Perceived Health Concerns of Children Thirdhand Smoke Exposure and Potential Remediation Strategies Among Nonsmoking Parents of Young Children

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Abstract

We examined nonsmoking parents' concerns about child thirdhand smoke exposure (THSe) and their likelihood of implementing remediation strategies based on hypothetical handwipe nicotine (HN) levels, a proxy for children's THSe levels. Parents (N=245) of 0-11-year-old children were told that "low" and "high" HN levels were 10ng/wipe and 200ng/wipe, respectively. Parents reported higher mean concern that THSe would affect their child's health (M=2.3, SD=1.1) and were more likely to implement THSe remediation strategies (M=2.7, SD=0.7) when presented with high HN levels compared to low HN levels (M=1.5, SD=1.0, p<0.001, and M=2.0, SD=1.0, p<0.001, respectively). The top three endorsed remediation strategies for high and low HN levels were deep cleaning or professionally cleaning the home (78.8% and 63.7%) and not allowing smokers to smoke in the home (72.7% and 67.3%) and car (72.7% and 67.3%). Given nonsmoking parents' concerns about THSe-related health risks, THSe education is needed among nonsmoking households with children.

Keywords: children's exposure, parents, tobacco smoke, smoking, thirdhand smoke, hand wipes

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Introduction

Thirdhand smoke exposure (THSe) from previous nonrestricted indoor tobacco smoking is a public health concern despite recent declines in cigarette smoking (Cornelius et al., 2023). Pollutants left behind from secondhand smoke exposure (SHSe) can settle on surfaces as dust and embed into carpets, upholstery, and building materials (Jacob et al., 2017; Matt et al., 2023). This residual tobacco smoke contamination, or thirdhand smoke (THS), can persist on surfaces for months or even years after smoking has ceased (Jacob et al., 2017; Matt et al., 2023; Matt et al., 2020). THS pollution levels are high in smoke-free settings that previously allowed smoking such as in low-income multiunit housing, casinos, and hotels (Matt et al., 2023; Matt et al., 2014; Matt et al., 2018). This is evident in research that indicates that 95% of children of nonsmokers had THSe, with the highest rates noted among children who were from low-income families (Matt et al., 2022). While the clinical effects of THSe are not fully understood, prior clinical research indicates that THSe is associated with respiratory- and infectious-related health risks in children with SHSe (Mahabee-Gittens et al., 2021), and laboratory research indicates that THSe is associated with cytotoxic, genotoxic, oxidative damage, and carcinogenic risks (Hang et al., 2020; Matt et al., 2023;

Sakamaki-Ching et al., 2022; Sarker & Hang, 2022).

Similar to secondhand smoke (SHS), individuals can be exposed to THS irrespective of their smoking status. For example, nonsmokers can be exposed to THS by inhabiting spaces in which tobacco smoke was used previously (Matt et al., 2020, 2021). Compared to adults, children are at increased risk for THS exposure (THSe), particularly through skin absorption and ingestion, due to hand-to-mouth behaviors such as crawling and mouthing objects found on surfaces (Mahabee-Gittens et al., 2022; Matt et al., 2022; Tang et al., 2022). Consequently, child handwipe nicotine (HN) levels can be used as a proxy for children's THSe levels (Mahabee-Gittens et al., 2019; Mahabee-Gittens et al., 2018; Mahabee-Gittens et al., 2022; Matt et al., 2022).

The general public remains largely unaware of THS and its associated risks and routes of exposure (Matt et al., 2023; Tang et al., 2022). A social media campaign that sought to improve awareness of THS indicated that there were significant improvements in THS-related knowledge and attitudes in adult nonsmokers and smokers and that messages concerning children's health were the most influential (Record et al., 2023). Other research suggests the belief that THS is harmful to children is associated with prohibiting tobacco smoking within the home (Drehmer et al., 2012; Shehab & Ziyab, 2021). Although efforts to minimize THS pollution in homes in which tobacco has been smoked may be beneficial (Matt et al., 2021), it is unknown if nonsmoking parents are interested in knowing or decreasing their children's THSe levels. It is important to assess this information prior to implementing strategies that may decrease THSe and THS pollution in smoke-free settings. Thus, we conducted a study to examine nonsmoking parents' THSe-related concerns and likelihood of implementing remediation strategies based on children's hypothetical HN levels.

Methods

Participants and Procedures

A convenience sample of parental participants who were part of an observational pediatric THSe trial (R01ES030743) in a U.S. tertiary care children's hospital was included. Parents of 0-11-year-old children were eligible if they were nonsmokers, had a home and car smoking ban implemented for >6 months, and if their child denied tobacco or cannabis use; however, children did not participate in this sub-study. Institutional Review Board approval was obtained, and parents completed electronic surveys.

Measures

Perceived Level of Concern about THS

Parents were asked to rate their level of concern about how THS will affect their child's health using a four-point Likert-type scale as follows: "not at all concerned," "a little concerned," "somewhat concerned," or "very concerned." Parents could also respond "I do not know what THS is." We summed the four-point scale ranging from 0-3, with higher scores indicating higher concern.

Hypothetical HN Levels

Parents were provided two hypothetical scenarios about their child's HN levels. With both scenarios, they were told that the normal amount of child HN is 0ng/wipe and that it is possible that the presence of nicotine on their child's hands may affect his/her health. The first scenario was finding their child had a low HN level <10ng/wipe. After presenting this hypothetical result, parents were asked to rate their level of concern about this low HN result using a four-point Likert-type scale as

follows: “not at all concerned,” “a little concerned,” “somewhat concerned,” or “very concerned.” We summed the four-point scale ranging from 0-3, with higher scores indicating higher concern.

Parents were asked to rate how likely they would be to implement strategies to reduce their child’s exposure, such as deep cleaning or professionally cleaning the home and not allowing others who smoke to visit the home, using a four-point Likert-type scale as follows: “not at all likely,” “a little likely,” “somewhat likely,” or “very likely.” We summed the four-point scale ranging from 0-3, with a higher score indicating a higher likelihood of implementing strategies.

Parents were asked a check all that applies question about which of the following eight strategies they would consider to reduce their child’s THSe: “deep cleaning or professionally cleaning the home,” “banning others who smoke from visiting the home,” “not allowing smokers to smoke in your home,” “banning others who smoke from riding in your car,” “not allowing smokers to smoke in your car,” “no longer allowing your child to visit the home of a smoker who smokes inside the home or car,” “no longer allowing your child to visit the home of a smoker even if they only smoke outside,” and “none of the above.”

The second scenario was finding their child had a high HN level >200ng/wipe. After presenting this high hypothetical result, parents were asked the same questions about their level of concern about the result, the likelihood of implementing strategies to reduce their child’s THSe, and strategies they would consider to reduce THSe.

Sociodemographic Characteristics

Parents reported about their child’s age, sex, race, and ethnicity, and self-reported their age, sex, race, ethnicity, education level, family income level before taxes, and the type of home they live in with their child.

Statistical Analyses

We calculated descriptive statistics including frequencies, means (*M*s), and standard deviations (SDs) for all variables of interest. To assess differences based on sociodemographic characteristics and parents’ perceived concern that THS would affect their child’s health, we conducted either Pearson correlations for continuous variables (i.e., child and parent age), t-tests (e.g., parent sex), or one-way ANOVA tests (e.g., parent race) with post-hoc tests for categorical variables to compare sample means. Additionally, we conducted t-tests to assess differences between parents’ perceived concern that THS would affect child health and the likelihood of implementing remediation strategies after being presented with the low versus high hypothetical HN results. We used SPSS version 29 to conduct analyses.

Results

The sociodemographic characteristics of the 245 participants are described in Table 1. Overall, parents’ mean (SD) level of concern that THS would affect their child’s health was 0.8 (SD=0.9); about 5% (*n*=13) did not know about THS. Parent sex and family income differed based on parents’ perceived concern that THS would affect their child’s health (see Table 1). Specifically, female parents (*M*=0.9, SD=0.9, *p*=0.035) had higher perceived concern compared to male parents (*M*=0.5, SD=0.8). Concerning post-hoc test results for income, parents with incomes of ≤$50,000 (*M*=1.3, SD=1.1) had higher perceived concern versus parents with incomes of $50,001-$90,000 (*M*=0.6, SD=0.7, *p*<0.001) and $90,001-$119,999 (*M*=0.6, SD=0.8, *p*=0.001). Additionally, parents with incomes of ≥$120,000 (*M*=1.0, SD=1.0) had higher perceived concern

compared to parents with incomes of $50,001-$90,000 (p=0.039).

There was a significant difference between parents' mean levels of concern that THS would affect their child's health after being presented with the two hypothetical HN results, with parents reporting higher concern after being presented with the high hypothetical HN results (M=2.3, SD=1.1) compared with the low results (M=1.5, SD=1.0, p<0.001). Similarly, parents were more likely to implement remediation strategies to reduce their child's THSe after being presented with the high versus low hypothetical HN results (M=2.7, SD=0.7 vs. M=2.0, SD=1.0, p<0.001).

Briefly, the top three endorsed remediation strategies parents would consider after being presented with high hypothetical HN results were deep or professionally cleaning the home (78.8%) and not allowing smokers to smoke inside the home (72.7%) or car (72.7%) (see Figure 1). The top three endorsed remediation strategies selected after being presented with low hypothetical HN results were not allowing smokers to smoke inside the home (67.3%) or car (67.3%) and deep or professionally cleaning the home (63.7%).

Discussion

The study results demonstrate that when presented with high HN levels, parents had greater concerns about THSe-related health risks and were more likely to implement THSe remediation strategies to protect their children versus when they were presented with low HN levels. Although these HN results were hypothetical, past research on a subsample of children in this study indicates that 95% of nonsmokers' children thought to be protected from THS had detectable HN, and that the upper HN level exceeded

Figure 1

Percentages of remediation strategies that parents would consider using based on high and low hypothetical hand nicotine results.

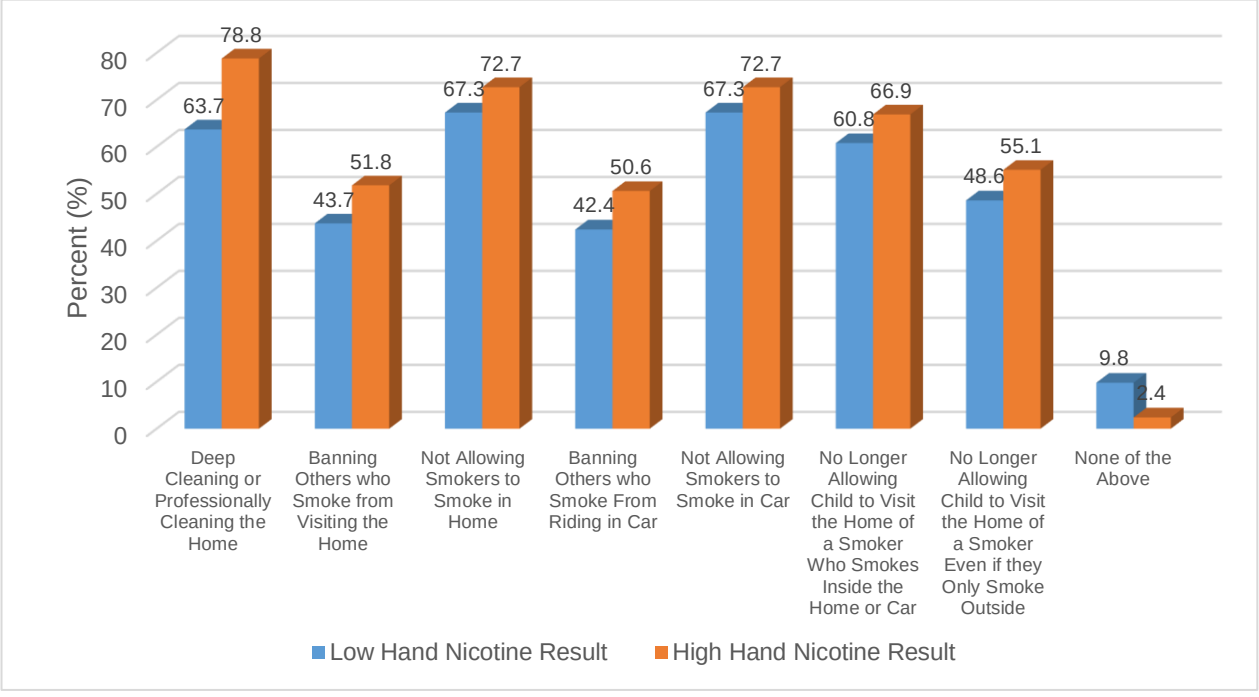

Table 1

Sociodemographic Characteristics Overall and based on Perceived Concern that Thirdhand Smoke (THS) will Affect Child Health

	Total Sample ***n*** **(%)**[a]	**Perceived Concern that THS Will Affect Child Health** ***M*** **(SD)**	***p*-value**
Sample Size	245	0.8 (0.9)	-
Child Age (years), *M* (SD)	6.1 (3.7)	-	0.292
Child Sex			0.073
Male	120 (49.0)	0.7 (0.9)	
Female	125 (51.0)	0.9 (1.0)	
Child Race			0.222
White	205 (83.7)	0.8 (0.9)	
Black/African American	28 (11.4)	0.9 (1.0)	
Other/Unknown	12 (4.9)	1.3 (1.3)	
Child Ethnicity			0.136
Non-Hispanic	236 (96.3)	0.8 (0.9)	
Hispanic	6 (2.4)	1.5 (1.6)	
Unknown	3 (1.2)	0.3 (0.6)	
Parent Age, *M* (SD)	36.0 (6.9)		0.084
Parent Sex			**0.035**
Male	34 (13.9)	0.5 (0.8)	
Female	211 (86.1)	0.9 (0.9)	
Parent Race			0.222
White	205 (83.7)	0.8 (0.9)	
Black/African American	28 (11.4)	0.9 (1.0)	
Other/Unknown	12 (4.9)	1.3 (1.3)	
Parent Ethnicity			0.863
Non-Hispanic	236 (96.3)	0.8 (0.9)	
Hispanic	9 (3.7)	0.8 (1.1)	
Parent Education			0.736
≤High School Graduate	28 (11.4)	0.9 (0.8)	
Some College	47 (19.2)	1.0 (1.2)	
College Graduate	90 (36.7)	0.8 (0.9)	
Post-Graduate	80 (32.7)	0.8 (0.9)	
Family Income			**<0.001**
≤$50,000	48 (19.6)	1.3 (1.1)	
$50,001-$90,000	77 (31.4)	0.6 (0.7)	
$90,001-$119,999	42 (17.1)	0.6 (0.8)	
≥$120,000	78 (31.8)	1.0 (1.0)	
Type of Home			0.151
Single-family	218 (89.3)	0.8 (0.9)	
Multiunit	26 (10.7)	1.1 (1.1)	

Abbreviation: THS, thirdhand smoke.

[a] Sample size and valid percent unless noted otherwise.

200ng/wipe (Matt et al., 2022). In that study, the Geometric mean (95% CI), median (IQR), and range for HN was 2.9 (2.5-3.4), 2.4 (1.0-5.7), and 0-233.1 ng/wipe, respectively (Matt et al., 2022). Thus, the hypothetical results could have represented actual HN levels in this sample. In this same subsample of nonsmokers' children, children in lower income groups of ≤$30,000 had higher HN levels than children in higher income groups (Matt et al., 2022). In the present study, parents with lower incomes of ≤$50,000 had higher perceived concerns compared to higher-income parents. Additionally, parents with incomes of ≥$120,000 had higher concerns compared to parents with mid-level incomes of $50,001-$90,000. These results suggest that nonsmoking parents of both low- and high-income groups may be interested in being informed about their children's HN levels in future work. Further, we observed that female parents were more concerned about their children's HN results compared to male parents. This finding parallels another study in which mothers were more concerned about their children's TSE compared to fathers (Myers et al., 2018). When presented with low or high HN levels, the most popular remediation strategies included implementing home and car smoking bans and deep cleaning or professionally cleaning the home. Our findings are supported by research indicating that parents believe THS is harmful to children and that this belief may be associated with the implementation of smoking bans (Drehmer et al., 2012; Shehab & Ziyab, 2021; Vanzi et al., 2023).

It is important that nonsmoking parents receive education about their children's THSe-related health risks, THS sources (e.g., old carpet and toys), and THSe remediation strategies. Strategies include strict enforcement of smoking bans in all areas in private and multiunit homes, delivering effective smoking cessation interventions, frequent and thorough home cleaning, and reducing THS reservoirs found in older homes (Matt et al., 2023). However, these strategies may not be possible or may only provide temporary relief in older homes in which many years of indoor smoking occurred (Matt et al., 2020). Thus, it is important to develop sensitive ways to report back children's THSe levels in a way that will empower and not frighten parents, especially if, for example, moving or buying new furniture is not possible. Recent guidance indicates that in the case of environmental exposures such as THS that resulted from the action of many individuals (e.g., indoor smoking permitted in multiunit housing), if a group of affected individuals are made aware of their exposure and then decide to act and reduce these exposures, then a systems change could occur (e.g., residents or landowners ensure that strict bans are enforced) (Korfmacher & Brody, 2023).

In summary, nonsmoking parents were concerned about the potential child THSe-related health risks, with higher concerns reported when children had high hypothetical HN results. Universal THSe education is needed among nonsmoking households with children.

Limitations

Study limitations include the reliance on hypothetical HN results and parent reports of potential actions. Future research should consider giving actual HN results to parents and exploring their reactions using a mixed-methods approach. Moreover, the remediation strategies have not been validated as being effective in decreasing children's THS exposure or home THS pollution. Thus, future studies are needed to examine these and other strategies. Finally, although thirdhand aerosol exposure due to electronic cigarettes is a concern in children (Jenssen et al., 2023), this concern was not

addressed in this study. Further, this study was conducted at a single hospital in the midwestern U.S., which limits the generalizability as it is unknown if the results would have been the same with a different study sample.

Implications for Health Behavior Research

The precaution adoption process model explains the stages that occur prior to conducting a new action, such as smoking cessation (Borrelli et al., 2016; Weinstein et al., 2020). Concerning THSe, these steps could include changes in: THSe awareness/knowledge, beliefs about THSe and children's health, interest in obtaining children's THSe level, engagement in identifying sources of THSe, and resolve to implement strategies/actions to decrease children's THSe. Given the study's findings, possible next steps include recruiting a sample of nonsmoking parents who live in apartments with heavy THS levels. Using a mixed-methods approach, parents can be given THSe-related education and their child's HN levels in an iterative fashion, which leverages past suggestions on how to best deliver this information. A facilitator would then help them collectively develop individual-based, building-wide, and community-based strategies to decrease their children's THSe. At the policy level, study findings can be leveraged to support initiatives to ban tobacco use in all home settings to reduce THS pollution (Matt et al., 2020), especially among nonsmoking families who implement safety measures and precautions such as home and car smoking bans and are still exposed to this toxic pollution.

Discussion Questions

- Our findings indicate that nonsmoking parents are concerned about their children's HN levels. What are the best approaches to sensitively give parents these results, especially if their children have high levels of HN?
- What are the next steps in informing the public about the presence of THS in environments in which tobacco smoke pollutants are not expected, and how can the study findings influence policy makers to ban tobacco use in homes to eradicate THS?

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