Hand Nicotine and Cotinine In Children Exposed to Cigars: A Pilot Study

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Objectives: Past research has not examined secondhand and thirdhand smoke (THS) exposure in children of cigar smokers. We examined hand nicotine and cotinine levels in children of cigar smokers to explore the contribution of cigar smoke to tobacco smoke exposure (TSE). **Methods:** Participants were children (N = 24; mean (SD) age = 6.5 (3.6) years) whose parents smoked cigars only or poly-used cigars and/or cigarettes. Primary outcomes were hand nicotine and urinary cotinine levels. **Results:** All children had detectable hand nicotine (range: 7.6-312.5ng/wipe) and cotinine (range: 0.3-100.3ng/ml). Positive correlations were found between hand nicotine and cotinine ($r = 0.693$, $p = .001$), hand nicotine and parents who also smoked cigarettes ($r = 0.407$, $p = .048$), and hand nicotine and number of smokers around the child ($r = 0.436$, $p = .03$). Hand nicotine ($r = -0.464$, $p = .02$), but not cotinine ($r = -0.266$, $p = .26$), was negatively correlated with child age. Multiple regression results indicated a positive association between hand nicotine and cotinine ($p = .002$; semi-partial $r^2 = 0.415$), irrespective of child age. **Conclusions:** The significant association of hand nicotine with urinary cotinine suggests that THS pollution should be assessed in evaluating children's overall TSE to cigars and other tobacco products, and hand nicotine may be a proxy for overall TSE. Younger children may have increased THS pollutant uptake.

Key words: adolescent/youth; cigar/cigarillo; secondhand smoke; thirdhand smoke; tobacco exposure; toxicant
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Although cigar use rates remain relatively high at 3.9% among adults in the United States (US),[1] past studies have not yet examined tobacco smoke exposure (TSE) in children exposed to cigars. Cigar use rates are highest in males, younger adults, and persons of low socioeconomic status.[1-3] Racial/ethnic disparities exist in cigar and cigarillo use with highest levels among black (4.9%) compared to white adults (4.1%).[1] The estimated annual healthcare services and expenditures attributable to cigar smoking are high amounting to $1.8 billion, of which $284 million is attributable to cigar only use and $1.5 billion due to poly-use of cigars and other tobacco products.[4] Given the disparities associated with cigar use, it is likely that males and non-Hispanic Blacks have the highest cigar-related healthcare expenditures. TSE rates are highest in children who are non-Hispanic black, low-income, or who live in rented homes.[5] Cigar smoke contains higher levels of harmful pollutants compared to cigarettes,[4] which may result in higher adverse effects on children exposed to cigar smoke compared to cigarette smoke. Moreover, availability, advertising, and marketing for little cigars and cigarillos is more widespread in neighborhoods where black or low-income populations reside, potentially leading to increased cigar use and exposure.[6]

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After tobacco has been smoked, chemical residue from secondhand smoke (SHS) remains on surfaces, clothes and skin, becomes embedded in materials, and accumulates in dust. This aged SHS, or thirdhand smoke (THS), contains nicotine and other tobacco smoke toxicants.[7] Nicotine residue is picked up by children on their hands even when active smoking is not occurring.[8] The association between hand nicotine and cotinine (ie, nicotine metabolite),[9] suggests that hand nicotine is a marker of overall TSE (SHS+THS) in children's environments.[8] Research indicates that all children of cigarette smokers, even those whose parents enforce smoking bans, have detectable hand nicotine and cotinine with higher levels in younger children and those exposed to more cigarettes.[5,8,10-13]

Whereas the nicotine concentration in cigars compared to cigarettes is similar, the total tobacco content in cigars is higher than cigarettes, and the smoke emissions and TSE patterns from cigars and cigarettes may vary.[14] TSE biomarker levels differ by cigar type and use patterns and the use of other tobacco products (eg, dual- or poly-use with cigars, cigarettes, and/or marijuana).[15,16] Thus, it is likely that biomarker levels of SHS and THS exposure differ in children who are exposed to cigars and other tobacco and non-tobacco products; an understudied area. To help fill this gap, we conducted a pilot study to investigate hand nicotine and urinary cotinine biomarker levels in children whose parents smoke cigars only or dual- or poly-used cigar products and cigarettes, and their relationship with child characteristics, parent-reported smoking, and TSE patterns.

METHODS

Child and parent dyads in this study were part of a 2-group randomized controlled trial, "Healthy Families" (clinicaltrials.gov:NCT02531594),[17] that was conducted in one of 2 pediatric emergency departments (PED) or urgent cares (UC) at a large children's hospital. This hospital IRB-approved study enrolled the study subset, all of whom had public insurance or were self-pay and presented to the PED/UC with a potential TSE-related complaint (eg, cough). Parents completed electronic assessments to determine tobacco use type and amount smoked around the child by parent and household members (Black and Milds (B&Ms), other cigars, cigarettes, electronic cigarettes) and whether home smoking bans were in place. Included children were ages 0-14 years, nonsmokers, had parents who reported smoking B&Ms and/or other cigars (N = 19), and dual- or poly-use with combustible cigarettes (N= 5). No parents currently used electronic cigarettes. There were 88 children with complete data on hand nicotine and parent tobacco use. Of those, 24 (27.3%) had parents who smoked B&Ms and/or cigars and were included in the present study. No differences in participant characteristics were found between those included (N = 24) and excluded (N = 64) in the study. Although 19 parents were B&M and/or other cigar smokers, 17 (89.5%) of these children were around 1-4 cigarette smokers (25^{th}-50^{th}-75^{th}: 1-2-3) in the past week.

The palm and volar aspect of children's dominant hands were wiped by research coordinators and analyzed for nicotine with a level of quantification (LOQ) = 0.1ng/wipe. Field blank hand wipes were collected to adjust for potential sample contamination[18] (range: < LOQ-6.7ng/wipe). A sub-sample provided a urine sample (N = 20) that was analyzed for cotinine (LOQ = 0.05ng/ml) using liquid chromatography-tandem mass spectrometry.[19] Urine samples were not collected from the full sample due to difficulty obtaining samples from young children. We assessed sociodemographics and parent-reported smoking and TSE patterns.

Data Analysis

Logarithmic transformations were performed of hand nicotine and cotinine to control for skew and unequal variances. We report geometric means (GeoM), confidence intervals (CI), medians (Mdn), and interquartile ranges (IQR). Simple linear regression and correlation analyses were conducted to examine associations between child characteristics, parent-reported smoking, TSE patterns, hand nicotine, and cotinine. We examined a multiple regression model to assess the association of hand nicotine and child age with cotinine as our outcome. All statistical tests were 2-tailed with the level of significance set at .05.

RESULTS

Table 1 shows participant characteristics. All children had detectable hand nicotine rang-

Table 1
PED/UC Patient Sociodemographic and Self-reported Smoking and TSE Patterns by Hand Nicotine and Urinary Cotinine Levels

		Hand Nicotine Concentration (ng/wipe; N = 24)[a]			Urinary Cotinine Concentration (ng/ml; N = 20)		
Variable	**N (%)[b]**	**GeoM (95%CI)**	**Mdn (IQR)**	**p-value[c]**	**GeoM (95%CI)**	**Mdn (IQR)**	**p-value[c]**
			Sociodemographic Characteristics				
Child Age, M (SD)	6.5 (3.6)	-	-	.02	-	-	.26
25th-50th-75th	4-6.5-8.75						
Child Sex				.89			.64
Male	10 (41.7)	45.2 (23.1-87.9)	80.3 (20.8-90.5)		5.6 (1.4-17.0)	3.3 (1.2-13.9)	
Female	14 (58.3)	47.8 (26.9-84.3)	44.3 (23.7-108.5)		7.7 (2.6-19.8)	7.5 (1.8-10.3)	
Child Race							
White, non-Hispanic	3 (12.5)	56.9 (15.2-206.1)	61.8 (-)	Ref	2.1 (0.7-35.5)	2.1 (-)	Ref
Black, non-Hispanic	20 (83.3)	49.0 (31.3-76.6)	56.4 (24.0-97.9)	.80	7.5 (3.4-15.3)	7.3 (1.7-13.9)	.31
Other, non-Hispanic	1 (4.2)	9.3 (-)	-	-	-	-	-
Parent Education Level				.02			.16
≤ High school graduate	11 (45.8)	74.8 (44.1-126.2)	90.2 (31.6-102.0)		11.0 (3.8-29.3)	7.1 (3.7-32.3)	
≥ Some college	13 (54.2)	31.3 (17.9-54.1)	32.5 (12.7-66.6)		4.3 (1.3-11.5)	1.8 (0.9-10.3)	
Income Level				.66			.48
< $15,000	20 (83.3)	44.9 (28.6-70.2)	44.3 (24.0-91.2)		5.9 (2.5-12.5)	5.0 (1.6-12.9)	
≥ $15,000	4 (16.7)	56.8 (11.3-268.6)	73.1 (20.0-122.7)		10.7 (-0.1-122.8)	8.4 (2.3-50.5)	
Housing Type				.81			.40
Single-family	5 (20.8)	51.3 (16.1-159.1)	91.5 (19.1-101.3)		4.0 (1.2-10.6)	3.3 (2.0-7.9)	
Multi-Unit/Apartment	19 (79.2)	45.6 (28.4-72.8)	53.4 (23.8-89.9)		7.9 (3.0-18.4)	7.5 (1.6-14.0)	

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ing from 7.6-312.5ng/wipe (GeoM = 46.7, 95% CI:[31.3;69.5]; Mdn = 56.4, IQR = 24.0-91.2) and urinary cotinine ranging from 0.3-100.3ng/ml (GeoM = 6.7, 95% CI:[3.2;13.0]; Mdn = 6.4, IQR = 1.6-12.9).

Children whose parents completed ≤ high school (GeoM = 74.8, p = .02) had higher mean hand nicotine than those whose parents completed ≥ some college (GeoM = 31.3). Children who lived with parents who smoked B&Ms and/or cigars with cigarettes had higher mean hand nicotine (GeoM = 96.9, p = .048) than those who lived with parents who smoked B&Ms and/or cigars (GeoM = 38.5). Children without home smoking bans (GeoM = 11.4, 95% CI:[5.3;23.3], p = .006) had higher mean cotinine than children living in homes with smoking bans (GeoM = 1.5ng/ml, 95% CI:[0.2;4.4]).

Hand nicotine (r = -0.464, p = .02), but not cotinine (r = -0.266, p = .26), was negatively correlated with child age. Of note, a one-year-old had the highest hand nicotine level. Positive correlations were found between hand nicotine level and parents who smoked cigars and cigarettes (vs cigars only) (r = 0.407, p = .048), and hand nicotine and cumulative number of tobacco smokers (ie, cigarillo, cigar, cigarette smokers) around the child in the past week (r = 0.436, p = .03). Hand nicotine was positively correlated with cotinine (r = 0.693, p = .001). A negative correlation was found

Table 1 (*continued*)
PED/UC Patient Sociodemographic and Self-reported Smoking and TSE Patterns by Hand Nicotine and Urinary Cotinine Levels

Variable	N (%)[b]	Hand Nicotine Concentration (ng/wipe; N = 24)[a]			Urinary Cotinine Concentration (ng/ml; N = 20)		
		GeoM (95%CI)	Mdn (IQR)	p-value[c]	GeoM (95%CI)	Mdn (IQR)	p-value[c]
Self-reported Smoking and TSE Patterns							
Parent Specific Tobacco Product Type Use Patterns							
Exclusive B&M Use	17 (70.8)	36.1 (22.4-57.8)	31.6 (17.1-90.0)	-	5.8 (2.6-11.9)	6.4 (1.7-11.1)	-
Exclusive Cigar Use	1 (4.2)	136.0 (-)	-	-	85.0 (-)	-	-
B&M and Cigar Use	1 (4.2)	32.5 (-)	-	-	1.6 (-)	-	-
B&M and Cigarette Use	4 (16.6)	72.2 (46.9-110.8)	74.5 (55.4-91.0)	-	3.2 (-)	-	-
B&M, Cigar, and Cigarette Use	1 (4.2)	312.5 (-)	-	-	73.5 (-)	-	-
Parent Smokes Cigarettes				.048			.85
No	19 (79.2)	38.5 (24.6-59.9)	32.5 (21.1-90.2)		6.5 (2.8-13.5)	6.4 (1.6-12.9)	
Yes	5 (20.8)	96.9 (40.5-229.7)	89.8 (57.4-169.3)		7.6 (-0.3-106.9)	5.1 (1.3-44.1)	
Home Smoking Ban				.16			.006
No	17 (70.8)	55.8 (34.3-90.3)	71.9 (25.4-101.3)		11.4 (5.3-23.3)	8.7 (4.1-21.4)	
Yes	7 (29.2)	30.2 (13.3-67.3)	32.5 (13.8-61.8)		1.5 (0.2-4.4)	1.2 (0.6-2.6)	
No. Tobacco Smokers Around Child, 25th-50th-75th[d,e]	2.25-3.5-4			.03			.10
No. B&M Smokers Around Child, 25th-50th-75th[e]	1-1-1	-	-	.86	-	-	.82
No. Cigar Smokers Around Child, 25th-50th-75th[e]	0-0-0	-	-	.12	-	-	.19
No. Cigarette Smokers Around Child, 25th-50th-75th[e]	1-2-3	-	-	.06	-	-	.18
No. Cigarettes Smoked Around Child, 25th-50th-75th[e]	0-2.5-9.75	-	-	.18	-	-	.14

Note.
Abbreviations: GeoM, geomean; CI, confidence interval; Mdn, median; IQR, interquartile range; ref, reference category; B&Ms, Black and Milds.
N = 24 and missing values excluded.
[a] Hand nicotine concentrations have been corrected for field blank contamination.
[b] N and percent unless noted otherwise.
[c] All p-values refer to linear regression model results.
[d] Tobacco smokers includes all smokers who use cigarillos, cigars, and/or cigarettes.
[e] Measures include all smokers (including the parent) the child was around in any location (home, car, outside).

between cotinine and having a home smoking ban (r = -0.588, p = 0.006), but no other associations were found between cotinine and the other covariates (ie, child age, number of cigarettes smoked).

A multiple linear regression model with cotinine as the outcome (R^2 = 0.49, F(2,17) = 8.04, p = .003) revealed that hand nicotine (semi-partial r^2 = 0.415; p = .002) had a significant positive linear association with cotinine independent of child age. That is, independent of age, higher hand nicotine levels were associated with higher cotinine levels. There was no association between child age (semi-partial r^2 = 0.006; p = .66) and cotinine independent of hand nicotine.

DISCUSSION

All nonsmoking children of cigar smokers had detectable hand nicotine (GeoM = 46.7 ng/wipe, 95% CI:[31.3;69.5]). These levels are in stark contrast to hand nicotine levels of children in THS-free homes of nonsmokers (GeoM: 0.7; 95% CI:[0.2;1]) and similar to those in homes of cigarette smokers with indoor smoking bans (GeoM:17.2; 95% CI:[7.1;39.9])[20] and without indoor smoking bans (GeoM:86.4; 95% CI:[61.0;122]).[8] Consistent with hand nicotine levels, urinary cotinine of 6.7ng/ml was comparable to children of cigarette smokers from our previous work.[12] Cotinine levels contrast with much lower levels in children of nonsmokers in THS-free homes (GeoM=0.08ng/ml, 95% CI:[0.0;0.17]).[20]

There was a strong positive correlation between cotinine and hand nicotine supporting the hypothesis that hand nicotine represents a measure of children's overall TSE via inhalation (eg, SHS) or via dermal absorption or ingestion (eg, from THS in dust or on surfaces).[8] Hand nicotine and urinary cotinine, however, are not redundant measures of TSE as indicated by the negative association of age with hand nicotine and the lack of association with cotinine. The negative correlation observed with child age and hand nicotine has not been reported previously. However, we have reported higher hand nicotine levels in 2-4-year-olds compared to younger and older children,[10] which is suspected to be the result of increased exploratory behaviors and contact with THS-polluted surfaces in this age group.[21] The finding that children who lived with parents who smoked cigars and cigarettes had higher hand nicotine levels may be due to increased overall THS levels in their homes. However, future studies should include larger numbers of parents who dual-used cigarettes and cigars and parents who smoke cigarettes only so that hand nicotine levels in these children can be compared. Finally, the finding that children in homes without smoking bans had higher mean cotinine is consistent with prior research on the effects of indoor smoking on SHS exposure.[22] Whereas it is known that homes with indoor smoking bans also have lower nicotine levels on surface levels,[23] we did not observe lower hand nicotine levels in children who lived in homes with smoking bans compared to those without bans. This could be due to higher levels of THS pollution from previous smokers in homes with smoking bans,[23,24] or differences in protective TSE practices in younger children's homes.[25] These findings need to be examined further in larger samples of varying sociodemographics and parental tobacco product use.

Study limitations include the small sample size which did not allow comparisons between children whose parents used B&Ms, other cigars, cigarettes, or who were dual- or poly-users. There was no control group of children of nonsmokers; thus, we were unable to differentiate between THS and SHS exposure. However, because nicotine can only be derived from tobacco products, nicotine on children's hands can be attributed only to SHS and THS in their environment, representing overall TSE. Further, given the varying ranges of nicotine content, additives and flavors in cigars,[14] future TSE biomarker studies should employ specific, detailed assessments about cigar use, including brands, cigar types (eg, traditional or little cigars, cigarillos), smoking topography (eg, puffs, duration), and locations of cigars smoked, all of which affect children's TSE. Although co-use of marijuana is common in tobacco product users,[16,26] marijuana use was not assessed, which could have affected our results. Furthermore, with the exception of B&Ms, we did not specifically assess types of cigars used which could have affected our study findings. Participants may have underreported cigar use or mistaken B&Ms for cigarettes due to their similar physical characteristics, but this was not assessed.[27,28] Additionally, recency and frequency of handwashing likely affects the amount of hand nicotine,[29] and future studies are advised to collect such information to adjust measured hand nicotine levels. Finally, there are other exposure-relevant variables (eg, amount of indoor time, distance to exposure source, hand-to-mouth behaviors, THS pollutant levels)[30-32] that future studies should incorporate to improve models of SHS and THS exposure to cigar smoke.

In conclusion, this study highlights the role of cigar use in children's overall TSE as it contributes to SHS and THS pollution of home environments. This study suggests that cigar use contributes to overall TSE through SHS and THS exposure. To study the unique and combined effects on exposure, future studies should measure different types of tobacco product use (eg, cigarettes, little and

traditional cigars, dual- and poly-use) and measure exposure through cotinine and hand nicotine to assess differential contributions of SHS and THS.

IMPLICATIONS FOR TOBACCO REGULATION

Cigar use in children's homes plays an important role in child TSE. The statistically significant association of hand nicotine with cotinine levels suggests that THS pollution at home should be assessed in evaluating children's overall TSE to toxicants in cigars and other tobacco products, and hand nicotine may be a useful proxy for overall TSE. Moreover, the statistically significant association between hand nicotine levels and child age suggests that younger children may have increased uptake of THS pollutants from their environments. Future studies should include biomarkers of SHS and THS exposure in children of cigar smokers with detailed assessments to differentiate biomarker patterns by type, frequency, and exposure patterns of cigar and other tobacco products. Given the lower regulation of cigar products compared to cigarettes,[33] the tobacco industry's push to place little cigars and cigarillos that have similar features to cigarettes (ie, shape, size, packaging) but are sold at a lower cost on the market, lower taxation, and the availability of flavors, there is a need for policies to regulate the sale of cigars that are equivalent to regulation of cigarettes.[6,28,34] Without these regulations, there is a risk of increased harm to vulnerable child populations that already have high TSE. Thus, policies are needed to decrease the availability and use of cigar products to protect children from toxicants due to cigar smoke exposure.

Human Subjects Approval Statement

This study was approved by the Institutional Review Board of Cincinnati Children's Hospital Medical Center.

Conflict of Interest Disclosure Statement

The authors have no conflicts of interest to disclose.

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