IJBPAS, February, 2023, 12(2): 518-527

ISSN: 2277–4998

International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS)

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

BREATH ANALYSIS TO DETECT RECENT EXPOSURE TO EXHALED CARBON MONOXIDE AND NICOTINE DEPENDENCE AMONG ADULTS - A CROSS SECTIONAL STUDY

SINGH T*, CHAUDHARY A, KAUR N, SHARMA V, BHALLA M AND GUPTA R

Department of Public Health Dentistry, K.D Dental College & Hospital, Mathura, Uttar Pradesh-281121, INDIA

***Corresponding Author: Dr. Tanya Singh: E Mail: rs393387@gmail.com**

Received 29th March 2022; Revised 29th April 2022; Accepted 19th July 2022; Available online 1st Feb. 2023

https://doi.org/10.31032/IJBPAS/2023/12.2.6722

ABSTRACT

Introduction: Carbon monoxide (CO) is one of the most common and widely distributed air pollutants.

Aim: To detect recent exposure to exhaled carbon monoxide and nicotine dependence among adults attending dental college in Mathura city.

Methods: A cross-sectional study was carried out by using hand held breath analyser to measure end expiratory carbon monoxide concentrations in 600 subjects. Questionnaire data were collected to assess the effect of common sources of carbon monoxide exposure on breath carbon monoxide levels. Smokers were used as a carbon monoxide exposed group for comparison with non smokers. Fagerstrom test for nicotine dependence was used to assess the levels of nicotine dependence in smokers

Results: The exhaled carbon monoxide level was normal in 227 non smokers and 50 smokers out of 371 non smokers and 229 smokers. The mean carbon monoxide concentration in smokers and non smokers was 2.26±0.805 and 1.39±0.494 (p= 0.000) respectively. Passive smokers and frequent use of motor vehicle were associated with slightly higher carbon monoxide concentration (p= 0.000) in the non smoking group. The frequency and years of smoking was found as a significant risk indicator for nicotine dependence.

Conclusion: The present study showed that exhaled carbon monoxide concentration was higher in smokers. In non smokers, exhaled carbon monoxide level was higher in those who were passive smokers,

using motor vehicle and fossil fuel. The exhaled CO levels, frequency and years of smoking indicated a marker for nicotine dependence in smokers.

Keywords: Carbon monoxide, Smokers, Nicotine dependence

INTRODUCTION

Tobacco use is one among the five greatest risk factors for mortality, and also the single most preventable cause of death. In developing countries like India, the disease burden, health care costs as well as other fiscal losses resulting from premature deaths attributable to tobacco consumption are increasing rapidly **[1]**.

Smoking is considered a prime cause of carbon monoxide (CO) exposure, though small amount of exposure can also occur due to vehicular smoke emission, occupational exposure, etc. The CO when inhaled from tobacco smoke is absorbed through lungs and enters into the blood stream and combines with haemoglobin to form carboxyhaemoglobin (COHb), which can be measured in the blood and is a useful marker of tobacco smoke absorption **[2]**.

The passive smokers also suffer from diseases related to smoking similar to active smokers. The CO remains in the blood for about 24 hours after inhalation of tobacco smoke depending on various factors such as gender, physical activity, and ventilation rate. It then reenters the alveoli because of concentration gradient at the alveoli. This CO that is present in expired air can be measured using portable CO analyser. The breath CO concentration has been found to be a reliable indicator of COHb level in the blood **[3]**.

Therefore, indirect measurement of COHb through breath analysis is preferred over direct measurement of blood COHb levels because of its non-invasive nature, easy procedure and better compliance. Besides the utility in tobacco smoking abuse, extremely high levels of detected carbon monoxide by these analyzers give an additional indication for potential carbon monoxide poisoning that can be secondary to undetected home environments or occupational environments related exposures to carbon monoxide **[4]**.

Fagerstrom Test for Nicotine Dependence (FTND) is widely used to assess the nicotine dependence among the smokers on different population groups globally **[5]**. Although studies were conducted to assess the nicotine dependence using FTND among Indian population, previous studies focussed on polydrug users and psychiatric patients **[6]**.

There is need to examine whether the exhaled CO levels indicate the nicotine dependence among smokers. Since there

have been very few studies conducted in this region to measure the breath CO concentration in smokers and to compare it with the exhaled breath CO concentration in non smokers. Therefore this study was conducted on Mathura population.

MATERIALS AND METHOD

A cross-sectional study was carried out among 600 adults (18 years and above) coming at O.P.D of dental college, during the month of July 2021 to September 2021. Subjects were selected by simple random sampling from OPD. Before scheduling the present study, the ethical clearance was obtained from institutional ethical clearance committee of dental College. Informed consent was also obtained from each participant before filling up the questionnaire. The study was explained in detail to each participant before beginning the interview, as well as that their anonymity will be preserved to ensure that there is no breach of confidentiality. Subjects, who smoked cigarette or bidi within the last 24 hours and asthmatics were included in the study. Asthmatics were included because asthma is common and it was important to see if self reported asthma influenced carbon monoxide levels. Participants who did not indicate since how long they has smoked were excluded from the study.

Sample size determination

Prior to being finalized, the questionnaire was pilot tested on 20 patients in dental OPD to ensure its validity and reliability. The Cronbach α value for the questionnaire was 0.77, indicating good internal reliability.

Sample size was determined by the following formula based on the study population (n)

$$n = \text{Sample size } (n) = \frac{(Z_{1-\alpha/2})^2 (p)(q)}{d^2}$$

Anticipated population proportion (p)= 40% = 0.4

Confidence level= 95% Z1-α/2 = 1.96

Permissible error (d) = 4% = 0.04

Therefore, Based on the sample size determination obtained for adult population it was necessary to take 576 as the minimum sample size. However, a higher sample size of 600 was selected to compensate for any kind of permissible error and to increase the accuracy of study and then divided in to two groups: Smokers and Non smokers

Study tool

The study tools comprised of a questionnaire for sociodemographic details and smoking characteristics and Fagerstrom Test for Nicotine Dependence (FTND) questionnaire to assess the nicotine dependence **[7]**. The Smokerlyzer, a portable CO monitor was used to measure the exhaled CO levels among the study participants

Breath CO was measured in subjects using portable breath CO analyser. Questionnaire data were collected to assess the effect of common sources of carbon monoxide exposure on breath carbon monoxide levels. Fagerstrom test for nicotine dependence was used to assess the level of nicotine dependence. Smokers were used as a carbon monoxide exposed group for comparison with the non-smokers.

Procedure

The portable CO analyzer (piCO™) was used to measure the exhaled CO levels among the subjects. The subjects were asked to inhale deeply, hold the breath for 15 seconds and then exhale fully into the mouthpiece of instrument. If the subjects were unable to hold breath for that long, they were asked to hold breath for as long as possible. Single measurement was taken in each case; repeat measurements were done only when the subjects failed to do it properly.

Statistical analysis

The data obtained were tabulated and analysed using statistical package for social sciences, version 23.0 (SPSS). Mean carbon monoxide concentrations were compared using the independent t test. Spearman's rank correlation test was used to correlate between the nicotine dependence, sociodemographic and smoking characteristics. p value of ≤ 0.05 was considered to be statistically significant.

RESULTS

Variables of the study population such as age, gender, education, passive smokers, motor vehicle, fossil fuel showed statistically significant results among both smokers and non smokers **(Table 1)**. Among smokers (n=229), results showed that exhaled carbon monoxide level was high (11-30 ppm) in 48.9% smokers, medium (7-10 ppm) in 29.5% smokers and normal (0-6 ppm) in 21.8% smokers. **(Table 2)**

The mean exhaled carbon monoxide concentration in smokers and non smokers was 2.27±0.805 and 1.39±0.494 respectively and results were found to be statistically significant (p= 0.000) **(Table 3, 4)**.

All independent variables such as gender, education, residence, passive smoker, motor vehicle use, fossil fuel use, age of onset of smoking, frequency of consumption and years of smoking respectively showed the statistically significant (p=0.000) relation with the dependent variable that is exhaled carbon monoxide level except age (0.289) and marital status (p=0.764). **Table 5**

All independent variables such as age, gender, education, passive smokers, motor vehicle use, fossil fuel use, age of onset of smoking, frequency of consumption and

years of smoking and exhaled carbon monoxide level respectively showed the statistically significant (p=0.000) relation with the dependent variable that is nicotine dependence except marital status (0.060) and residence (p= 0.070) **Table 6**.

Table 1: Characteristics of Study Population

CHARACTERISTICS	CLASSIFICATION	SMOKERS (N=229)	NON-SMOKERS (N=371)	P VALUE
AGE	18-30 YEARS	69 (31.2)	159(%)	
	31-45 YEARS	83 (36.2%)	112 (%)	
	46-60 YEARS	56 (24.4%)	66 (%)	0.001**
	61-75 YEARS	21 (9.17%)	34 (10.1%)	
GENDER	MALE	187(81.8%)	176(52.5%)	0.001**
	FEMALE	42(18.4%)	195 (47.5%)	
MARITAL STATUS	MARRIED	179 (78.2)	328 (88.4%)	0.307
	UNMARRIED	50 (21.8)	43(11.6%)	
EDUCATION	NO FORMAL EDUCATION	39(17.03)	51(13.7%)	
	STUDIED UPTO CLASS X	50(21.8%)	110(29.6%)	0.001**
	STUDIED UPTO CLASS XII	100(43.6%)	130(35.2%)	
	GRADUATE OR MORE	40(17.4%)	80(21.5%)	
RESIDENCE	RURAL	143(62.4)	245(66.1%)	0.851
	URBAN	86(37.6)	126(33.9%)	
PASSIVE SMOKERS	YES	188 (82%)	152(40.9%)	0.001**
	NO	36 (18%)	190 (59.1%)	
MOTOR VEHICLE	USE	202(88.2%)	178 (47.9%)	0.001**
	NOT USE	27 (11.8%)	193 (52.1%)	
FOSSIL FUEL	USE	115(50.2%)	118(31.8%)	0.001**
	NOT USE	114(49.8%)	253(68.2%)	

Test used = Independent t test

Table 2: Exhaled Carbon Monoxide Among Smokers (N =229)

EXHALED CARBON MONOXIDE LEVEL	SMOKERS (%)	CHI SQUARE VALUE	P VALUE
NORMAL (0-6 PPM)	50 (21.8)	226.3	0.000**
MEDIUM (7-10 PPM)	67 (29.5)		
HIGH (11-30 PPM)	112(48.9)		

Table 3: Exhaled Carbon Monoxide Among The Non-Smokers (n=371)

EXHALED CARBON MONOXIDE LEVEL	NON SMOKERS (%)	CHI SQUARE VALUE	P VALUE
NORMAL (0-6 PPM)	227 (61.1)	226.3	0.000**
MEDIUM (7-10)	143 (38.5)		
HIGH (11-30)	1 (0.4)		

Table 4: Mean Exhaled Carbon Monoxide In Smokers And Non-Smokers

Carbon monoxide concentration		MEAN±S.D	MEAN DIFFERENCE	CONFIDENCE INTERVAL		P VALUE
				LOWER	UPPER	
	SMOKERS	2.27±0.805	0.875	0.770	0.980	0.000**
	NON SMOKERS	1.39±0.494	0.875	0.757	0.994	

Test used = Independent t test

Table 5: Correlation Between The Exhaled Carbon Monoxide Level, Sociodemographic And Smoking Characteristics Of The Study Participants

DEPENDENT VARIABLE	INDEPENDENT VARIABLES	CORRELATION COEFFICIENT ®	P VALUE
Exhaled carbon monoxide level	Age	0.044	0.289
	Gender	0.269	0.000**
	Marital status	0.012	0.764
	Education	0.269	0.000**
	Residence	0.432	0.000**
	Passive smoker	0.532	0.000**
	Motor vehicle use	0.279	0.000**
	Fossil fuel use	0.231	0.000**
	Age of onset of smoking	0.380	0.000**
	Frequency of consumption	0.602	0.000**
	Years of smoking	0.550	0.000**

Test used = spearman's rank correlation; ** statistically significant value (p≤0.05)

Table 6: Correlation Between The Nicotine Dependence, Sociodemographic And Smoking Characteristics Of The Study Participants

DEPENDENT VARIABLE	INDEPENDENT VARIABLES	CORRELATION COEFFICIENT ®	P VALUE
Nicotine dependence (FTND)	Age	0.124	0.003**
	Gender	0.332	0.000**
	Marital status	0.078	0.060
	Education	0.268	0.000**
	Residence	0.079	0.070
	Passive smoker	0.367	0.000**
	Motor vehicle use	0.381	0.000**
	Fossil fuel use	0.219	0.000**
	Age of onset of smoking	0.512	0.000**
	Frequency of consumption	0.973	0.000**
	Years of smoking	0.550	0.000**
	Exhaled carbon monoxide level	0.389	0.000**

Test used = spearman'srank correlation; ** statistically significant value (p≤0.05)

DISCUSSIONS

In present study, marital status and residence showed no statistically significant difference among smokers and non smokers. On a contrary, in a study conducted by K. J. Divinakumar *et al* (2017) **[8]** a statistically significant difference among smokers and non smokers was found.

The values of CO were significantly higher in males and in frequent motor vehicle users, but these differences were very small. Motor vehicle users and fossil fuel users may have slightly greater exposure than non-users to exogenous carbon monoxide in the form of exhaust fumes.

Exhaled carbon monoxide level was high in smokers and normal in non smokers in the present study. Previous study conducted by Sugavanesh P *et al* (2018) **[9]**, A J Cunnington *et al* (2002) **[10]** and Jane Hung *et al* (2006) **[11]** also found similar results. A study was conducted by Bhawana Agrawal *et*

al **[12]** in which exhaled carbon monoxide level was higher in smokers and normal in non smokers.

In the present study the mean carbon monoxide concentration in smokers and non smokers was 2.27±0.805 and 1.39±0.494 respectively and difference was found to be statistically significant. The result of the present study was in agreement with a study conducted by A J Cunnington *et al* (2002) **[10]**, Raj Kumar *et al* (2010) **[2]** and Bhawana Agrawal *et al* **[12]** which also showed that mean carbon monoxide concentration among smokers and non smokers was statistically significant.

In present study, independent variables such as age, gender, education passive smokers, motor vehicle use, fossil fuel use, age of onset of smoking, frequency of consumption and year of smoking respectively were highly correlated with nicotine dependence except the marital status and residence. In the previous study conducted by Sugavanesh P *et al* (2018) **[9]** and Bhawana Agrawal *et al* (2019) **[12]** similar results were found in relation to age, gender, passive smoker, motor vehicle use, fossil fuel use, frequency of consumption and exhaled carbon monoxide level. Conversely, in a study conducted to assess the socioeconomic variations on nicotine dependence, self-efficacy, and intention to quit, lower level of education was associated with higher levels of nicotine dependence, low self-efficacy, and no intention to quit **[13]**.

The number of years of smoking was significantly correlated with the nicotine dependence ($p = 0.000$). As the person smokes for more the number of years, chronic exposure to nicotine occurs in the nicotinic acetylcholine receptors with resultant neuroadaptation to nicotine, and consecutively the participants tend to smoke more **[11]**.

Several studies have revealed the variables age and age of onset of smoking as risk indicators for nicotine dependence **[14]**. Age of onset of smoking is important as the persons start smoking at the younger age, sensitization of receptors in the brain to nicotine occurs leading to the craving for cigarettes. However, in the present study, the age of onset of smoking was not significantly correlated with the nicotine dependence ($P = 0.000$)

In the present study, CO level was measured among the participants to verify the self-reported smoking status and to determine whether CO level correlates with the nicotine dependence as it indirectly reflects the nicotine seeking and dependence. The exhaled CO levels among the participants

depend on the passive smoking, motor vehicle and fossil fuel use, age of onset of smoking, frequency of consumption and years of smoking.

In the present study, CO level was significantly correlated with the nicotine dependence (P = 0.000) and (r = 0.389). In a similar study among Malaysian smokers, the exhaled CO levels were significantly correlated with the nicotine dependence **[15]**. Hence, exhaled CO levels could be used to indicate nicotine dependence among the smokers.

The exhaled CO levels were measured using the Pico smokerlyzer, with levels calibrated as 0-6 ppm, 7-10 ppm, 11-30 ppm. Hence, we were not able to calculate the exact cut-off level of CO for correlating with the nicotine dependence. The question about time since last bidi- cigarette smoke was not asked from the respondent that might have explained that due to which some smokers were showing green indicator on smoke check, since the half life of carboxyhemoglobin is 5 hours and it even reduces during exercise.

The results of the study can be shared with the policymakers, nongovernmental organizations, and voluntary organizations to initiate appropriate interventions accordingly at the micro, meso, and the macro level. The exhaled CO monitor can be used to monitor smoking status and can be combined with a smoking cessation program for health promotion since a reading of >6 ppm is a good cut-off point that strongly indicates that an individual is a current smoker.

CONCLUSION

Smokers had very much higher breath CO levels than non- smokers. In non smokers also exhaled CO level was higher in those who were passive smokers, those using motor vehicle and fossil fuel. The exhaled CO levels among the participants depend on the number of cigarettes smoked, passive smokers, motor vehicle use, fossil fuel use, age of onset of smoking, frequency of consumption and years of smoking. Therefore, it was proved from the current study that the exhaled CO levels, frequency and years of smoking can indicated as a marker for nicotine dependence in smokers.

REFERENCES

[1] Ramya Kalyanpur, K Pushpanjal, KVV Prasad, Kumar Gaurav Chhabra. Tobacco cessation in India: A contemporary issue in public health dentistry. *Indian Journal of Dental Research* 2012; 23 (1): 123-126.

[2] Raj Kumar, Gopal C. Mahakud, Jitendra K. Nagar, S.P. Singh, N. Raj and V.K. Vijayan. Breath carbon

monoxide level of non-smokers exposed to environmental tobacco smoke. *The Indian Journal of Chest Diseases & Allied Sciences* 2011; 53(8):215-220.

[3] Raj Kumar, Suraj Prakash, A.S. Kushwah, V.K. Vijayan. Breath carbon monoxide concentration in cigarette and bidi smokers in India. *The Indian Journal of Chest Diseases & Allied Sciences* 2010; 52(4):19-24.

[4] Pradeep Aggarwal, Saurabh Varshney, Sunil D. Kandpal, Divya Gupta. Tobacco smoking status as assessed by oral questionnaire results 30% under-reporting by adult males in rural India: A Confirmatory Comparison by Exhaled Breath Carbon Monoxide Analysis. *Journal of Family Medicine and Primary Care* 2014; 3(3) :199-203.

[5] Heatherton TF, Kozlowski LT, Frecker RC, Fagerström KO. The Fagerström test for nicotine dependence: A revision of the Fagerström tolerance questionnaire. *Br J Addict* 1991;86:1119-27

[6] Chandra PS, Carey MP, Carey KB, Jairam KR, Girish NS, Rudresh HP, *et al* . Prevalence and correlates of tobacco use and nicotine dependence among psychiatric patients in India. *Addict Behav*iour 2005;30:1290-9.

[7] Karl Fagerström, Cristina Russ, Ching-Ray Yu, Carla Yunis, Jonathan Fouls. The Fagerstrom Test for Nicotine Dependence as a Predictor of Smoking Abstinence: A Pooled Analysis of Varenicline Clinical Trial Data. *Nicotine & Tobacco Research* 2012; 6:1-8.

[8] K. J. Divinakumar, P. Patra, Jyoti Prakash, Arun Daniel. Prevalence and patterns of tobacco use and nicotine dependence among males industrial worker. *Industrial Psychiatry Journal* 2017 ;26 (1) :19-23.

[9] Sugavanesh P, K. Pushpanjali. Nicotine dependence, its risk indicators, and exhaled carbon monoxide levels among the smokers in Bengaluru, India. *Indian Journal of Community Medicine* 2018; 43(3):220-225.

[10] A J Cunnington, P Hormbrey. Breath analysis to detect recent exposure to carbon monoxide. *Postgraduate Medical Journal* 2002; 78 (2):233–238.

[11] Jane Hung, Ching-Hua Lin, Jung-Der Wang, Chang Chuan Chan. Exhaled carbon monoxide level as

an indicator of cigarette consumption in a workplace cessation program in Taiwan. *J Formos Med Assoc* 2006 ;105 (3): 210-213.

[12] Bhawana Agrawal, Navpreet Kaur, Vivek Sharma, Manish Bhalla, Roopali Gupta and Gagan Raj, Breath analysis to detect recent exposure to exhaled carbon monoxide and nicotine dependence in Mathura – a cross-sectional study, *International Journal of Dental Science and Innovative Research* 2019 ;3(4): 156-163.

[13] Zhang J, Yao X, Yu R, Bai J, Sun Y, Huang M, *et al* . Exhaled carbon monoxide in asthmatics: A meta-analysis. *Respir Research* 2010;11:50.

[14] Roberts B, Gilmore A, Stickley A, Kizilova K, Prohoda V, Rotman D, *et al* . Prevalence and psychosocial determinants of nicotine dependence in nine countries of the former soviet union. *Nicotine Tob Res*earch 2013;15:271-6.

[15] Guan NC, Ann AY. Exhaled carbon monoxide levels among Malaysian male smokers with nicotine dependence. *Southeast Asian J Trop Med Public Health* 2012;43:212-8.