational support services considered between birth time and third grade. To determine approximate mean of annual concentration of Benzene, Toluene, Ethylbenzene and Xylene (BTEX), EPA's National Air Toxics Assessment/NATA was used. Discrete-time hazard model is adjusted to data and modified for ambiguous cases such as congenital factors, childhood conditions, and neighborhood living factors. Statistical analysis of study designed the discrete-time hazard model in order to evaluate the relationship between metrics or exposure to mentioned substances and using academic support services. Results of this study showed that children with more exposure to BTEX combinations might more likely receive educational support services such as speech therapy, job therapy, etc. during childhood. For instance, the modified hazard ratio in persons with higher benzene exposure is equal to 1.09 compared to individual exposure to lower values. Fixed results obtained for individual exposure to BTEX compounds. Sensitivity in exposure to 4 types of BTEX pollutions has been assessed for various analyses. According to findings of this study, air pollution in cities may affect the neural growth of children and their educational process. In addition, it is recommended to use public health information system to promote heath studies on children's environment [14].

3. Conclusion

In general, mind is the topic of cognitive sciences. Study of twins indicated genetic and environment affects various parts of brain. According to the study published in Journal of Nuclear Medicine in March shows that effect of genes on glucose metabolism plays a vital role in parietal lobe and left temporal lobe while environment effects can be seen in other regions of brain [15].

Hatazawa states about the mentioned study, although previous studies have examined considerable effect of genetic on volume of gray matter in the frontal cortex, this study shows that glucose metabolism in forehead is more affected by environmental factors. If we know those parts of brain that are more affected by environment and pollutant agents, we will understand neurologic disorders and cognitive function better [15].

Reviewing selected papers in this research, it was found that

- In many of these studies, IQ inheritance and role of genetic in mental performance have been ignored and individuals have been similarly studied despite their hereditary differences and genetic adaptations. Moreover, spatial and time models for pollutant concentration estimation and climate conditions in certain time intervals should be used as the base for assessing air pollution effect on mental performance.
- In some of studies, researchers have not considered air pollutant factors in accordance with long-term and short-term effects on mind of individuals in order to examine effect of air pollution on cognitive function of people. Environmental and epidemiological studies are about long-term effect of long-term exposure to air pollutants requiring estimation of average exposure of human to pollutants for long-term period so that changes in concentration of pollutants during one of several years should be examined in these studies. This estimation and appraisal should be done for air pollution rate in open spaces and places such as school, workplace, and other places where people spend their time.

Of studied papers, research of Cacciottolo and colleagues was neuro epidemiologic-pollution research about particulate air pollutants and APOE alleles' contributions to cognitive impairment in older women; in this research, distribution model was prepared for air pollution at a 10-year section. Exposure to PMn and APOE genotype of persons in 3-year time interval was adjusted to experimental model. In this study, dementia in older people was examined in accordance with 3-year exposure to $PM_{2.5}$ without pointing to assessment method; such result may have been obtained from clinical record of these people.

In this study, side effects of $PM_{2.5}$ on cognitive impairment of older women have been determined and classified by APOE allele. Estimations were based on the age, geographical region, stochastic effect of place, academic year, household income, occupation status, factors related lifestyle (smoking, alcohol consumption, physical activities) and clinical specifications (having hormone treatment, depression, BMI, Hypercholesterolemia, Hypertension, Diabetes and History of Cardiovascular Diseases).

- Every researcher has a specific method to assess intelligence and memory of people exposure to air pollutants; hence, there is not a coherent method for this subject in different communities. Although study of one subject using different method leads to innovation, it would be better to use a valid similar method that its validity and reliability has been proved to obtain accurate and reliable results considering the similar brain physiology of all humans in case of assessing cognitive functions and understanding power capabilities such as IQ, working memory, verbal memory, etc.
- In some researches, number of hospitalized patients in brain centers and psychiatric hospitals has been mentioned as a reason for effect of particulate air pollution on brain impairment, while hospitalization of patients within a time section in mentioned hospitals may be related to that specific time despite the consistency with pollution. Hospitalization of more people is not a good reason for correlation between air pollution and mental dysfunction or dementia in case of evaluating acute effects of PM on hospitalization of people in brain disorder ward so it might be required to examined various genetic, climate, nutrition and other aspects in studied society. In other words, such methodology does not have

an appropriate validity and its results cannot be generalized to all of societies; hence, it is not reliable.

- It is essential to differentiate air pollutant factors to determine effect of each factor on cognitive function and mental capabilities of people. In some studies, specific effect of air pollutant factors on brain lobes has not been examined; in other words, total effect of air pollutant factors has not been differentiated.

As it is seen in reviewed researches, some of pollutant factors such as $PM_{2.5}$ or PM_{10} have harmful similar effects on IQ, memory or mental performance decline of persons in different conditions and societies. In addition, effects of heavy metals such as Hg and Pb on cognitive performance of individuals in various studies have been similar. Majority of studies pointed to the insignificant relationship between heavy metals existing in respiratory air and mental performance, IQ, and memory of people.

However, such studies approved destructive effect of some elements such as Pb and Hg on behavioral performance such as aggression and hyperactivity in children.

- In some of studies, assessment of air pollution effect on cognitive performance of people in accordance with old health documents of them relying on data obtained from stations for air quality assessment that are not reliable and update. Although results of such studies are sometimes real, old and invalid data are not reliable in a scientific study.
- In some researches that did not confirm the effect of some air pollutant factors such as Pb on cognitive performance but found it different in case of IQ of girls and boys, there is a conflict between abstract and conclusion of study so that evidences of study did not certainly support the relationship between pollutant element and cognitive performance of people.
- There is lack of scientific framework in abstract, research instruments and methodologies of some studies so that the result has been expressed without preparing the required content for each part. Such issue can be seen in a study entitled "cognitive deficits due to thermal stress" that was an exploratory study on soldiers in deserts. Seemingly, this has been a study on research activities of military force.
- In case of study on effect of environmental factors such as air pollution on cognitive performance of brain, IQ, memory and other cognitive performance, it is recommended to use valid tests designed by psychiatry centers and scientific brain and neurology centers for children and adults that have confirmed validity and reliability of these tests.

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