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Original Research Article

A cross-sectional study on beliefs about thirdhand smoke among the general population in Bangalore city, India

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ABSTRACT

Background: Thirdhand smoke (THS) is a recently discovered health hazard which has become a public concern over the recent years due to its wide distribution in indoor environment and significant adverse biological and health ill effects. The "four R's" that define the concept of THS include tobacco chemicals (some toxic) that remain, react, re-emit and/or are re-suspended long after active smoking ends. Harmful effects of active smoking and second-hand smoke were widely studied, however, only few studies were conducted on THS and its health effects. The aim of the study is to assess the beliefs about THS among the general population in Bangalore city, India
Methods: This cross-sectional study used a structured multiple-choice questionnaire which incorporated the participant's characteristics and the beliefs about THS (BATHS) scale. A sample size of 206 participants was obtained after study duration of 2 months. One-way ANOVA, student T test, generalized linear model and Pearson's correlation were used for statistical analysis in SPSS version 22 software.
Results: The test results showed a significant association between age (in years), gender, highest level of education, and smoking status with overall mean BATHS scale and subscales score. Pearson correlation analysis revealed the BATHS scale and its subscales scores to be interdependent.
Conclusions: Older participants, females, participants who had a high level of education, and non-smokers were found to have higher knowledge regarding THS and its impact on health and persistence in the environment.

Keywords: THS, Beliefs about THS (BATHS) scale, Tobacco

INTRODUCTION

Smoking along with associated diseases and related mortalities is still a major public health problem in the world.[1] About 1.1 billion people are current smokers worldwide and this is expected to increase to over 1.6 billion by the year 2025. Approximately one-half of the children in the world reside in countries where there is no legislation relevant to tobacco smoking, furthermore, only 5% of the world population is protected by antismoking bans.[2] About 22% of cancer-related mortalities are associated with smoking worldwide.[1] The international cancer research center reported that by the year 2020, there would be 10 million cigarettes-related deaths per year, with 70% occurring in developing countries.[1]

Thirdhand smoke (THS) is a recently discovered health hazard which has become a public concern over the recent years due to its wide distribution in indoor environment and significant adverse biological and health ill effects.[3,4] It refers to tobacco smoke toxicants that settle on indoor surfaces, fabrics and dust.[5] Thirdhand smoke is defined as the contamination of surfaces in contact with compounds emitted in secondhand smoke (SHS), the products generated by chemical transformations of these components, and the off-gassing of volatile components into the air. The "four R's" that define the concept of Thirdhand smoke include tobacco chemicals (some toxic) that remain, react, re-emit and/ or are re-suspended long after the active smoking ends.[4]

Compared to SHS, the THS linger on surfaces typically much longer, e.g., weeks and months. Furthermore, THS is difficult to eliminate from a polluted environment.[4,6] Matt et al found that harmful particulates remain even after weeks and months on countertops, floors, carpets, clothing, and other surfaces long after a cigarette has been smoked. Moreover, elimination of nicotine residues from surfaces like carpet and walls has been found to be almost impossible, leading to persistent exposure. THS persists in homes of smokers' long after they move out and even after the homes are cleaned and repainted for new residents. Non-smokers residing in homes (houses, condos, apartments) formerly used by smokers are hence involuntarily exposed to THS.[3,6]

People can get exposed to THS either through inhalation, ingestion, and/or dermal uptake.[7]THS can get re-emitted into the gas phase and can react with ozone and nitrous acid gases present in cars and houses to undergo chemical transformations which may yield secondary highly carcinogenic contaminants like formaldehyde, tobacco-specific nitrosamines, 4-(methylnitrosamino)-4-(3-pyridyl)butanal, and 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone as well as tobacco-related toxicants, including volatile N-nitrosamines, aromatic amides, polycyclic aromatic hydrocarbons, and volatile carbonyls.[5]

Acute or chronic exposure to THS increased DNA damage (genotoxicity) in human cell lines, which could lead to carcinogenicity.[3] Research has shown that THS-related genotoxicity, carcinogenicity, and oxidative stress resulted in cytotoxicity or cell death in a variety of cultured cells and caused physiological and developmental effects in live mice.[8]

A study by Hang et al reported that THS exposure causes significant DNA damage to human cells. In vivo studies had confirmed that THS is highly toxic to fibroblast and neurocytes, and zebrafish development was delayed with many embryos dying following exposure to textiles contaminated with cigarette smoke.[9]

It poses a likely health hazard even to non-smokers who are exposed. Infants and young children are especially susceptible to THS exposure.[10,11] This is due to their underdeveloped respiratory and immune systems, thin skin, more spent time at home and on the floor increasing the probability of them to crawl and play on, inhale, touch and hand-to-mouth contaminated surfaces; disturbing the collected dust and resuspending it into the air.[3,7] Studies also reported that THS is potentially hazardous to the fetal health. Furthermore, the underprivileged are more likely to be exposed to THS due to the increased prevalence of smoking and SHS in low-income households.[3]

Interestingly, the first studies on THS toxicity go back to the 1980s and were done by tobacco industry. The secondary analysis of animal experiments carried out by the Philip Morris tobacco aging process" of SHS, i.e., the formation of THS, has become a focus of research interest since it may reveal a hidden environmental risk factor especially for children and non-smokers.[4]

Harmful effects of active smoking and SHS were widely studied and were correlated with smoking cessation and reduction.[1] Active smoking was causally linked to many diseases such as cancer, stroke, coronary heart disease, respiratory diseases, diabetes mellitus, rheumatoid arthritis, and impaired immune system.[1] However, only few studies were conducted on THS and its health effects and how they may impact preventive smoking-related behaviors. The concept of exposure to THS is relatively new concept and is an area which requires thorough research. The aim of the study is to explore the beliefs about THS among general population in Bangalore city.

METHODS

Study population and setting

An online cross-sectional study was conducted to assess the beliefs regarding THS among general population in Bangalore city. Adult participants aged above 18 years currently residing in Bangalore city and who gave consent were included in the study. Participants who resided outside Bangalore city were excluded. Institutional ethical approval was obtained before commence of the study.

Study questionnaire

A structured multiple-choice questionnaire which incorporated the participant's characteristics and the Beliefs about THS (BATHS) scale [3]was used in the study. The questionnaire was constructed and validated for its content by a panel of 5 members including the staffs of department of public health dentistry. The questionnaire was in English language and consisted of two sections. Section A comprised of a series of questions related to socio-demographic data such as age, gender, marital status, highest level of education, annual house hold income and smoking status. Section B comprises of 9 questions from the BATHS scale used to assess the beliefs about THS. The participants responses were recorded in a 5-point likert scale ranging from strongly disagree to strongly agree. The questions were grouped under 2 subscales: THS impact on health subscale and THS persistence in the environment subscale. The scoring criteria and developments of subscales are given elsewhere.[3]

Sample size calculation

Taking a total population in Bangalore city to be 8,443,675 (from Census 2011), 80% power and 5% confidence interval, the minimum sample size obtained was 165. A sample of 206 participants was obtained after the study duration of 2 months. (May 2021-June 2021).

Collection of data

Data was collected using an online questionnaire created with the help of Google forms. A convenience sampling technique was used for the study. Different online groups in different online platforms were selected and the questionnaire was sent randomly to the participants. An online informed consent was obtained from the participants before the study after explaining the objectives and methodology of the study. Those participants who filled the questionnaire in the allotted time period of the study were included in the study.

Statistical analysis

Quantile-quantile (QQ) plots was used for checking the normality of data. Levene's test was used to assess the homogeneity of variance. One-Way ANOVA and Student's T test with welch's correction were used for univariate analysis, and generalized linear model was used for multivariable analysis of BATHS scale and subscales. Correlation between BATHS scale and subscales were assessed using Pearson's correlation analysis and correlation scatter plots were plotted. Descriptive Statistical analyses and statistical tests were performed using Statistical Package for Social Sciences software (SPSS version 22).

RESULTS

The present cross-sectional study was conducted to assess the beliefs about THS among general population in Bangalore city

Characteristics of the study population

The study included a total of 206 participants (104 females and 102 males) who filled the questionnaire within the allotted time period for data collection. The mean age of the study participants was 33.69±9.97 years. The study participants reported a mean annual household income of 441553 (SD=237638) rupees. The age and annual household income was further categorized into 3 groups for the purpose of the study.

The gender-wise distribution showed almost equal distribution with 50.49% female and 49.51% male participants. Out of 206 study participants, 122 (59.22%) were married and 84 (40.78%) were not married. Majority of the study participants (62.14%) had a graduate degree as the highest level of education. The participant characteristics are given in Table 1.

When asked about the smoking status, 48.52% of the study participants reported current and/or previous smoking experience while 51.46% of the participants had no history of smoking.

The normality of data was checked using Q-Q plots which showed that the data obtained followed a normal distribution. Three times interquartile range rule was applied on obtained data to check for extreme outliers.

Univariate analysis for BATHS scale and subscale

One-Way ANOVA and Student T test with Welch's correction was applied to compare overall BATHS scale score with various demographic factors. The results of the test are given in Table 1. P≤0.05 was taken as a statistically significant result. Levene's test was used to assess the homogeneity of variance.

The test results showed a significant association between age, gender, highest level of education, and smoking status with overall mean BATHS scale score. Participants in their 4th decade of life (p=0.003), females (p=0.000), participants with higher level of education (p=0.000), and non-smokers (p=0.000) were more likely to obtain higher scores in the BATHS scale, signifying higher knowledge.

Univariate analysis was also performed for the BATHS subscale, results for which are given in Table 1. Results obtained were almost the same as that of the BATHS scale. However, there was no significant difference by age in THS persistence in environment subscale.

Multivariate analysis for BATHS scale and subscale

Generalized linear model was used for multivariable analysis to predict the factors influencing the overall BATHS scale score and its subscales. The model was adjusted for age, gender, marital status, highest level of education, annual household income, and smoking status. The overall model for BATHS scale and subscales were found to be statistically significant (p<0.05). The variables which showed an association with the BATHS scale and subscales scoring were age, gender, highest level of education and smoking status of the participants.

The results obtained for multivariate analysis on BATHS scale (Table 2). Younger participants (≤30 years) were 51.1% less likely to obtain higher scores in BATHS scale compared to those from a higher age group of >40 years [OR=0.489, 95% CI 0.382-0.626, p=0.000]. Male participants showed lower odds of obtaining a higher score in BATHS scale by 27.4% compared to female participants [OR=0.726, 95% CI 0.593-0.889, p=0.002].

The results also showed that the study participants who had a lower level of education obtained lower scores in the BATHS scale. The participants who had high school education [OR=0.369, 95% CI 0.239-0.568, p=0.000] or a higher secondary level of education [OR=0.397, 95% CI 0.269-0.586, p=0.000] were nearly 60 % less likely to obtain higher scores in the BATHS scale, whereas those who had a graduate degree [OR=0.817, 95% CI 0.672-0.994. p=0.043] were only 18.3% less likely to obtain the same when compared to the participants who had a postgraduate degree.

Results also indicated that study participants with current or former smoking experience obtained lower odds of obtaining a higher BATHS scale score when compared to participants who were non-smokers.

Multivariate analysis was also performed for the BATHS subscales the results for which are given in Table 2. The results obtained were similar to those obtained for BATHS scale.

Correlation between BATHS scale and its subscales

Pearson correlation analysis revealed significant positive linear correlations between BATHS scale and THS impact on health subscale (THS health), BATHS scale and THS persistence in the environment subscale (THS persistence) and, THS health and THS persistence subscales as shown in Table 3. From these results, it is evident that the BATHS scale and its subscales scores are interdependent. Higher the scoring in the BATHS scale, higher will be the knowledge about THS impact on health and persistence in the environment. The correlation scatter plots are illustrated in Figure 1-3.

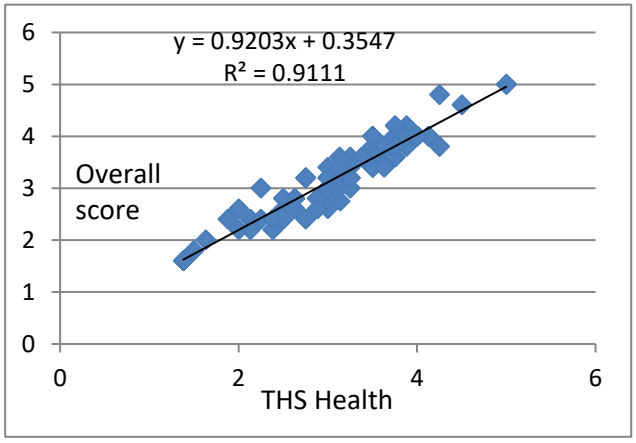

Figure 1: Correlation scatter between BATHS scale and THS health subscale.

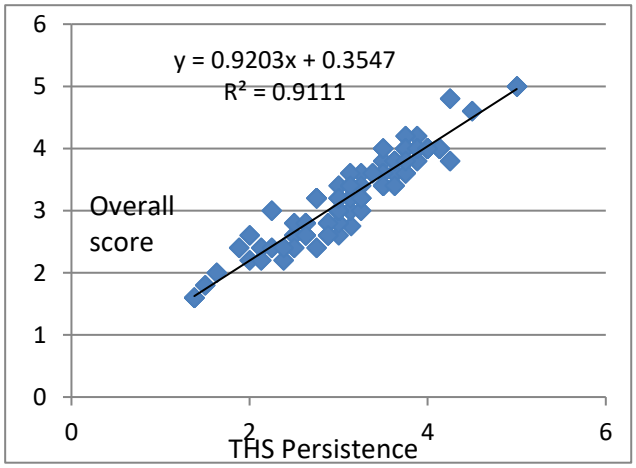

Figure 2: Correlation scatter between BATHS scale and THS persistence.

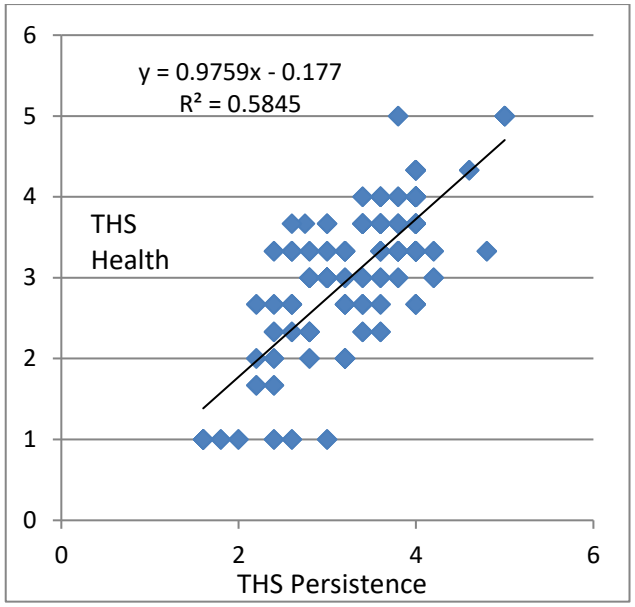

Figure 3: Correlation scatter between THS health and THS persistence.

DISCUSSION

THS is a novel concept that is not fully explored and only a few studies had been conducted on this topic of concern. This cross-sectional study provides an insight into the beliefs about THS among the general population in Bangalore city. The survey provides an evidence base for a paradigm shift from old tobacco control interventions and counselling to THS incorporated novel strategies.

The study results showed a significant association between age (in years), gender, highest level of education, and smoking status with overall mean BATHS scale score and its subscales. Older participants, females, participants who had a high level of education, and non-smokers were more likely to strongly believe in THS 's impact on health and its persistence in the environment. A similar study done by Xie et al showed similar results, except that younger participant obtained higher scores in the BATHS scale and subscales.[5]Another study done by Susan et al among health care professionals showed that men were less likely to endorse the belief that THS is harmful, relative to women even after controlling for other variables involved.[9]

The current study showed that non-smokers were more likely to obtain higher scores in the BATHS scale and its subscales and had stronger beliefs regarding the impact of the same on health and persistence in the environment. This was consistent with a study done by Roberts et al in which current non-smokers and participants who had never smoked were more likely to perceive negative effects of environmental tobacco smoke on a child's health than current smokers and previous smokers.[10]

Table 1: Characteristics of the participants and differences in beliefs about thirdhand smoke (THS) scale and subscales scores among general population in Bangalore city.

Characteristics of the population	N (%)	THS health, mean ± SD	P value	THS persistence, mean ±SD	P value	Overall score, mean ± SD	P value
Age (Years)*							
≤30	114 (55.3)	3.18±0.72		3.03±0.94		3.12±0.76	
>30 and ≤40	44 (21.4)	3.7±0.69	0.000	3.35±1.06	0.132	3.57±0.80	0.003
> 40	48 (23.3)	3.48±0.63		3.04±0.69		3.31±0.60	
Gender**							
Male	102 (49.5)	3.13±0.78	0.000	2.78±1.00	0.000	3.00±0.81	0.000
Female	104 (50.5)	3.58±0.59		3.42±0.72		3.52±0.58	
Marital status**							
Married	122 (59.2)	3.42±0.73	0.120	3.13±0.94	0.565	3.31±0.78	0.232
Unmarried	84 (40.8)	3.26±0.71		3.06±0.90		3.19±0.71	
Educational level*							
High school education	10 (4.9)	2.92±0.37		2±0.97		2.58±0.57	
Higher secondary education	12 (5.8)	2.6±0.48	0.000	2.44±0.38	0.000	2.54±0.42	0.000
Graduate	128 (62.1)	3.38±0.75		3.07±0.95		3.26±0.78	
Postgraduate	56 (27.2)	3.54±0.61		3.51±0.64		3.53±0.57	
Annual household income (Lakhs)*							
≤ 3	76 (36.9)	3.31±0.70		3±0.89		3.19±0.72	
>3 and ≤ 5	68 (33)	3.38±0.62	0.782	3.07±0.73	0.289	3.26±0.60	0.554
>5	62 (30.1)	3.40±0.85		3.27±1.12		3.35±0.92	
Smoking status*							
Current every day smoker	22 (10.7)	2.95±1.15		2.33±1.33		2.72±1.19	
Current someday smoker	52 (25.2)	3.23±0.71	0.003	2.86±0.91	0.000	3.10±0.72	0.000
Former smoker	26 (12.6)	3.17±0.70		2.79±0.94		3.03±0.76	
Non-smoker	106 (51.5)	3.54±0.57		3.45±0.64		3.51±0.53	

P<0.05, one-way ANOVA* and student T test with Welch's correction**

Table 2: Analysis of the factors influencing the beliefs about thirdhand smoke (BATHS) scale and subscale scores using generalized linear model among general population in Bangalore city.

Variables	OR* overall score	P value	OR* THS health	P value	OR* THS persistence	P value
Age (Years)						
≤30	0.489	0.000	0.444	0.000	0.574	0.001
>30 and ≤40	1.021	0.872	0.984	0.900	1.084	0.623
>40	1		1		1	
Gender						
Male	0.726	0.002	0.709	0.001	0.756	0.034
Female	1		1		1	
Marital status						
Married	0.924	0.446	0.881	0.205	1.003	0.982
Single	1		1		1	
Educational level						
High school	0.369	0.000	0.454	0.000	0.261	0.000
Higher secondary	0.397	0.000	0.379	0.000	0.431	0.001
Graduate	0.817	0.043	0.889	0.225	0.710	0.007
Postgraduate	1		1		1	
Annual household income (Lakhs)						
≤ 3	0.955	0.667	0.999	0.996	0.884	0.366
>3 and ≤5	1.074	0.501	1.143	0.195	0.969	0.819
>5	1		1		1	

Continued.

Variables	OR* overall score	P value	OR* THS health	P value	OR* THS persistence	P value
Smoking status						
Current every day smoker	0.616	0.005	0.748	0.082	0.445	0.000
Current someday smoker	0.728	0.006	0.770	0.020	0.662	0.005
Former smoker	0.562	0.000	0.615	0.001	0.484	0.000
Nonsmoker	1		1	0.000	1	

*Odds ratio was adjusted for age, gender, marital status, highest level of education, annual household income and smoking status, p<0.05 [Generalized linear model].

Table 3: Correlation between BATHS scale and its subscales.

Variables	BATHS scale	THS health	THS persistence
BATHS scale	1	0.955**	0.922**
THS health		1	0.765**
THS persistence			1

Pearson correlation, r<0.01 (2-tailed)

Strengths and limitations

The strength of the study includes the use of the BATHS scale which is a valid and reliable tool for the assessment of beliefs about THS. The study had included smoking community, smoke-free community and, former smokers from an age range of 18 to 60 years. The beliefs about the impact of THS on health and persistence in the environment were assessed and compared with the overall beliefs about THS among the study participants. The final model obtained was adjusted for age, gender, marital status, highest level of education, annual household income, and smoking status.

Limitations of the current study include its cross-sectional design which precludes causality. The responses of the study participants may be influenced by social desirability bias, although they were informed that it would be kept confidential as part of the consent process. Those who had good proficiency in English language could only fill the responses as the questionnaire used was not translated to native languages. Hence the differences between those who knew and did not know English could not be assessed. Only those participants who had access to internet services were included in the study.

CONCLUSION

Adequate research has to be carried out to shed light on the unexplored areas regarding THS and its effect on health, chemistry, and extent of environmental persistence. Studies should be conducted addressing SHS and THS exposure separately and jointly as sources of pollution and exposure. Since it is difficult to distinguish SHS from THS, more extensive field studies of THS exposure are required that incorporate specific biomarkers.

In conclusion, the findings of the study contribute to the scarce research on the topic of THS. Older participants, females, participants who had a high level of education, and non-smokers were found to have higher knowledge regarding THS and its impact on health and persistence in the environment. Educational sessions can be provided to increase public health awareness. A focused approach on smokers can be adopted to encourage them to quit the habit. THS incorporated tobacco cessation counselling strategies can be given to support the ones who are trying to quit. Further, in the regulatory approach, there is a need for policy changes considering the negative impact of THS on one's health and environment.

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