ORIGINAL RESEARCH ARTICLE

Prevalence of Secondhand Smoke Exposure and Thirdhand Smoke Awareness among Adults in Urban Kattankulathur, Chengalpattu, India: A Community-Based Cross-Sectional Study

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DOI: 10.55489/njcm.170620266521

ABSTRACT

Background: Tobacco-related environmental exposure remains a major public health concern in India. This study assessed second-hand smoke exposure and thirdhand smoke awareness among adults in urban Kattankulathur, Tamil Nadu, India.

Methods: A community-based cross-sectional study was conducted among 230 adults using multistage random sampling. Data were collected using questionnaires adapted from the Global Adult Tobacco Survey and Beliefs About Thirdhand Smoke scale. Multivariable logistic regression identified predictors of exposure and awareness.

Results: Overall, 65.2% participants reported second-hand smoke exposure during the previous seven days, particularly in outdoor enclosed public spaces and friends' or relatives' homes. Among never smokers, 52.4% experienced involuntary exposure. Current smoking and cohabitation with smokers were independently associated with exposure. Although awareness regarding harmful effects of second-hand smoke was high, detailed understanding of thirdhand smoke persistence and indirect exposure pathways remained limited. Never smokers and individuals not living with smokers demonstrated significantly higher awareness.

Conclusion: Second-hand smoke exposure remains highly prevalent despite tobacco-control measures, while important knowledge gaps regarding residual tobacco hazards persist. Strengthened smoke-free policy enforcement, promotion of smoke-free homes, and targeted community education are essential to reduce environmental tobacco exposure. Focused behavioural interventions targeting smoker households may improve awareness and reduce involuntary exposure among vulnerable nonsmokers.

Keywords: Second-hand Smoke (SHS) Exposure, Third-hand Smoke (THS), Tobacco Control, Community-Based Study, Urban Population

ARTICLE INFO

Financial Support: None declared

Conflict of Interest: The authors have declared that no conflict of interest exists.

Received: 14-02-2026, **Accepted**: 24-04-2026, **Published**: 01-06-2026

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How to cite this article: Kaarunya A, Abinaya P, Sathya Priya T, Anantharaman VV. Prevalence of Secondhand Smoke Exposure and Thirdhand Smoke Awareness among Adults in Urban Kattankulathur, Chengalpattu, India: A Community-Based Cross-Sectional Study. Natl J Community Med 2026;17(6):423-431. DOI: 10.55489/njcm.170620266521

Introduction

Tobacco use significantly impacts global health and death rates. According to WHO, every year, tobacco use causes over 7 million deaths annually, including about 1.6 million deaths due to secondhand smoke among non-smokers. Tobacco use continues to be a major global health concern. About eighty percent of the 1.3 billion tobacco users worldwide live in middle- and low-income countries.[1] The tobacco-attributable mortality burden in the WHO South-East Asia Region is substantial, with recent estimates suggesting over four million deaths annually of which 63.9% occur in India.[2] Within this disproportionate LMIC burden, secondhand smoke (SHS) remains a significant contributor to morbidity and mortality among non-smokers. Based on estimates from the Global Burden of Disease (GBD) 2021 study, approximately 1.29 million deaths globally are attributable to SHS exposure.[3]

SHS is the result of combining mainstream smoke, which is diluted in the surrounding air after being exhaled by the smoker with side stream smoke[4], which originates from the burning tip of a cigarette or other tobacco product. It is also known as environmental, passive or involuntary smoke.[4] Places where secondhand smoke is major include public areas like restaurants, bars, or leisure areas and also home.[4] SHS has no safe exposure threshold[5,6] and is categorized as a "group 1" carcinogen by the International Agency for Research on Cancer (IARC).[7] Within 60 minutes of exposure, SHS can cause detrimental respiratory and inflammatory effects that can persist for at least three hours.[5]

SHS raises the risk of lung cancer (20-30%; >7,300 deaths/year), stroke (20-30%), and coronary heart disease (25-30%; ~34,000 U.S. deaths/year) in non-smoking adults.[4] It also causes SIDS in infants, low birth weight/preterm delivery in pregnant women, and respiratory infections, restricted lung development in children.[4] 62.9% of adolescents aged twelve to sixteen globally were exposed to secondhand smoke, according to an analysis of the Global Youth Tobacco Survey (GYTS). India's Cigarettes and Other Tobacco Products Act (COTPA, 2003)-particularly bans smoking in public places and workplaces to mitigate SHS exposure.[8]

SHS causes immediate health effects, while THS residues persist long after smoking ends. Thirdhand smoke (THS) comprises tobacco residue toxins that stay on household surfaces, fabrics, and dust after smoking stops.[9] THS exposure is higher in children and infants, as exposure can occur through oral, dermal, and inhalation routes from household dust and surfaces.[10] Among the essential components of THS discovered thus far are naphthalene, nicotine, phenol, 3-ethenylpyridine (3-EP), and tobacco-specific nitrosamines, among others.[11]

Thirdhand smoke is still less studied, and secondhand smoke exposure among non-smokers remains a persistent public health concern**.** Nationally, GATS-II reported SHS exposure among non-smokers as 35% at home, 26.2% at the workplace, while 25.7% of all adults reported exposure in public places.[12] A secondary analysis of GATS I and II showed a decline from 48% to 35% at home and from 29.0% to 25.7% in public places.[13] No published study from Kattankulathur or Chengalpattu district has concurrently assessed both secondhand smoke (SHS) exposure and thirdhand smoke (THS) awareness among adults creating critical evidence gaps for intervention design. This cross-sectional study addresses this paucity by estimating SHS prevalence in domestic, workplace, and public venues, while evaluating knowledge of SHS health risks and THS awareness/beliefs among adults ≥18 years in urban Kattankulathur, Chengalpattu district, Tamil Nadu. Findings will guide targeted smoke-free policies and risk communication strategies in high-burden LMIC contexts.

Methodology

Study setting and design: This cross-sectional community-based study was conducted in urban Kattankulathur, Chengalpattu district, Tamil Nadu, India. Data collection occurred from 1 July to 30 September 2025, and all participants were enrolled within this period only.

Study participants and eligibility characteristics: Eligible participants comprised adults aged ≥18 years residing in Kattankulathur for ≥6 months who could communicate in English or Tamil and provided written informed consent. Both smokers and non-smokers were included. Individuals refusing consent or unable to participate due to cognitive/physical limitations were excluded.

Sample size: The sample size was formulated based on the proportion of secondhand smoke exposure among adults (p = 15.4%) reported by Bhandari et al.[8] With Z = 1.96 at a 95% confidence level, 5% absolute precision, and q = 100 - p, the minimum required sample size was 201. The sample size was changed to 224 and rounded to 230 participants with a 10% non-response rate.

Method of Sampling: A four-stage multistage random sampling technique was employed in urban Kattankulathur block, Chengalpattu district.

Stage 1: From the eight administrative blocks in Chengalpattu district, Kattankulathur block was selected using simple random sampling.

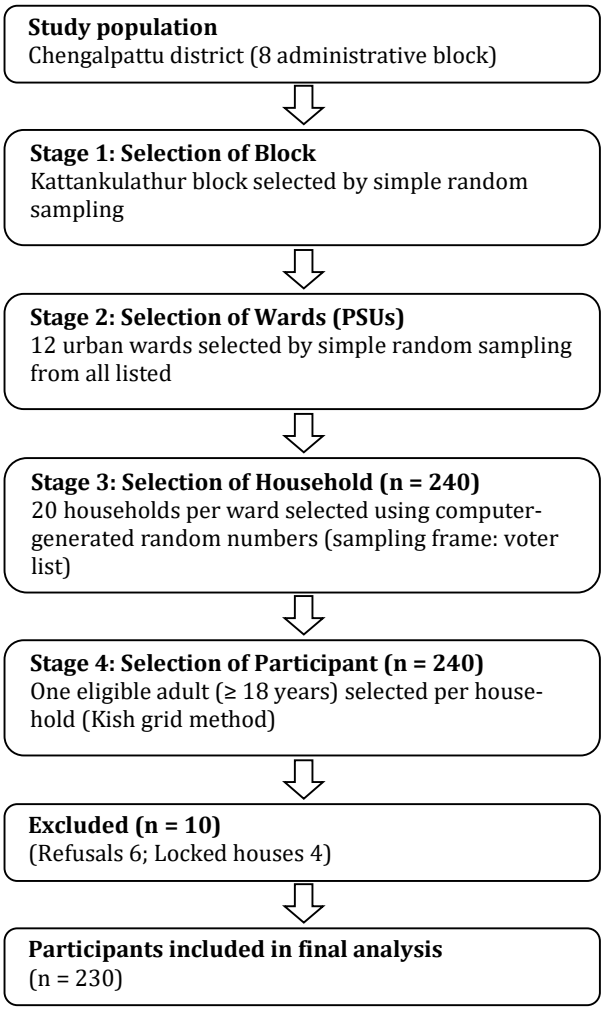
Stage 2: All wards within Kattankulathur block were listed as primary sampling units (PSUs), and 12 urban wards were selected by simple random sampling.

Stage 3: Within each selected ward, households were enumerated using the voter list as the sampling frame. Twenty households per ward were selected

using computer-generated random numbers (total = 240 households).

Stage 4: From each selected household, one eligible adult (≥18 years) was chosen using the Kish grid method when multiple eligible individuals were present. Face-to-face interviews were conducted after obtaining written informed consent.

A final sample of 230 participants was achieved.



PSU: Primary sampling units

Figure 1: Participant flow diagram of the four-stage multistage random sampling process (n = 230)

Study tool and data collection: A structured, pre-tested questionnaire adapted from two validated instruments-the Global Adult Tobacco Survey (GATS) Core Questionnaire (2020 update)[14] The Beliefs About Thirdhand Smoke (BATHS) questionnaire[15] was used for data collection. The BATHS questionnaire includes items assessing beliefs regarding the persistence and health effects of thirdhand smoke (THS).

The BATHS tool was pre-tested among study participants, and its internal consistency was found to be high (Cronbach's α = 0.89). The final questionnaire comprised items on socio-demographic characteristics (age, gender, occupation, marital status, and household income), socioeconomic status assessed using the Modified BG Prasad classification (2025 update)[16], tobacco use, and exposure to secondhand smoke across home, workplace or educational institutions, vehicles, and public places.

It also included measures of awareness, beliefs, and attitudes regarding thirdhand smoke, assessed using items from the BATHS Likert scale.

Study Variables: The primary outcome variables were secondhand smoke (SHS) exposure and thirdhand smoke (THS) awareness. Secondhand smoke (SHS) exposure was defined as any involuntary exposure to tobacco smoke from others at least once in the preceding 7 days across specified setting, and for THS awareness a composite THS awareness score was derived from responses to BATHS items. The median score of the study population was 4, and this value was used as the cutoff to categorize participants into: THS aware (score ≥4); Not aware (score <4). Independent variables included sociodemographic characteristics, socioeconomic status, smoking status, and cohabitation with a smoker.

Translation & Validation: The English questionnaire was forward-translated into Tamil by a bilingual expert and back-translated by an independent translator to ensure linguistic equivalence. Content validity was confirmed by a Community Medicine expert panel for cultural relevance and clarity.

Statistical Methods: Data input and interpretation were done using Microsoft Excel and the Statistical Package for the Social Sciences (SPSS) version 27.0. Descriptive statistics were applied to summarize socio-demographic profile, exposure to secondhand smoke (SHS), knowledge regarding SHS, and awareness of thirdhand smoke (THS). Frequencies and percentages were used to represent categorical variables.

To investigate relationships between categorical variables, the Chi-square test was employed. Univariate logistic regression analysis was performed to estimate unadjusted odds ratios (uOR) with 95% confidence intervals (CI). Variables with a p-value <0.05 in univariate analysis were considered for inclusion in the multivariable logistic regression model to identify independent predictors of secondhand smoke (SHS) exposure and thirdhand smoke (THS) awareness. Adjusted odds ratios (aOR) with 95% confidence intervals were computed. A p-value <0.05 was considered statistically significant.

Multicollinearity among independent variables was assessed using variance inflation factor (VIF), and model fit was evaluated using the Hosmer-Lemeshow goodness-of-fit test. For analytical purposes, the five socioeconomic status categories were regrouped into three broader categories (upper/upper middle, middle, and lower/lower middle) to ensure adequate cell frequencies and to meet the assumptions required for chi-square test and logistic regression analysis. This study was conducted and

reported in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for cross-sectional studies.

Approval of Institutional Ethical Review Board: The study was approved by the Institutional Ethics Committee (IEC) of SRM Medical College Hospital and Research Centre (Approval No: SRMIEC-ST1125-4008). This study was not registered in any clinical trial registry, as it was an observational cross-sectional study.

RESULTS

Among 230 participants, the largest age group was 31-45 years (43.5%, n=100), followed by 18-30 years, with fewer older adults. (Table 1). Males slightly outnumbered females, and most participants were married and had at least secondary or higher education. More than half of the participants were never smokers (53.9%), while nearly one-third were current smokers. Notably, over one-quarter of participants reported living with a smoker, indicating potential risk for household SHS exposure.

Overall, 65.2% (n=150) of participants reported any SHS exposure in the preceding 7 days. Exposure was most prevalent in outdoor enclosed public spaces - likely restaurants/cafes-and friends'/relatives' homes while comparatively lower exposure was observed in workplaces and vehicles (Table 2). Among never smokers (n=124), 52.4% (n=65) experienced involuntary exposure, underscoring vulnerable non-smoker burden.

Awareness of SHS was high among participants, with most recognizing its harmful effects on health (Table 3). Participants most commonly identified respiratory problems (83.9%, n=193) and SHS harm to children (89.1%, n=205), followed by heart disease, pregnancy risks and cancer. Knowledge gaps persisted for cancer association (32.2% unaware).

Using the BATHS Likert scale (Table 4), 69.2% (agree/strongly agree) recognized THS harms infants/children, followed by adult harm and cancer risk from particles. Whereas, awareness of its persistence on surfaces and resistance to removal through ventilation was comparatively lower (Table 4). Understanding of indirect exposure pathways, such as transfer via surfaces and clothing, was also limited.

Univariate χ^2 tests identified significant associations with sex, smoking status, and cohabitation with smokers (all $p<0.05$). In multivariable logistic regression analysis (Table 5), males had significantly higher odds of SHS exposure compared to females (aOR=1.82, 95% CI: 1.05-3.15, p=0.032).

Current smokers showed markedly elevated odds of exposure compared to never smokers (aOR=4.96, 95% CI: 2.12-11.61, $p<0.001$), while living with smokers conferred the highest risk (aOR=8.47, 95% CI: 2.86-25.07, $p<0.001$).

Table 1: Sociodemographic profile of Participants included in the study (N = 230)

Variable	Participants (%)
Age Group (Years)	
18-30	75 (32.6)
31-45	100 (43.5)
46-60	40 (17.4)
>60	15 (6.5)
Sex	
Male	126 (54.8)
Female	104 (45.2)
Marital Status	
Unmarried	38 (16.5)
Married	192 (83.5)
Educational Status	
No formal education	30 (13)
Primary	25 (10.9)
Secondary	72 (31.3)
Graduate & above	103 (44.8)
Occupation	
Government employee	26 (11.3)
Non-government employee	64 (27.8)
Self-employed	23 (10)
Unemployed	30 (13)
Student	49 (21.3)
Homemaker	38 (16.5)
Socio-Economic Status	
Upper class	22 (9.6)
Upper middle class	64 (27.8)
Middle class	86 (37.4)
Lower middle class	44 (19.1)
Lower class	14 (6.1)
Smoking Status	
Current smoker	68 (29.6)
Former smoker	38 (16.5)
Never smoker	124 (53.9)
Living With a Smoker	62 (27)

Table 2: Any exposure to Secondhand smoke (SHS) in different settings during the last 7 days among study participants (N = 230)

Place of Exposure*	Exposed (%)
At home	70 (30.4)
In car or another vehicle	45 (19.6)
At friend / relative's home	95 (41.3)
At workplace	60 (26.1)
Public indoor places	82 (35.7)
Outdoor enclosed public spaces	110 (47.8)

*SHS exposure defined as any involuntary inhalation of tobacco smoke from others-at least once-in the preceding 7 days across settings.

Table 3. Knowledge of Secondhand Smoke (SHS) and Associated Health Effects among Study Participants (N = 230)

Knowledge Item	Participants having knowledge (%)
Ever heard of secondhand smoke	198 (86.1)
Think SHS is harmful to health?	207 (90.0)
SHS can cause respiratory problems	193 (83.9)
SHS can cause heart disease	173 (75.2)
SHS can cause cancer	156 (67.8)
SHS is harmful to children	205 (89.1)
SHS is harmful during pregnancy	183 (79.6)

Table 4: Awareness and Beliefs Regarding Thirdhand Smoke (THS) among Study Participants (N = 230)

Statement	Strongly Disagree (%)	Disagree (%)	Not sure (%)	Agree (%)	Strongly Agree (%)	Agree + Strongly Agree (%)
THS can harm infants and children	7 (3.0)	15 (6.5)	49 (21.3)	97 (42.2)	62 (27.0)	159 (69.2)
THS can harm adults	15 (6.5)	22 (9.6)	56 (24.3)	77 (33.5)	60 (26.1)	137 (59.6)
Smoke particles can cause cancer	12 (5.2)	28 (12.2)	68 (29.6)	85 (37.0)	37 (16.1)	122 (53.1)
Smoke particles remain for days	18 (7.8)	35 (15.2)	72 (31.3)	68 (29.6)	37 (16.1)	105 (45.7)
Smoke particles remain for weeks	25 (10.9)	42 (18.3)	78 (33.9)	62 (27.0)	23 (10.0)	85 (37.0)
Smoke particles get absorbed into furniture/walls	22 (9.6)	38 (16.5)	65 (28.3)	72 (31.3)	33 (14.3)	105 (45.6)
Ventilation does not remove all smoke particles	30 (13.0)	45 (19.6)	70 (30.4)	58 (25.2)	27 (11.7)	85 (36.9)
Smoke particles transfer via skin/clothes	35 (15.2)	48 (20.9)	62 (27.0)	55 (23.9)	30 (13.0)	85 (36.9)

THS: Thirdhand smoke; Responses recorded using a five-point Likert scale.

Table 5: The association between study participants' sociodemographic traits and their exposure to secondhand smoke (SHS) (n = 230)

Category	Exposed (%) (n=150)	Not Exposed (%) (n=80)	p-value	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	p-value
Age						
18-30	52 (69.3)	23 (30.7)	0.603	1.98 (0.61-6.43)	-	-
31-45	68 (68.0)	32 (32.0)		1.86 (0.59-5.85)	-	-
46-60	22 (55.0)	18 (45.0)		1.07 (0.32-3.55)	-	-
>60	8 (53.3)	7 (46.7)		1.00 (reference)	-	-
Sex						
Male	92 (73.0)	34 (27.0)	0.008	2.15 (1.28-3.61)	1.82 (1.05-3.15)	0.032
Female	58 (55.8)	46 (44.2)		1.00 (reference)	1.00 (reference)	-
Marital Status						
Unmarried	26 (68.4)	12 (31.6)	0.881	1.19 (0.56-2.54)	-	-
Married	124 (64.6)	68 (35.4)		1.00 (reference)	-	-
Educational Status						
≤ Secondary	90 (70.9)	37 (29.1)	0.073	1.74 (1.01-3.01)	-	-
Graduate & above	60 (58.3)	43 (41.7)		1.00 (reference)	-	-
SES						
Upper/Upper middle	50 (58.1)	36 (41.9)	0.124	1.00 (reference)	-	-
Middle	60 (69.8)	26 (30.2)		1.66 (0.88-3.14)	-	-
Lower/Lower middle	40 (69.0)	18 (31.0)		1.60 (0.77-3.30)	-	-
Smoking Status						
Current smoker	60 (88.2)	8 (11.8)	<0.001	6.81 (3.02-15.36)	4.96 (2.12-11.61)	<0.001
Former smoker	25 (65.8)	13 (34.2)		1.75 (0.82-3.72)	1.32 (0.60-2.90)	0.263
Never smoker	65 (52.4)	59 (47.6)		1.00 (reference)	1.00 (reference)	-
Living with smoker						
Yes	58 (93.5)	4 (6.5)	<0.001	11.98 (4.05-35.42)	8.47 (2.86-25.07)	<0.001
No	92 (54.8)	76 (45.2)		1.00 (reference)	1.00 (reference)	-

χ^2 test for univariate associations; multivariable logistic regression for variables with p<0.05 (aOR with 95% CI; p<0.05 significant). Ref=reference category.

The observed reduction in effect sizes from unadjusted to adjusted estimates for smoking status and cohabitation suggests the presence of confounding. Age, marital status, education, and socioeconomic status were not significantly associated after adjustment. Multicollinearity assessment showed no significant collinearity among independent variables (all VIF values <5). The multivariable model demonstrated moderate explanatory power (Nagelkerke R^2 = 0.32). The Hosmer-Lemeshow goodness-of-fit test was non-significant (χ^2 = 6.24, p = 0.621), indicating adequate model fit.

Univariate analysis identified significant associations of THS awareness with education, socioeconomic status, smoking status, and cohabitation. In multivariable logistic regression analysis (Table 6), never smokers had significantly higher odds of awareness compared to current smokers (aOR=3.21, 95% CI: 1.61-6.38, p=0.001).

Participants not living with smokers also demonstrated higher awareness than those cohabiting with smokers (aOR=2.87, 95% CI: 1.47-5.61, p=0.002). Additionally, individuals belonging to the middle socioeconomic group had higher odds of awareness compared to the upper socioeconomic group. Although education showed a strong association in univariate analysis (uOR=0.19, 95% CI: 0.10-0.37), this association was not retained after adjustment (aOR=0.72, 95% CI: 0.35-1.47, p=0.211), suggesting confounding. Age and sex were not significantly associated with THS awareness. Multicollinearity assessment showed no significant collinearity among independent variables (all VIF values <5). The multivariable model demonstrated moderate explanatory power (Nagelkerke R^2 = 0.28). The Hosmer-Lemeshow goodness-of-fit test was non-significant (χ^2 = 7.83, p = 0.449), indicating good model fit.

Table 6: Association between Sociodemographic Characteristics and Study Participants' Knowledge of Thirdhand Smoke (THS) (n = 230)

Category	Aware (%) (n=159)	Not aware (%) (n=71)	p-value	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	p-value
Age						
18-30	58 (77.3)	17 (22.7)	0.259	2.27 (0.73-7.04)	-	-
31-45	70 (70.0)	30 (30.0)		1.56 (0.54-4.50)	-	-
46-60	22 (55.0)	18 (45.0)		0.81 (0.26-2.55)	-	-
>60	9 (60.0)	6 (40.0)		1.00 (reference)	-	-
Sex						
Male	80 (63.5)	46 (36.5)	0.080	0.55 (0.31-0.98)	-	-
Female	79 (76.0)	25 (24.0)		1.00 (reference)	-	-
Marital Status						
Unmarried	27 (71.1)	11 (28.9)	0.920	1.12 (0.51-2.45)	-	-
Married	132 (68.8)	60 (31.2)		1.00 (reference)	-	-
Educational Status						
≤ Secondary	70 (55.1)	57 (44.9)	<0.001	0.19 (0.10-0.37)	0.72 (0.35-1.47)	0.211
Graduate & above	89 (86.4)	14 (13.6)		1.00 (reference)	1.00 (reference)	
SES						
Upper/Upper middle	70 (81.4)	16 (18.6)	0.011	1.00 (reference)	1.00 (reference)	-
Middle	55 (64.0)	31 (36.0)		0.41 (0.20-0.82)	2.41 (1.19-4.88)	0.014
Lower/Lower middle	34 (58.6)	24 (41.4)		0.32 (0.15-0.68)	1.39 (0.72-2.69)	0.318
Smoking Status						
Current smoker	34 (50.0)	34 (50.0)	<0.001	1.00 (reference)	1.00 (reference)	-
Former smoker	26 (68.4)	12 (31.6)		2.16 (0.95-4.90)	1.76 (0.79-3.91)	0.164
Never smoker	99 (79.8)	25 (20.2)		3.96 (2.08-7.62)	3.21 (1.61-6.38)	0.001
Living with smoker						
Yes	32 (51.6)	30 (48.4)	<0.001	1.00 (reference)	1.00 (reference)	-
No	127 (75.6)	41 (24.4)		2.90 (1.57-5.31)	2.87 (1.47-5.61)	0.002

χ^2 test for univariate associations; multivariable logistic regression for variables with p<0.05 (aOR with 95% CI; p<0.05 significant). Ref=reference category.

Discussion

This community-based cross-sectional study conducted in urban Kattankulathur reveals substantial secondhand smoke (SHS) exposure, with 65.2% of adults reporting involuntary exposure in the preceding 7 days across multiple settings. Exposure was most prevalent in outdoor enclosed public spaces (47.8%) and social visits - At friend / relative's home (41.3%), while 30.4% reported household exposure, indicating persistent indoor smoking. Although 69.1% demonstrated thirdhand smoke (THS) awareness, only 37-46% recognized residue persistence on surfaces, highlighting specific knowledge gaps.

The 65.2% overall SHS prevalence exceeds GATS-2 national estimates (29.0% public places, 34.7% home; 30-day recall)[13], Bhandari Y et al.'s 15.4%[8] Delhi urban adults, and recent youth studies (24.7% urban non-smokers)[17]. This difference may be partly attributable to differences in recall periods. While GATS-II assesses exposure over a 30-day period, the present study used a 7-day recall period, which may capture more recent exposure events. This methodological difference limits direct comparability between the findings.

Household exposure at 30.4% aligns closely with GATS-2's national prevalence of 34.7% among adults,[13] aligns closely with 36.9% prevalence among non-smoking pregnant women[18], and 33% home exposure to SHS was observed among pregnant women in Dehradun[19]. These comparisons across national surveys, pregnant women cohorts, urban non-smokers, and regional studies confirm persistent domestic SHS exposure despite COTPA/NTCP implementation gaps.[20,21]

SHS exposure predominated in outdoor/semi-enclosed public spaces (47.8%), exceeding national benchmarks. A 2024 urban study reported 28.0% public place exposure among adults[8], while GATS-II showed a decline in SHS exposure among non-smokers, from 29.0% in GATS I to 25.7% in public places.[13] This elevated exposure reflects our predominantly male working population profile, where males consistently face 1.5-2x higher public/workplace SHS driven by urban transport use and male-dominated work cultures[13]. Studies in educational institutions have also reported poor COTPA compliance, including high violation of Section 4 and tobacco sales within 100 yards of schools.[22] Despite legal mandates, COTPA enforcement under the National Tobacco Control Programme has only partly succeeded, with irregular training, limited monitoring, and weak accountability contributing to poor compliance.[21] Targeted interventions like workplace monitoring, transit hub signage, and male-focused programs for cessation could address these population-specific gaps while strengthening broader compliance.

Both current smoking and cohabitation with smokers were independently associated with increased SHS exposure, highlighting the influence of social smoking networks and household-level tobacco use on

sustained exposure risk. This finding is consistent with GATS-II data, which demonstrate that tobacco users experience higher exposure across multiple settings and that the presence of household smokers remains the principal determinant of SHS exposure in India.[13]

A notable attenuation in the association between cohabitation with a smoker and SHS exposure was observed after multivariable adjustment (uOR=11.98 to aOR=8.47), suggesting the presence of confounding by variables such as sex and smoking status. Individuals who were male and current smokers had higher baseline exposure, which may partially explain the stronger crude association observed among those living with smokers. This finding indicates that both household-level and individual-level factors contribute to SHS exposure, and the adjusted estimates provide a more accurate representation of the independent effect of cohabitation.

Education and socioeconomic status showed no independent protective effect after multivariable adjustment in our study which is in contrast to other studies where greater educational attainment correlated with reduced SHS exposure.[13,17,23] Education and socioeconomic status showed significant associations with THS awareness in univariate analysis, these associations attenuated after adjustment. This suggests that the relationship may be influenced by confounding or mediation through variables such as smoking status, which is likely associated with both educational level and awareness of thirdhand smoke.

Although 69.1% of participants demonstrated awareness of thirdhand smoke (THS), detailed understanding of its persistence and residual contamination remained limited, with fewer than half recognizing that smoke particles can persist on surfaces for prolonged periods or resist removal through ventilation. Similar gaps between general awareness and in-depth knowledge have been reported among medical students and community populations, where familiarity with the term "Thirdhand smoke" did not consistently translate into accurate understanding of exposure pathways and surface contamination.[24] In this context, a forthcoming RCT protocol[25] proposes to evaluate educational interventions to reduce THS exposure among pregnant women. Systematic reviews examining THS chemistry have also emphasized the prolonged retention of nicotine-derived toxicants on indoor surfaces and their particular relevance for infants and young children.[26] In the present study, never smokers were significantly more likely to demonstrate THS awareness compared to current smokers (aOR=3.21, 95% CI: 1.61-6.38), and participants not cohabiting with smokers had higher awareness than those living with smokers (aOR=2.87, 95% CI: 1.47-5.61). Comparable patterns observed in community-based KAP studies suggest that nonsmokers have better knowledge of SHS and THS than smokers, but meaningful knowledge gaps still present.[27] Differences have been particularly noted in understanding the persistence of smoke residues on indoor surfaces such as furniture, fabrics, and enclosed environments.[27] These findings indicate that THS awareness remains socially patterned and underscore the need for targeted risk communication strategies within NTCP that specifically address smoker households and emphasize the persistence of tobacco toxins beyond active smoking.

The findings of this study highlight the substantial burden of secondhand smoke exposure in urban Kattankulathur, where a considerable proportion of adults reported recent exposure despite existing legislative measures. The strong association between cohabitation with smokers and SHS exposure indicates that the household environment continues to serve as a major source of involuntary exposure. Additionally, the discrepancy between overall THS awareness and limited understanding of its persistence on indoor surfaces suggests gaps in risk comprehension that may hinder adoption of protective behaviors. A key strength of this study is the concurrent assessment of SHS exposure across multiple settings alongside evaluation of THS awareness, allowing a more comprehensive appraisal of tobacco-related environmental risks.

Implications for Practice and Policy: Future research should focus on longitudinal studies to establish temporal relationships between thirdhand smoke exposure and health outcomes. Intervention studies evaluating the effectiveness of integrating THS awareness into National Tobacco Control Programme (NTCP) activities are also warranted. Additionally, studies incorporating biomarker-based assessments, such as cotinine estimation, may provide more objective measures of SHS and THS exposure. Future studies should also incorporate subgroup analyses to examine variations in secondhand smoke exposure across settings by sex and differences in thirdhand smoke awareness by smoking status and educational level, to enable more targeted public health interventions.

From a public health perspective, comprehensive tobacco control in peri-urban settings requires strengthened enforcement of COTPA Section 4 through mandatory signage and regular inspections at transit hubs and semi-enclosed public spaces. NTCP-supported 'smoke-free home' initiatives targeting cohabiting households, structured THS education through primary health centers emphasizing residue persistence, and gender-sensitive workplace cessation programs for the male working population may further help reduce exposure.

LIMITATIONS

The cross-sectional design limits causal inference between identified sociodemographic predictors and tobacco exposure outcomes. Exposure assessment was based on self-reported data and may be subject to recall and social desirability bias. The use of a 7-day recall period for assessing secondhand smoke

exposure, compared to the 30-day recall period used in GATS-II, limits the direct comparability of prevalence estimates and may influence the observed prevalence. Biochemical validation using objective markers such as urinary or salivary cotinine was not performed, which may have provided more precise estimates of involuntary nicotine exposure. THS awareness was categorized using a median split of the composite score. Sensitivity analyses using alternative cutoff points were not performed, which may limit the robustness of this classification. Furthermore, as the study was conducted within a single urban block of Chengalpattu district, the findings may not be fully generalizable to rural settings or other regions with differing tobacco control contexts.

Conclusion

This study demonstrates a substantial burden of secondhand smoke exposure among adults in urban Kattankulathur, with the highest prevalence observed in outdoor and semi-enclosed public spaces, followed by considerable exposure within households. These findings suggest ongoing gaps in enforcement of smoke-free public place regulations under COTPA, alongside continued vulnerability within domestic environments. Although awareness of thirdhand smoke was moderate, incomplete understanding of THS highlights the need for strengthened risk communication. Comprehensive tobacco control efforts must therefore integrate stricter public place enforcement with promotion of smoke-free homes and education on residual tobacco hazards to achieve meaningful reductions in environmental tobacco exposure.

Acknowledgement: The authors acknowledge SRM Medical College Hospital and Research Centre, Faculty of Medicine and Health Sciences, SRM Institute of Science and Technology (SRMIST), Kattankulathur, Chengalpattu, Tamil Nadu, India for administrative support & financial support towards publication cost.

Individual Authors' Contributions: KA was involved in all stages of the study, including study conception, design, data collection, data analysis, and manuscript preparation. **AbP** contributed to study conception and design, data analysis, and manuscript preparation. **SaT** was involved in study conception and design and contributed to manuscript preparation. **AVV** contributed to study conception and manuscript preparation.

Availability of Data: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Declaration of Non-use of Generative AI Tools: This article was prepared without the use of generative AI tools for content creation, analysis, or data generation. All findings and interpretations are based solely on the authors' independent work and expertise.

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