Original Article

Association between Nicotine Dependence and Exhaled Carbon Monoxide Level among Truck Drivers in Chennai City

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Abstract

Background: Between 2009 and 2016, India has made progress in reducing the prevalence of the use of both smoked and smokeless forms of tobacco. Efforts to quit tobacco use have increased, but successful quitting remains low. One of the known factors that hindered smoking cessation is nicotine dependence. There are two methods of measurement that are currently being used in order to assess the nicotine dependence, a self-reported method by the smokers, and the other being biochemical assessment of nicotine metabolite. The aim of our study was to determine the prevalence of smokers among truck drivers in Chennai city and to assess the association between the Fagerstrom Test for Nicotine Dependence (FTND) and the exhaled carbon monoxide (CO) level among them. **Materials and Method:** A cross-sectional study was conducted with a convenient sample of 493 truck drivers above 18 years of age. Dependence was assessed using the modified FTND scale. A CO breath analyzer was used to assess the amount of CO in the breath. **Results:** The mean age of the participants was 38.92 ± 10.43 ranging from 19 to 75 years. Nicotine dependence of smokers had a significant moderate correlation with CO level. **Conclusions**: The result of the present study showed that the exhaled CO level was associated with self-reported nicotine dependence and it may serve as a more objective method in detecting smoking.

Keywords: Carbon monoxide level, nicotine dependence, Tobacco

Introduction

According to the Global Adult Tobacco Survey 2 (GATS2), the prevalence rate of tobacco use has declined from 34.6% in 2009–2010 to 28.6% in 2016–2017. This decline in prevalence was equivalent to a 17% relative decrease, and the number of tobacco users has reduced by about 8.1 million.[1] These results are indicative of a transition in tobacco epidemic in India, from peak to declining limb along the curve of tobacco epidemic. It also emphasizes the success of tobacco control policy initiatives taken from time to time, especially after 2009–2010. However, it is a cumulative effect of all the policy initiatives taken since the formulation of the Cigarettes Act in 1975, as it takes persistent efforts over decades, for the results to show up.[2]

Between 2009 and 2016, India has made progress in reducing the prevalence of the use of both smoked and smokeless forms of tobacco. Efforts to quit tobacco use have increased, but successful quitting remains low (WHO report).

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One of the known factors that hindered smoking cessation is nicotine dependence. Nicotine dependence is a hypothetical construct that is designed to explain and predict societally important outcomes such as problems caused by smoking. The importance of nicotine in smoking maintenance and cessation difficulty has been acknowledged in the last decade and thus led to efforts to measure nicotine dependence. In clinical research, tools for nicotine dependence assessment are important. With an increase in smoking cessation program, reliable indicators for nicotine dependence are needed to accurately assess the efficacy of the programs. The measurement of the nicotine dependence is important, as it can be helpful when deciding the types of support needed by the smokers to quit smoking and provide valuable measures in studies that seek to gain a better understanding of cigarette dependence and best way to overcome or prevent it.[3]

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There are two methods of measurement that are currently being used in order to assess the nicotine dependence, a self-reported method by the smokers, and the other being biochemical assessment of nicotine metabolite. Depending on the use of information, both self-reported and biochemical assessments are useful when trying to measure the smoking exposure.[3]

The most common self-reported dependence assessment scale is the Fagerstrom Test for Nicotine Dependence (FTND) developed by Karl-Olov Fagerstrom in 1978 and later modified by Todd Heatherton *et al*. in 1991.[4] Self-reported measurement may be unreliable as respondents may be unwilling to admit to a health problem or social behavior that many perceive to be undesirable or when there are laws banning certain behaviors.[3]

Hence, reliable biochemical markers of nicotine exposure are an important adjunct to self-reports for the objective evaluation of newer approaches in achieving smoking cessation.[5]

Cotinine is a major metabolite of nicotine in body fluids. Its concentration is high in urine than in blood because of its pH. Research studies have found that urinary cotinine level may be positively correlated with smokers who claimed to be nonsmokers.[6] Cotinine, by virtue of its longer half-life, offers a window of 5–7 days for the detection of nicotine exposure.[5] The sensitivity and specificity of urine cotinine test are 90% and 97%, respectively.[7] One potential obstacle to implementing routine screening is that the instrumentation used to detect low levels of cotinine using liquid chromatography and mass spectrometry is expensive and requires highly trained operators.[8]

Expired carbon monoxide (CO) is a well-characterized marker of cigarette smoking.[5] CO is a gas produced during combustion of all organic matters (e.g., tobacco, petroleum products, and home/office furnishings). CO is produced along with the approximately 4000 other chemicals in tobacco smoke when cigarettes burn or combust. During each inhalation, CO transverses across the pulmonary alveolar-blood capillary membrane where it binds with the hemoglobin in the red blood cells (erythrocytes). The resultant molecule is called carboxyhemoglobin (CO-Hb). High concentrations of CO-Hb are fatal and are known to cause compensatory hemoconcentration, elevating erythrocytes, risking clotting, and lowering oxygen-carrying capacity. Expired breath CO (BCO) correlates well with the percentage of blood CO-Hb (0.98). There is some evidence that expired CO measurements correlate with levels of plasma nicotine and the severity of tobacco dependency.[9] However, with its short half-life, CO only indicates relatively recent exposure (about 6–9 h) or documents acute abstinence.

Despite this limitation, because it is noninvasive and inexpensive and provides information in real time, expired CO measurements are understandably attractive and have been used to document abstinence in the majority of large-scale smoking cessation clinical trials with both nicotine and nonnicotine medications.[5] The topography of smoking (e.g., number of puffs, depth of inhalation, breath holding, puff volume, interpuff interval and velocity, and so on) contributes greatly to the expired CO level and blood nicotine concentrations.[9] It also has a sensitivity and specificity of 83% and 87%, respectively.[10] Sensitivity and specificity are not necessarily the same in all populations.

Literature review has shown truck drivers being a target risk group for smoking and smokeless tobacco use. Since truck drivers are exposed to CO from truck exhaust fumes, in addition to leaks from their own truck, exhaust fumes from other trucks cause elevations in the fractional concentrations of CO in expired air.[9] Hence, the CO level was used as an objective method to assess nicotine dependence among them.

The aim of our study was to determine the prevalence of smokers among truck drivers in Chennai city and to assess the association between the FTND and the exhaled CO level among them.

Materials and Methods

Design

A cross-sectional study was performed among truck drivers in Madhavaram, Chennai, from September to December 2018.

Ethical clearance

The study was conducted following approval by the Ethical Committee, Ragas Dental College and Hospital, Chennai. Further, permission was also obtained from the proprietors of the concerned truck agencies. The general guidelines to ensure the rights of participants were followed. Before the investigation, informed consent was obtained from individual participants and the study information was reaffirmed orally.

Participants

The sample size was calculated based on data obtained from the study conducted by Aparna *et al*. (2018) among bus drivers at Koyambedu, Chennai. The prevalence of smoking (19%) among private bus drivers and the prevalence of smoking in India according to the GATS2 (12.8%) were considered for the sample size calculation. G power (version 3.1, Heinrich-Heine-University, Germany, Europe) software was used for sample size calculation. Considering a prevalence of 19% and 12.8% using a power of 80%, the sample size was calculated as 172. The sample was diverse in nature pertaining to ethnicity, socioeconomic status, and education.

Inclusion and exclusion criteria

The participants who were above the age of 18 years and present on the day of the study and willing to participate in the study and who had completed a minimum of 1 year of working experience with heavy-duty license were included in the study. Truckers who had a history of any systemic illness or disability were excluded.

Data collection

Materials

Data were collected through a face-to-face interview. Demographic characteristics, which included questions concerning age, gender, education, and marital status, were enquired initially. Dependence was assessed using the modified FTND scale for smoking and smokeless tobacco; each scale consisted of six questions with Likert response. The questionnaire which was both in English and local language (Tamil) was given to the study participants to know the tobacco usage. The overall score was the summation of scores of all questions. The minimum score was 0 and the maximum score was 10. A CO breath analyzer (Smokerlyzer – piCO™) from Bedfont Scientific Manufacturer was used to assess the amount of CO in the breath in parts per million (ppm).

Method

The data were collected during a tobacco intervention program for truck drivers working in private agencies in Chennai. There were about 40 truck agencies operating in Madhavaram, Chennai. About 500 drivers were employed in these agencies. Participants were asked to answer the questions as per their experience of tobacco consumption. The procedure took about 10–15 min for each participant to complete the questionnaire. After questionnaire administration, expired air CO was assessed through breath CO monitor following a 20-s breath hold before slowly expiring air into the monitor mouthpiece. This was followed by dental examination by three calibrated dentists. Since three examiners carried out the examination, interexaminer calibration was performed (kappa: 0.89). A total of 493 participants were examined during the study.

Statistical analysis

Data collection and management were conducted using the Microsoft Office Excel package in association with the SPSS 20.0 software package (SPSS Inc, IBM Corp., Armonk, NY, USA) for the statistical analysis.

Results

The mean age of the participants was 38.92 ± 10.43 ranging from 19 to 75 years. According to the presence or absence of tobacco habit, among 493 participants, 133 (26.8%) were smokers, 110 (22.3%) had a habit of chewing tobacco, 51 (10.3%) participants had a habit of both, and 199 (40.6%) had reported the absence of these habits. As presented in Table 1, nicotine dependence of smokers had a significant moderate correlation of 0.463 with CO level ($P < 0.01$) [Table 1].

While comparing self-reports with expired CO, 199 participants were identified as abstainers by both self-report and expired CO levels (cut off: 6 ppm). Fifty-eight of the 133 (43.94%) admitted smokers were nonsmokers according to expired CO level. Mildly addicted smokers according to expired CO (34 [25.76%]) level were less than those classified by self-reports (65 [48.49%]), moderately addicted smokers according to expired CO level (19 [14.39%]) were less than those classified by self-reports (44 [33.33%]), and only 1 (0.75%) of the smoker was severely addicted according to CO level which was about 24 (18.18%) according to self-reports.

Discussion

Many studies had stated that a self-reported measurement is not accurate and reliable as the majority of the respondents will underreport the nicotine dependence using the FTND scale.

Table 1: Distribution of participants according to dependence based on the Fagerstrom Test for Nicotine Dependence compared to breath carbon monoxide and association between the Fagerstrom Test for Nicotine Dependence and exhaled carbon monoxide (CO) level

	Tobacco use status among truck drivers (total-493), *n* (%)	Category based on FTND score			Category based on breath CO levels (ppm)				
		Mild dependence, *n* (%)	Moderate dependence, *n* (%)	Severe dependence, *n* (%)	Nonsmoker (0-6), *n* (%)	Border-line addiction (7-9), *n* (%)	Mild addiction (10-15), *n* (%)	Moderate addiction (16-25), *n* (%)	Severe addiction (>25), *n* (%)
Smoking tobacco users	133 (26.8)	65 (48.49)	44 (33.33)	24 (18.18)	58 (43.94)	20 (15.16)	34 (25.76)	19 (14.39)	1 (0.75)
Smokeless tobacco users	110 (22.3)	76 (69.10)	33 (30)	1 (0.90)	101 (91.84)	4 (3.63)	3 (2.72)	2 (1.81)	0
Nontobacco users	199 (40.6)				199 (100)	0	0	0	0
Both	51 (10.3)				23 (45.11)	17 (33.33)	7 (13.72)	4 (7.84)	0

Association between nicotine dependence scale and CO level in smokers

Smoking tobacco	Correlation	CO level	FTND score
CO level	Pearson correlation	1	0.463**
	Significant (two-tailed)		0.000
	n	493	493
FTND score	Pearson correlation	0.463**	1
	Significant (two-tailed)	0.000	
	n	493	493

**Correlation is significant at the 0.01 level (two-tailed). CO: Carbon monoxide, FTND: Fagerstrom Test for Nicotine Dependence

However, self-reported nicotine dependence is also important to truly identify the smoker's nicotine dependence as FTND demonstrated better psychometric properties such as internal consistency and ability to predict cessation outcomes. FTND also reflects both the instrument's concentration on cigarette smoking and smoker's general understanding that tobacco dependence is driven by factors in addition to nicotine.[4]

However, biochemical confirmation is needed for accurate assessments of tobacco use to overcome inaccuracies of self-reported tobacco use.[4] Expired CO is a well-characterized marker of cigarette smoking.[7]

The transit workers usually get exposed to tobacco habits early in their life. Our study results reported high prevalence of smokers (43.94%) among truck drivers which was in agreement with the findings of Jain *et al*. who stated that the prevalence of ever smoking was highest among long-haul truck drivers (67%).[11]

This study showed that the correlation was significant between the FTND score and the CO level of the smokers. Our findings about smokers were different from the finding of other studies, as it was found that the self-reported measurement is different with the biochemical measurement of smoking exposure.[12]

In a recent large-scale study involving 309 participants, MacLaren *et al*. reported a good agreement between self-reported tobacco smoking and BCO.[13]

A 1-year follow-up study conducted in Switzerland found a good correlation between exhaled CO levels and self-reported smoking habits. Brügger *et al*. found that the CO levels were influenced by the number of cigarettes smoked daily ($P < 0.001$) and by the pack-year values ($P = 0.005$ at the initial visit and $P = 0.006$ at the follow-up visit).[14]

In spite of high air pollution levels, exhaled BCO levels still correlate well with the smoking status, number of cigarettes smoked per day, and time since last smoke. Therefore, it was concluded that BCO analyzers provide a logical and immediate assessment of participants' current smoking status.[15]

Jarvis *et al*.[16] among others concluded that the availability of reliable and low-cost CO analyzers should allow application in health care and health education settings.[17]

Limitation

These data were collected in face-to-face interviews and the presence of another individual at these interviews (e.g., patient and visitor) may have been enough to distort the results. Because "social desirability bias" involves the systematic distortion of responses in a certain direction, contorted marginal distributions in the participants' responses must be considered when looking at the results. Despite these shortcomings, even though the study was conducted among transit workers of one city, the sample size is fairly adequate and represents the overall pattern of adverse addictive tobacco habits and occupational stress among transit workers. These results can be applied to Indian population as a whole. Although the CO has a short half-life and lowered ability to detect atypical or light smokers, CO breath analyzer is still a reasonably dependable tool in detecting habitual smokers by inevitable increase in CO concentration in their breath.[15]

Conclusions

The result of the present study showed that the exhaled CO level was associated with self-reported nicotine dependence and it may serve as a more objective method in detecting smoking. Thus, the CO breath analyzers have been proven to be effective to detect environmental tobacco exposure in patients who are asked to self-report the use of tobacco. These habits coupled with stress associated with their profession increase the disease burden among this community. Hence, a multirisk approach and workplace interventions to reduce job stress, psychotherapy sessions, and counseling for already established nicotine dependence and motivational programs are the need for status in quo.

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Conflicts of interest

There are no conflicts of interest.

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