

Original article

Impact of exposure to Volatile organic Compounds (VOCs) on Cognitive functions among domestic painters

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ABSTRACT

Exposure to volatile organic compounds (VOCs) at work is a health concern in the recent decades. VOCs include benzene, toluene, xylene, styrene, polycyclic aromatic hydrocarbons, chlorinated solvents etc., which are present in paints, varnishes, paint pigments and adhesives. Domestic painters are exposed to a range of paints with varying levels of VOCs and are reported to affect neurological functions and cause neurotoxicity. While studies exist on VOC exposure among automobile painters, industry workers, carpenters, lab technicians etc in India, there is a significant gap in research on occupational health risks specifically for domestic painters. The present study aims to address this gap and assess their potential impacts on cognitive health of the domestic painters. The cognitive status was assessed with the help of Montreal cognitive assessment tool (MoCA). Domestic painters and the controls between the age group of 18-72 were involved in this study, with total 220 samples. The responses for the series of tasks and their scores were recorded as per the established guidelines. The scores were analysed using SPSS version 22 (IBM Corp. Released 2013). The total MoCA score observed was lesser for painters when compared with control population. Also, painters who had greater work experience were found to score less compared to people with less work experience. The present study suggests that chronic exposure to VOCs might influence the cognitive function and could affect the quality of their life even after retirement.

(keywords: Cognition, Volatile organic compounds, VOCs, Cognitive tests, Cognitive function, Montreal Cognitive Assessment, MoCA, Domestic painters

Introduction:

The health implications on exposure to Volatile organic compounds (VOCs) at work place is a significant focal point in recent decades. The painting profession is an integral part of the construction and maintenance industry in which the Domestic painters play a substantial role. They are regularly exposed to potentially harmful chemicals collectively called as Volatile organic compounds. Volatile organic compounds are the substances that evaporate easily at room temperature.¹ VOCs in paints include benzene, ethylbenzene, toluene, xylene, styrene, polyaromatic hydrocarbons – PAHs, chlorinated solvents like dichloromethane, trichloromethane and aromatic azodyes.^{1, 2} Studies have suggested that chronic exposure to these chemicals may affect the central nervous system CNS, leading to subtle but significant impairments in cognitive performance.^{3, 4} While studies exist on automobile painters, painting industry workers, carpenters, histopathology lab technicians and personal exposure to individual VOCs in India there is a notable dearth in studying the occupational health and exposure to volatile organic compounds among domestic painters. The present study proposes to examine if long-term or short-term exposure of the VOCs has any evident effect on cognitive function among domestic painters in Coimbatore.

Materials and Methods:

Study Population:

Domestic painters and control population of 220, between the age group of 18-72 were involved in the study. Personal data of the study participants that included age, occupation, number of years of painting, nature of painting brush, roller, spray, type of painting surfaces, varieties of paints handled with, duration of working hours, educational & social background, sleep hygiene, sports activities, past /present h/o illness & medications

on the same were collected using general structured questionnaire. All the above details of the control population were also collected similarly except for the painting details.

Study design:

This is a cross-sectional comparative study conducted among the domestic painters and controls in the city of Coimbatore, Tamilnadu between December 2022 till August 2023. The study the participants were evaluated for the study and met the inclusion criteria. Cognitive assessment of each of the study participant was evaluated with the Montreal Cognitive Assessment MoCA, a globally validated cognitive screening tool.⁵⁻⁸ MoCA assesses the key domains like Visuospatial skill, naming, attention, language, abstraction, memory and orientation. The test was administered after completing the certification and training through the official MoCA website. To ensure cultural relevance and accuracy the test was administered in the participant's preferred language.⁹ This study employed both English and Tamil MoCA. Participants were fully informed about the test and its tasks beforehand, with reassurances about the confidentiality and purpose of the assessment of research. The MoCA test result were scored as per the established guidelines. Each domain of the tool has individual scoring with the total of 30 points. The cut-off value for English MoCA was 26/30 and for Tamil MoCA was 24/30.^{5,9} The score below this predefined score was indicative of potential cognitive impairment. Individuals who had less than 12 years of education were added 1 point extra as per the terms and conditions mentioned 5.

Ethics:

According to Indian Council of Medical Research rules Ref No. 61/MMCH&RI/2021, the protocol was authorized by the Institution Committee of Ethics in Human Research, which is part of Chettinad Academy of Research and Education CARE with the reference number - IHEC-II/0160/22. After being informed, every patient signed a written informed consent form for willingness to take part in the research.

Sample size:

The sample size for this study was determined based on the available literature on cognitive function assessments among workers exposed to organic solvents. Using the standard formula for comparing two means, the required sample size was calculated considering a confidence level of 95%. The expected mean difference and standard deviation were derived from previous studies investigating cognitive function impairments among occupationally exposed populations. Based on these parameters, the estimated sample size per group was 110, with an additional adjustment for potential dropouts resulting in a final sample size of 100 domestic painters and 100 controls.

Statistics:

The values were observed and analysed using SPSS version 22 software IBM SPSS Statistics V22.0.

Results:

Table: 1 MoCA comparison between Painters and Control group

MoCA	N	Mean $\pm$	SD	t-value	DF	p-value
Painter Group	112	16.51 $\pm$	3.44	-30.88	220	.000**
Control Group	110	27.85 $\pm$	1.76			

Note: ** $P < 0.01$

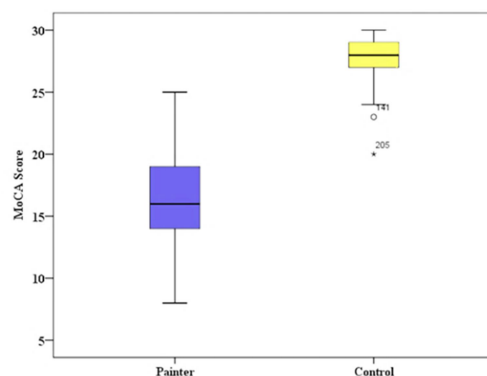


Fig:1 MoCA Score Comparison between Painters and Control

The total MoCA score comparison between the domestic painters and the control on the whole which is shown in Table:1. The **P value** <0.01 indicate statistical significance of exposure.

Table:2 MoCA- Evaluation of Cognitive Impairment

MoCA	Normal	Mild Cognitive	Moderate Cognitive	Severe Cognitive	Total
Painter Group	1 0.9%	43 38.4%	64 57.1%	4 3.6%	112
Control Group	106 96.4%	4 3.6%	0 0%	0 0%	110

The cognitive function range was compared between the two groups to understand if they have mild, moderate or severe impairment in percentage which is shown in Table 2. The normal MoCA score of control was 96.4% while of the exposed group was 0.9%. Around 38.4% were recorded to have mild cognitive impairment among the exposed group when compared to control 3.6%. 57.1% and 3.6% of painters were observed to have moderate and severe cognitive impairment respectively.

Table:3 MoCA Score Age Comparison between the control and painters

MoCA Score for age group	N	Mean	SD	F	Sig.
Painters					
Below 30 years	27	18.85 ±	3.49	13.14	.000**
31-40 years	33	17.45 ±	2.66		
41-50 years	35	14.60 ±	3.04		
Above 50 years	17	14.88 ±	2.52		
Control					
Below 30 years	34	28.79 ±	1.32	6.49	.000**
31-40 years	26	27.85 ±	2.29		

41-50 years	31	27.39 ±	1.54		
Above 50 years	19	26.95 ±	1.18		

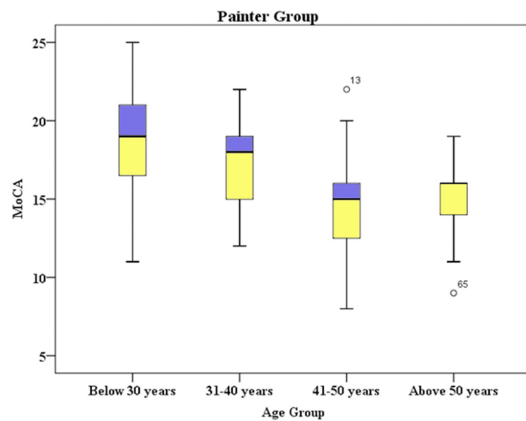


Fig 2: MoCA-Painters Age comparison

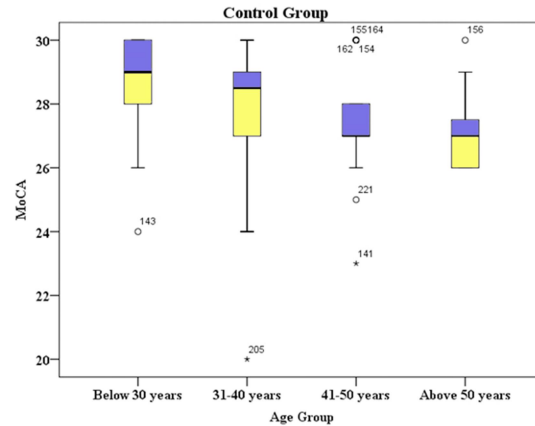


Fig 3: MoCA-Control Age Comparison

The MoCA test score compared across age groups for both the painters and the control population is shown in Table:3. The P value is less than 0.000 which shows significance in both the groups that there is decline in cognitive functions with increase in age but the values were more significant among the exposed population when compared with the reference group. Painters above 50 years of age performed lesser when compared to the other groups.

Tab:4 MoCA total score of Painters based on years of Experience

MoCA based on years of experience	N	Mean	SD	F	Sig.
1-5 years	19	19.00 ±	3.54	8.18	.000**
6-10 years	33	17.21 ±	3.07		
11-15 years	26	16.08 ±	3.40		
Above 15 years	34	14.76 ±	2.75		

Note: **.P<0.01

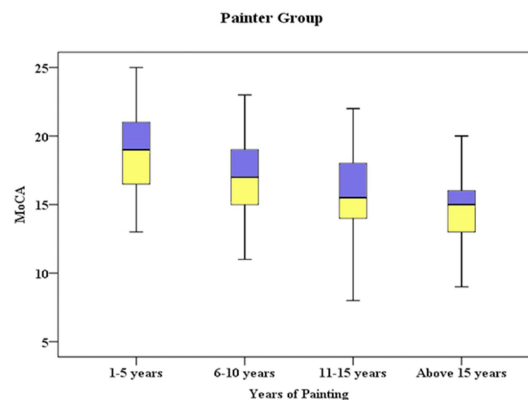


Fig4 : Painters Vs Years of Experience

Variations with the total MoCA score were observed among painters with respect to their years of experience Tab:4 and Fig 5. With increase in number of years of exposure there was decrease in performance with F value 8.18 and P< 0.01 indicating significance.

Tab:5 MoCA Domain of Painters and control

MoCA Domains	N	Mean	SD	t	df	p-value
Visuospatial						
Painter Group	112	1.59	±1.35	-20.08	220	.000**
Control Group	110	4.55	±0.76			
Naming						
Painter Group	112	2.96	±0.19	-2.13	220	.034*
Control Group	110	3.02	±0.19			
Attention						
Painter Group	112	2.40	±1.20	-22.38	220	.000**
Control Group	110	5.42	±0.76			
Language						
Painter Group	112	.71	±0.69	-20.20	220	.000**
Control Group	110	2.51	±0.63			
Abstraction						
Painter Group	112	.64	±0.61	-17.74	220	.000**
Control Group	110	1.85	±0.36			
Delayed Recall						
Painter Group	112	2.13	±1.22	-17.66	220	.000**
Control Group	110	4.47	±0.69			
Orientation						
Painter Group	112	5.40	±0.91	-6.79	220	.000**
Control Group	110	5.99	±0.09			

Note: The p value less than 0.00 and 0.05.

The MoCA domains like visuospatial skill, Naming, Attention, Language, Abstraction, Delayed recall memory and orientation were compared between domestic painters and the control population that showed statistical significance across all domains.

Tab :6 MoCA domain of painters with age categorisation

MoCA Domain	<30 years n=27		31-40 years n=33		41-50 years n=35		>50 years n=17		F	p- Value
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD		
Visuospatial	2.33	±1.41	1.94	±1.34	1.03	±1.04	0.88	±1.05	8.42	.000**
Naming	2.96	±0.19	2.97	±0.17	2.94	±0.24	3.00	±0.00	0.37	.778
Attention	2.89	±1.25	2.70	±1.01	1.86	±1.24	2.18	±0.88	5.34	.002**
Language	0.85	±0.72	0.91	±0.63	0.49	±0.61	0.59	±0.79	2.84	.041*
Abstraction	0.67	±0.48	0.82	±0.73	0.49	±0.51	0.59	±0.71	1.76	.159
Delayed Recall	2.78	±1.48	2.06	±0.97	1.69	±0.99	2.12	±1.27	4.54	.005**
Orientation	5.63	±0.69	5.55	±0.67	5.31	±1.02	4.94	±1.20	2.52	.061

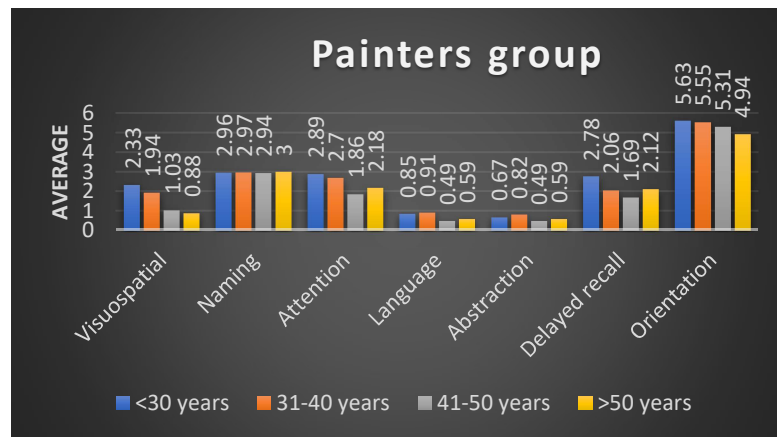


Fig 5: MoCA domain among painters across different age group

Each of the MoCA domain was analysed among the domestic painters with different age groups like below 30, 31-40, 41-50 and above 50. There was statistical significance observed in visuospatial execution, attention, language and delayed recall memory across these age groups.

Tab: 7 MoCA domain Control comparison with Age

MoCA Domain	<30 years n=34		31-40 years n=26		41-50 years n=31		>50 years n=19		F	p-value
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD		
Visuospatial	4.53	±0.61	4.69	±0.84	4.45	±0.92	4.58	±0.61	0.48	.694
Naming	3.00	±0.00	3.00	±0.00	3.06	±0.36	3.00	±0.00	0.85	.472
Attention	5.79	±0.48	5.42	±0.86	5.13	±0.88	5.21	±0.53	5.32	.002**
Language	2.88	±0.33	2.58	±0.58	2.26	±0.68	2.16	±0.69	9.42	.000**
Abstraction	1.94	±0.24	1.77	±0.43	1.84	±0.37	1.79	±0.42	1.34	.267

Delayed recall	4.68	±0.59	4.50	±0.91	4.42	±0.50	4.16	±0.69	2.50	.063
Orientation	6.00	±0.00	5.96	±0.20	6.00	±0.00	6.00	±0.00	1.08	.361

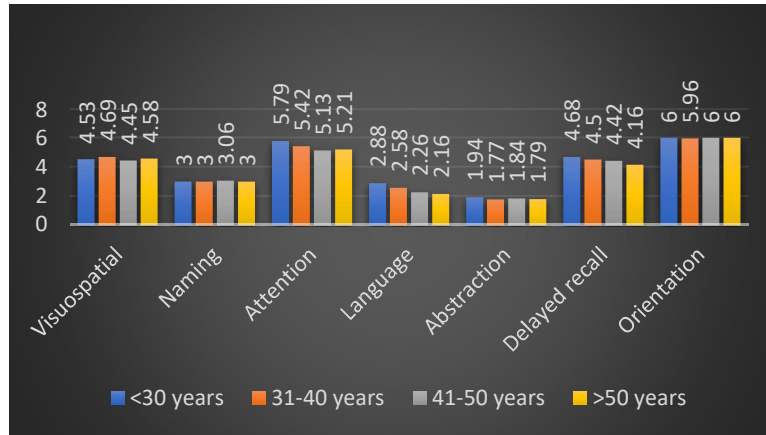


Fig 6 : MoCA domain among control across different age group

Similar to the painters group the control population were also categorised into four groups according to their age. The significance was observed in the domains like attention and language where as other domains did not exhibit significance.

Tab 8: Painter Group Comparison with Years of experience

MoCA domain	1-5 years n=19		6-10 years n=33		11-15 years n=26		>15 years n=34		F	p-value
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD		
Visuospatial	2.26	±1.45	1.97	±1.49	1.27	±1.25	1.09	±0.96	4.96	.003**
Naming	2.95	±0.23	3.00	±0.00	2.96	±0.20	2.94	±0.24	0.63	.600
Attention	2.63	±1.26	2.91	±1.04	2.27	±1.31	1.88	±1.01	4.93	.003**
Language	0.89	±0.81	0.82	±0.58	0.62	±0.64	0.59	±0.74	1.25	.296
Abstraction	0.74	±0.56	0.64	±0.55	0.69	±0.62	0.56	±0.70	0.41	.744
Delayed recall	2.95	±1.61	1.91	±0.98	2.04	±0.96	1.94	±1.20	3.81	.012*
Orientation	5.63	±0.76	5.45	±0.87	5.42	±0.81	5.21	±1.07	0.98	.405

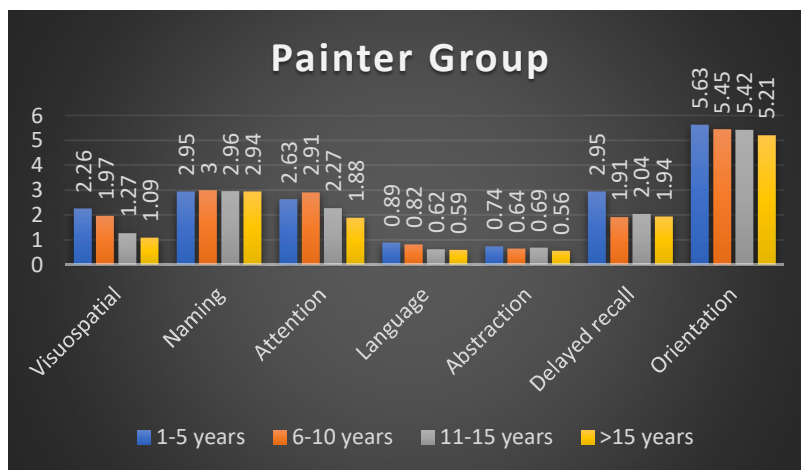


Fig 7: MoCA domain among painters based on work experience

The domestic painters were categorised based on their work experience into 4 groups like 1-5 years, 6 – 10 years, 11-15 years and above 15 years. Painters who had more than 10 years pf job experience showed less value in most of the domains with statistical significance except for naming, abstraction and delayed recall memory.

Post hoc analysis:

Post hoc Tukey HSD was subjected after ANOVA in order to understand the higher significance between the age groups for MoCA score and there was statistical significance between the ae groups between below 30 and 41-50 and above 50. Age group 41-50 and above 50 did not have any difference. But when compared the same age group of painters with the controls 41-50 and above 50 there were significance while the control group among themselves did not exhibit any differences.

Of all the domains, visuospatial skill and the delayed recall memory showed statistical significance between the age group of below 30 and above 50. Age group and below 30 and 41-50 age group among the painters with no difference exhibited among the other age groups. The control population had significance between below 30 and above 50 alone in both the domains like visuospatial skill and delayed recall memory. The other domains like naming, attention, language, abstraction and orientation did not show any statistical significance among the age groups though there were difference between the controls and the painters of the same age categories.

DISCUSSION

This study aimed to investigate the correlation between volatile organic compounds VOC exposure and cognitive function among domestic painters in Coimbatore. Out of 200 painters interviewed, 112, aged 18 to 70, participated n=112. A control group of 110 participants from various occupations, such as office workers, clerks, and drivers, was included. All participants received detailed information about the study objectives, methods, and potential health implications. The over-all MoCA score was less among the domestic painters when compared with the reference group with the cut-off value being 26/30 ad 24/30 T-MoCA. Individuals who had education less than 12 years were given an additional point in sum as per the guide lines.^{5,9} The decrease in total MoCA score in comparison of the painters with controls were statistically significant P value <0.01.

Among Mexico paint factory workers, that were categorised as high and low exposed groups and exposed to solvents for a longer period especially to toluene and xylene, the high exposed group manifested with lower cognitive score similar to our study.¹⁰ The study analysed for different age groups like below 30, between 31- 40, 41-50 and above 50. There was decline in the cognitive functions of the elderly painters of age above 50 when compared to other age groups among them and with the corresponding control population with statistical significance. Life time exposure to organic solvents among French utility workers showed association of cognitive decline over the age group of 55 proving the dose-effect relationship between solvent exposure and VOCs similar to our study.¹¹ In the present study we evidenced 38.4% of domestic painters were found to have mild cognitive impairment MCI, 57.1% moderate cognitive impairment and 3.6% severe impairment proving the association of occupational hazard to VOCs.

Participants below the age group of 30 performed better when compared to the other groups but lower with the reference group of the same age which is similar to the study that have reported cognitive deficits

among workers exposed even below the occupation exposure limits.^{12,13} In contrast to this, South African painters who were exposed to solvents below the maximum allowable limit value American Conference of Governmental Industrial Hygienists 1990 threshold value showed no effect of exposure which might be due to adherence of proper guidelines mentioned in the exposure limits.¹⁴ Statistical significance was evident even within the control group of participants below 30 years with those aged above 40 and above 50 but was not significant with the painters below the age of 30. There might be decline in cognitive functions observed due to aging process but a longitudinal study among printers who had sustained exposure of solvents contribute to negative outcomes during the aging journey.^{15,16}

Chronic exposure of the solvents especially to toluene among Japanese industrial painters mentioned poor performances in cognitive function after adjusted for age, education and alcohol intake with the reference group alike the present study.¹⁷ The painters were compared for the number of years of exposure and grouped as 1- 5 years of exposure, 6-10 years, 11-15 years and more than 15 years. Those who had job experience for more than 10 years presented with less MoCA score when compared with the other groups who had less work experience proving persistent exposure of solvents and reduction in the cognitive skills. This is consistent with the previous studies in which the workers who had long term contact with the solvents for 5-10 years exhibited more severe and diffused neurobehavioral deficits.^{18,19}

There was a significant difference in certain domains like visuo-spatial skill, attention, abstraction and delayed recall memory observed between the domestic painters and the control population in the present study. This aligns with the existing literature that has documented reduced performance in attention, working memory and poor motor performance among workers exposed to organic solvents.²⁰ Though there was difference in domains like naming and orientation between the two groups, the value was not statistically significant among the painters indicating mild cognitive impairment may not affect these domains.²¹

Daily exposure to solvents for more than five years had been linked to the development of a condition called Chronic solvent-induced encephalopathy CSE were illustrated in fewer studies.^{22,23,24} The International Labour Organisation have recognised officially CSE as an Occupational disease.²⁵ With this interpretation from the study on domestic painters who were chronically exposed to solvents are at risk of milder cognitive impairment. Some of the studies opinionated that not only extended duration of exposure to solvents caused cognitive impairment but also the affects persisted even after the exposure have ceased.^{26,27} Occupational exposure in the field of painting were categorised as a Group I carcinogen according to the IARC monograph volume 47 IARC 1989 which was established due to an elevated risk of lung cancer and reaffirmed in Monograph Volume 98 IARC,2010, a.²⁸

CONCLUSION:

Our findings conclude that both low level and chronic exposure were significant among domestic painters. Though Central Pollution Control Board have identified that contribution of VOCs from paint to the atmosphere is 46% among other sources the domestic painters are often unaddressed with very less awareness regarding the harmful effects of solvent exposure. Persistent daily exposure to VOCs especially among the domestic painters in their job in an unprotected and uncontrolled atmosphere may end up with adverse health effects. The observed health effects suggest the importance of revisiting and strengthening occupational health policies and regulations to protect the well-being of domestic painters. Use of proper personal protective devices, nose dust mask, hand gloves, respirator with filter during working hours, periodic medical examinations, working with products that has lesser solvent concentration has to be implemented in order can help identify early signs of health issues on exposure to VOCs.

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