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Title:

Nicotine, cotinine and tobacco-specific nitrosamines (TSNAs) measured in children's silicone wristbands in relation to secondhand smoke and e-cigarette vapor exposure.

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Abstract (250 words)

Introduction: Simple silicone wristbands hold promise for exposure assessment in children. We previously reported strong correlations between nicotine in wristbands worn by children and urinary cotinine. Here, we investigated differences in wristband chemical concentrations among children exposed to secondhand smoke from conventional cigarettes (CC) or secondhand vapor from electronic cigarettes (EC), and children living with non-users of either product (NS).

Methods: Children (n=53) wore three wristbands and a passive nicotine air sampler for 7 days and one wristband for 2 days, and gave a urine sample on day 7. Caregivers reported daily exposures during the 7-day period. We determined nicotine, cotinine, and tobacco-specific nitrosamines (TSNA) concentrations in wristbands, nicotine in air samplers, and urinary cotinine through isotope-dilution liquid chromatography with triple-quadrupole mass spectrometry (LC-MS/MS).

Results: Nicotine and cotinine levels in wristbands (WB) in children differentiated between groups of children recruited into NS, EC exposed, and CC exposed groups in a similar manner to urinary cotinine (UC). Wristband levels were significantly higher in the CC group (WB nicotine median 233.8 ng/g silicone, UC median 3.6 ng/ml, n=15) than the EC group (WB nicotine median: 28.9 ng/g, UC 0.5 ng/ml, n=19), and both CC and EC group levels were higher than the NS group (WB nicotine median: 3.7 ng/g, UC 0.1 ng/ml, n=19). TSNAs, including the known carcinogen NNK, were detected in 39% of wristbands.

Conclusion: Silicone wristbands show promise for sensitive detection of exposure to tobacco-related contaminants from traditional and electronic cigarettes and have potential for tobacco control efforts.

IMPLICATIONS

Silicone wristbands worn by children can absorb nicotine, cotinine and tobacco-specific nitrosamines, and amounts of these compounds are closely related to the child' urinary cotinine. Levels of tobacco-specific compounds in the silicone wristbands can distinguish patterns of children's exposure to secondhand smoke and e-cigarette vapor. Silicone wristbands are simple to use and acceptable to children, and therefore may be useful for tobacco control activities such as parental awareness and behavior change, and effects of smoke-free policy implementation.

INTRODUCTION

Simple techniques for measuring exposure to secondhand and thirdhand tobacco smoke (SHS, THS) and second and thirdhand vapor from electronic cigarettes (SHeV, THeV) can assist tobacco control efforts. Methods for assessing these exposures in children are especially needed [1]. Current methods, while accurate, often rely on biological specimens such as urine and saliva, which can be difficult to obtain, and require special handling of specimens [2]. Silicone wristbands, which are already worn by children by choice, have been shown to absorb toxic chemicals from the wearer's environment when worn for several days to weeks [3-11].

Our group was the first to apply silicone wristbands to measurement of tobacco product exposure in children, and we demonstrated that nicotine levels in silicone wristbands worn by children (n = 31) for 2 and 7 days were both highly correlated with cotinine, a metabolite of nicotine, in urine from the same child [12]. Here, we further investigated the ability of silicone wristbands to record differences in nicotine exposures among children recruited into different exposure groups: children exposed to SHS or those exposed to SHeV compared to children living with non-users of either conventional or electronic cigarettes. We also compare silicone wristband performance to air monitors carried by the children as well as to urinary cotinine. We expand analysis of tobacco products measured in silicone wristbands to cotinine and tobacco-specific nitrosamines (TSNAs) a group of chemicals specific to tobacco that includes known carcinogens [13].

METHODS

Recruitment

Approvals were obtained from the Human Research Protection Program at San Diego State University and informed consent and assent was obtained. Participants were recruited from a past home air quality study who had agreed to be re-contacted (n = 27), referrals from other study participants (n = 5), tabling, i.e. research assistants recruited at tables placed in public locations such as shopping centers (n = 8) and advertisements on Craigslist (n = 1), Facebook (n = 11), and Instagram (n = 1). Children were all nonusers of conventional cigarettes (CC) or electronic cigarettes (EC). We recruited children who lived with at least one adult who smoked a minimum of 7 CC/week inside the home (n = 19), children who lived with at least one adult who used EC at least 4 days/week inside the home and used e-liquids with nicotine (n = 19), and children not exposed to nicotine products, who lived with adult nonsmokers and nonusers of EC who had a complete ban on smoking and EC use inside their home (n = 15). Participants in the CC and EC groups were more likely to be classified as African-American/Black or Biracial/mixed race (82%) than Latinos (33%, $p<0.05$).

Sample Collection

All samples and interview data were collected during two visits to participants' homes between March 2017 and December 2018.

Face-to-face home interviews. Parents/caregivers were interviewed by trained research assistants to collect data on education level, family income, and child's age, gender, race/ethnicity; household characteristics including number of residents and rooms, and years living in the current home; child's exposure to CC and EC over the sampling week; actual household residents' usage frequency and amount of CC and EC products over the sampling week; the location (inside home, inside the car, or outside) where CC and EC were used when child was present.

Daily monitoring. Caregivers were asked to report their daily use of CC/EC and the child's exposure to CC/EC during brief (5-minute) daily telephone calls with a research assistant, and to verify wearing of the air monitor and wristband through a daily texted photo.

Urine samples. Single spot urine samples were collected from child participants using procedures from our previous studies [12,14,15]. Caregivers were asked to have the child collect their sample on the morning of the second home visit, but sometimes samples were collected at other times due to child and caregiver schedules.

Silicone wristbands. Cleaned prepared bulk wristbands in Teflon bags were obtained from K. Anderson.[8] Wristbands were individually stored and transported in clear glass jars with polytetrafluoroethylene (PTFE)-faced PE-lined caps, or 2.0 mil thick Teflon PFA bags (2-day wristband). Each child participant received three wristbands at the initial home visit. Two were placed on the child's arm at the home visit, to be worn for 7 days, and one was given to the caregiver for child to wear for the last 2 days. A reminder was given by phone to caregivers on the morning of day 5 to place wristband on child. The actual wearing time for the 7-day wristbands was from 5.8 days to 8.7 days, with a median of 7.0 days and 2.4 days for the 2-day wristbands. The research assistants also collected a wristband field blank for each participant, handling and transporting it in the same way as the worn wristbands, except it was immediately replaced in the container. Caregivers texted a picture of the child wearing the wristband and air monitor (below) once a day to verify wearing. Participants were asked to wear wristbands at all times during the study. Most (36/53) children received 'small' size wristbands (median weight 3.8 g), 8/53 received 'extra small' size wristbands (median weight 3.7 g) and 9/53 received 'large' size wristbands (median weight 4.3 g). Nicotine was present in 8/36 of the analyzed field blanks, and the average blank value was 1.14 ng nicotine/wristband. The majority (6/8) of the field blanks with detectable nicotine levels were from CC group, with one from EC group and the lowest one (0.6 ng nicotine/wristband) in NS group. We reported results as ng nicotine/ wristband in our previous paper. Here we report nicotine, cotinine, and TSNAs in ng nicotine/g silicone in wristband as in other studies [6,16].For 31 wristbands used for nicotine analysis, the actual wristband weight was not recorded, so we used the median weight of wristbands in that size category. Both 2-day and 7-day wristband nicotine and cotinine levels adjusted for silicone wristband weight (ng/g silicone) were highly correlated with levels expressed as ng/wristband (all *rho* > 0.99, $p<0.01$). Sample wristbands and field blanks were transported cooled in individual borosilicate amber glass vials, with Thermoset lids lined with PTFE, and stored at -20ºC until analysis.

Air nicotine. Air nicotine concentrations were measured using passive air monitors [17]. Child participants were asked to wear the passive diffusion monitor badge (protected by a stainless steel mesh 'tea ball') pinned to their outer clothing or backpack strap over one week, and to wear the badge at all times except when bathing, swimming, sleeping, or when it interfered with activities such as engaging in vigorous sports. Many participants reported not wearing the monitors for short times (for example, forgetting in car when at church). The times were not adjusted for non-wearing of the badge. Deployment time was used to calculate minutes monitor was exposed and ranged from 5.9 days to 12 days (median 7.0 days). An air monitor field blank was collected for each participant. Of these, 10% were analyzed, and if the average blank level was < 30% of the level in the sample, the average blank level was subtracted from the sample level. If the average blank level was > 30% of the level in the sample, the sample was censored. Results are reported as ng nicotine/m^3 of air.

Laboratory Analysis

Detailed laboratory methods are available in online supporting materials.

Wristband Nicotine. The QuEChERS extraction procedure modified for nicotine analyses in dust and surface wipes was utilized to extract nicotine from the silicone wristbands [18]. Nicotine quantification was conducted by LC-MS/MS (Agilent 1200 Series LC system coupled to an Agilent 6460 Triple Quadrupole system) operated in positive electrospray ionization (ESI+) mode. The estimated method detection limit (MDL) [19] was 0.19 ng/wristband. Detailed information on the sample preparation, extraction and quantification of nicotine from wristbands has been described [12].

Wristband Cotinine. Cotinine was extracted from the same wristband as nicotine using the nicotine wristband extraction method, above, with a final spiked cotinine-d3 concentration of 5 ng/mL, and quantified with the same instrumental method as for urinary cotinine, below [14,15]. The estimated MDL was 0.10 ng/wristband. We added this analyte to the second half of samples (n = 22) after considering literature suggesting that sweat could be a route of exposure for the wristbands.

Wristband TSNAs. The extraction procedure is described in detail in the supporting materials. A separate wristband was analyzed for TSNAs. One half of the wristband was weighed, then spiked with the four internal standards (NNK-d4, NAB-d4, NAT-d4, NNN-d4). The final concentration of each of the deuterated TSNAs was 12.5 ng/mL. The TSNAs were quantified by LC-MS/MS, operated in positive electrospray ionization (ESI+) mode as in [15]. The estimated MDL was 0.10 ng/wristband. A total of 51 wristbands were analyzed for TSNAs.

Urinary Cotinine. Urinary cotinine was determined though isotope dilution LC-MS/MS [12,14,15].The estimated MDL was 0.033 ng/mL urine, and cotinine levels were reported in ng/mL urine [20].

Air Nicotine. The extraction procedure is described in detail in the supporting materials, and used a procedure similar to nicotine in wristbands. The final concentration of nicotine-d_4 was 5 ng/mL. The instrumental method and calibration procedure described for wristband nicotine was used for quantification.[12] The estimated MDL was 0.13 ng/badge.

Statistical Analysis

Descriptive statistics were produced using SPSS v26. The Kruskal Wallis test followed by pairwise Mann-Whitney U-test were utilized to determine differences of nicotine and cotinine concentrations among participants' groups. Spearman rank-order correlations (*rho*) were used to determine associations. The Type I error rate was set at 5% (two-tailed). Statistical tests were conducted with SPSS v25 and 26.

RESULTS

Demographic characteristics

All children recruited for this study were nonsmokers and nonusers of EC. The majority of participants were multiracial (39.6%) or Latino/a (22.6%) (Table 1). The majority of children were females (60%), and a median 9 years of age (range 3 – 14). Participants in this study lived a median 3 years in their home with a median number of occupants of 5 (range 2 – 16). African American and multiracial participants had significantly higher urinary cotinine than Latino participants.

Detection levels for nicotine and cotinine in wristbands, cotinine in urine and air nicotine samplers

Nicotine was detected in 100% of all silicone wristbands, with a range over three orders of magnitude (from 2.5 ng of nicotine to over 3000 ng per wristband) (supporting online material Table S2) and cotinine in almost all wristbands (91% and 95%, 7-day and 2-day, respectively). Urinary cotinine had a similar detection frequency with only one non-detect, <2%). In contrast, only 36% of air samples had detectable levels of nicotine (Table S1).

Differences in wristband, air, and urine measures between exposure group

Table 2 gives the medians by exposure group for the children for 7-day wristband nicotine, 7-day wristband cotinine, urinary cotinine and air nicotine. In addition to children's exposure groups based on recruitment criteria (Table 2, classification I), we present groups classified based on daily interviews during the 7 day period that the child was wearing the wristband, which differed in some cases from the report at recruitment: these groups are reported exposure of the child in the same indoor room (classification II), as well as product use by residents, whether or not the child was present (classification III).

Nicotine and cotinine levels in wristbands distinguished between CC, EC, and NS recruitment groups (Table 2, classification I), as did urinary cotinine and air nicotine. Nicotine and cotinine levels were significantly higher in 7-day wristbands (WB), as well as children's urinary cotinine recruited in the CC group (WB nicotine median: 233.8 ng/g silicone; urinary cotinine: 3.6 ng/ml) than the EC group (WB nicotine median: 28.9 ng/g; urinary cotinine: 0.5 ng/ml), and both CC and EC group levels were higher than in the NS group (WB nicotine median: 3.7 ng/g; urinary cotinine: 0.1 ng/ml). Wristband cotinine concentrations also distinguished between the CC, EC and NS recruitment groups (Table, 2, classification I). Table S3 (supporting online materials), presents data for 2-day wristband nicotine and cotinine, with similar results.

Classifications II and III were based on caregiver report over the 7 days of the study. For all measures, the wristbands worn by children in the CC group were significantly more contaminated compared to EC and NS groups (Table 2, classifications II and III). Examining the residents' use of CC use group further (detailed examination of III, Table 2), it is clear that the highest WB nicotine? levels, as well as air and urinary cotinine levels, were measured when residents smoked CC inside: WB nicotine for CC inside group median 428.4 ng/g silicone vs. CC outside only median 36.7 ng/g, p <0.01, Table 2. For WB nicotine, cotinine and urinary cotinine, the EC group was also significantly higher than NS groups for classification III (Table 2). We further examined the NS groups in II and III to examine wristband sensitivity to low levels of exposure. In classification II, 24 of the children were classified as 'NS' by their caregivers, and of these, 14 were classified as NS in both II and III (Table 2). The 10 children (24 total – 14) from homes where residents used CC or EC but the caregiver reported the child was not exposed (NS in classification II only) had significantly higher, WB nicotine, WB cotinine and urinary cotinine than the 14 children from homes with no EC/CC use and a total ban (classification as NS in both II and III). For WB nicotine, the median was 46.5 ng/g silicone) vs. 3.9 ng/g, for WB cotinine 22.3 ng/g vs. 0.3 ng/g, and for urinary cotinine 0.3 ng/ml (0.2-3.5) vs. 0.1 ng/ml (0.0-0.2), all p<0.01.

Correlation of wristband nicotine and cotinine with quantitative measures of tobacco-product use

To determine whether levels of nicotine and cotinine in silicone wristbands were sensitive to the levels of tobacco product use, we determined correlations with reported measures of indoor CC and EC use (Table 3). For both the child's exposure as reported by the caregiver (exposure classification II) as well as by the resident's reported use, classification III), the amount of nicotine (ng/g silicone) in the wristband was significantly correlated with the number of cigarettes smoked indoors over the 7 day period (*rho* = 0.706, 0.725, respectively, $p<0.01$). The amount of vaping reported was also significantly correlated with nicotine levels in wristbands, both for reported exposure to EC in minutes (*rho* = 0.442, 0.557, respectively, $p<0.01$) and in reported mLs of EC-fluid used per week (*rho* = 0.557, 0.581, respectively, $p<0.01$), even though the amount of nicotine in the product was unknown.

Measurement of tobacco-specific nitrosamines in silicone wristbands

We detected TSNAs in 39% of silicone wristbands (online supporting material Table S1), mostly in children exposed to CC (Table 4). For recruitment group (I) as well as exposure (II) and use (III) group, the CC group had a higher level of total TSNAs on the wristbands (median 0.25 ng/g silicone vs 0.05 ng/g silicone in III NS group, Table 4) mainly due to the well-studied lung carcinogen NNK (64% detection in product use CC group, 46% detection in CC plus EC group, 7 % in EC group and 0% in NS group). Details for each individual TSNA (NNK, NAT, NAB, NNN) are given in the supporting online material (Table S4). NAB was the only TSNA to be detected in the NS groups I, II or III (14%, 9%, and 14% detection in NS groups, respectively, Table 4).

Correlations between analytes

The 2-day and the 7-day wristband nicotine levels were highly correlated (*rho* = 0.94), with a median 28% difference, and both 2-day and 7-day wristband nicotine levels were highly correlated with urinary cotinine on day 7 (both *rho* > 0.90) (supporting online material Table S5). Cotinine in wristbands was also highly correlated with wristband nicotine (both *rho* > 0.90) and urinary cotinine (*rho* = 0.87). The median ratio of cotinine to nicotine measured in the same wristband decreased in more highly exposed groups, though none of the decreases were statistically significant e.g., from a median 0.74 in NS recruitment group vs. 0.50 in EC group and 0.20 in CC group) (supporting online materials Table S6).

DISCUSSION

Silicone wristbands recorded nicotine and cotinine over a range spanning three orders of magnitude, with 100% detection rate for nicotine. We demonstrated significant differences in silicone wristband nicotine and cotinine between groups of children recruited into non-smoker, EC exposed, and CC exposed groups in a manner similar to urinary cotinine, demonstrating the validity of the silicone wristband sampler in measuring exposure to tobacco products. Silicone wristbands had a sensitive detection limit for nicotine and cotinine: In children reported as non-exposed by the caregiver, nicotine in wristbands more closely tracked caregiver's use patterns regardless of children's presence, rather than child's exposure as reported by the caregiver, as did urinary cotinine. This increase might be due to child exposures to drifting SHS or SHeV unnoticed by the caregiver [21], and/or potential exposure to thirdhand smoke residue [22-24], and demonstrates the sensitivity of the silicone wristband sampler. The highest levels for wristbands were clearly associated with exposure to CC indoors, demonstrating the ability of the sampler to detect high exposures in a similar matter to urinary cotinine. Within groups, we also detected significant correlations with the number of CC or amount of EC used, indicating silicone wristbands can detect an exposure-response relationship. Silicone wristbands performed in a similar manner to urinary cotinine, and the cost of analysis is similar to air nicotine and cotinine, but wristbands are simpler to deploy and collect. Although wristbands were deployed and retrieved in-person in this study, other studies have shipped wristbands internationally at ambient temperatures [4,25], and semi-volatile organic compounds (SVOCs) concentrations were found to be stable in wristbands at room temperatures (nicotine is an SVOC) [26]. The next step is to validate remote deployment and collection of wristbands for tobacco-related compounds collected under standard mailing conditions to assist in community-based exposure studies.

We demonstrated that children exposed to secondhand EC vapor by their caregivers have higher levels of nicotine on their wristbands than do children of non-smokers/users. E-cigarette use in the home has been reported to result in measurable air nicotine (geomean 130 ng/m^3 nicotine in homes of indoor e-cigarette users compared to 20 ng/m^3 in homes of non-smokers/non-users)[27] and 200 ng/m^3 nicotine in homes of indoor e-cigarette users in another study [28]. In our study, less than 50% of the air monitors carried by children in the EC-only caregiver use registered above our nicotine in air detection limit (median 0.0, 75th percentile 22.0 ng/m^3, maximum 180.5), but the air monitor in our study traveled with the child, as opposed to a static home measurement, so these integrated air levels were likely lower. To our knowledge, the elevated level of nicotine in wristbands is the first report of personal measurement of nicotine from secondhand e-cigarette exposure in children.

In our data, the 7-day wearing time and the 2-day wearing time produced comparable results. The 7-day measurement was higher in nicotine, but only by 28%, rather than the 350% expected if the levels were linear over the time exposed. This may be due to saturation of the wristband or degradation of nicotine over time, and this requires further study. The shorter time of wearing may be preferable, as a few 7-day wristbands were accidentally lost.

The routes of exposure assessed by the silicone wristbands, whether inhalation, dermal, or ingestion, or a combination, has been debated. Early deployments of the silicone wristbands focused on the ability of the silicone to sample air exposures, which would presumably partition into the wristband based on chemical characteristics [26], and PAHs in active air samplers correlated with PAHs in the paired wristbands [3]. Some data have emerged implicating other routes of exposure, such as dermal and ingestion exposures. Aerts et al.[29] detected pesticide residues in wristbands not present in paired air samples, suggesting that silicone wristbands directly worn on the skin may also capture ingested or dermal contaminants. Wang et al. [30] found that wristband analytes were better correlated with dermal wipes plus air measurements than with air alone, indicating that inhalation and dermal routes of exposure were measured by the silicone wristband sampler. The route of exposure assessed by the wristband in children exposed to tobacco products should be further investigated.

Nicotine and cotinine in the wristbands may arise from contact of the wristbands with sweat, as both of these compounds are excreted in sweat, as well as related nicotine metabolites (e.g. OH-cotinine) [31-33]. Evidence that sweat may contribute to observed nicotine and cotinine on the wristband is supported by the strong correlation (*rho* > 0.9) between urinary cotinine and wristband nicotine. This correlation is much stronger than reported from other silicone wristband studies that compared urinary and wristband levels for other toxicants [3,5]. Between 87 and 203 ng of nicotine were collected on a commercial sweat patch worn for 72 hours by 5 adults exposed to SHS [34]. In our participant wristbands, a median 571 ng (range 130 - 2629 ng) of nicotine were collected on wristbands worn for 2 days by children exposed to SHS. In the wristbands, the ratio of cotinine to nicotine in the same wristband decreased (though non-significantly) in more highly exposed subjects. We could not determine the ratio between nicotine and cotinine in sweat from the studies cited for comparison, however. It is possible that sweat is a major contributor to observed levels at lower doses, but air nicotine increasingly contributes to nicotine in wristbands at higher air levels of nicotine.

We detected TSNAs in silicone wristbands worn for 7 days, mostly in children exposed to CC, including the well-studied lung carcinogen NNK[13]. It is unknown whether a wearing period would increase detection, or if a shorter wearing time would record similar levels of detection. Also, it is possible that we would have detected metabolites of TSNAs excreted in sweat, as well as parent

TSNAs, for reasons discussed above. It is possible that TSNA exposure could arise through thirdhand smoke residue in dust or on surfaces [22], as even in the NS group a TSNA (NAB) was detected.

There are limitations to this study. One is the complex behavior around children's exposure to tobacco-related products. Classification of exposure based on recruitment self-report did not always match up with the classification based on smoking and vaping behavior during the 7-day study period. For example, some in the 'exposed to EC indoors' recruitment group were only exposed outdoors during the study period (n = 2) or exposed to CC outdoors as well (n = 5). Due to budget limitations, we could not collect dust or wipe samples to assess the extent of thirdhand smoke contamination in the child's home, which may be an unmeasured factor contributing to wristband nicotine or TSNA levels[15]. Also, if we could have measured children's sweat directly, we could compare levels and ratios of nicotine and cotinine in sweat with wristband levels.

CONCLUSION

The simple silicone wristband demonstrates a wide range over three orders of magnitude and with 100% detection for wristband nicotine. Silicone wristband nicotine and cotinine levels can discriminate between groups of children exposed to SHS (CC), SHeV (EC) and children not living with a user or smoker, with sample sizes between 15 and 20 children for each group. The wristbands detected low and high exposures within groups and discriminated between exposure groups for children in a manner similar to urinary cotinine. Our data also indicate that children living with e-cigarette users are significantly more exposed to nicotine from e-cigarettes than children living with non-smokers.

We demonstrate that silicone wristbands can be used to detect multiple classes of chemicals related to tobacco smoke (nicotine, cotinine, TSNAs). We detected carcinogenic TSNAs in silicone wristbands worn for 7 days, mostly in children exposed to CC smokers. Significant questions remain whether the silicone wristband captures pollutants on the skin or in the sweat of wearer or pollutants in the air. The silicone wristband is a simple-to-deploy method for assessing exposure to tobacco-related products that shows promise for tobacco control efforts.

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Conflict of Interest

KAA discloses a financial interest in MyExposome that is marketing products related to the research being reported. The terms of this arrangement have been reviewed and approved by Oregon State University in accordance with its policy on research conflict of interest. The other authors declare no conflict of interest.

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Table 1. Demographic and household characteristics in relation to urinary cotinine (n = 53)

Demographics	n (%)	Urinary Cotinine (ng/ml) (median, p25-p75)	*p*-value
Gender			
Male	21 (40)	0.3 (0.1-2.6)	0.960
Female	32 (60)	0.5 (0.1-2.8)	
Ethnicity			
Latino/Hispanic	12 (23)	**0.1 (0.1-2.7)**	
African American/Black	7(13)	**2.8 (1.2-9.9)[a]**	
Caucasian/White	11 (21)	0.3 (0.2-0.0)	**0.014**
Asian/ Pacific Islander	2 (4)	0.8 (0.5)	
Bi or Multiracial	21 (40)	**1.3 (0.1-4.5)[a]**	
Yearly income			
$20,000 and less	11 (21)	1.2 (0.1-4.9)	
$20,001 to $50,000	19 (36)	0.9 (0.1-3.6)	0.672
$50,001 and above	23 (43)	0.3 (0.1-1.4)	
Parents/caregivers education			
High school and below	7 (13)	2.0 (0.3-6.7)	
Some college	26 (49)	0.5 (0.1-3.5)	0.395
Received higher education diploma	20 (38)	0.3 (0.1-1.4)	
Children's age groups			
3 to < 6 years of age	12 (23)	0.8 (0.2-2.6)	
6 to < 11 years of age	28 (53)	0.8 (0.2-3.6)	0.355
11 to 14 years of age	13 (25)	0.0 (0.0-3.1)	
Household characteristics			
Number of occupants			
<= 3	10 (19)	0.3 (0.2-6.2)	
4 - 5	25 (47)	0.5 (0.1-1.7)	0.825
>= 6	18 (34)	0.7 (0.2-2.9)	
Number of rooms			
<= 6	20 (38)	1.0 (0.2-3.5)	
7	15 (28)	0.2 (0.0-1.3)	0.080
>= 8	18 (34)	0.7 (0.3-3.0)	
Years living in residence			
</= 2	19 (37)	1.2 (0.3-4.7)	
2 - <= 5	17 (33)	0.3 (0.1-1.5)	0.139
>= 6	15 (29)	0.5 (0.1-1.9)	

p25-p75: 25th and 75th percentile. [a]African-American/Black and Multiracial groups had significantly higher levels than Latinos. Note: bolded values are significant ($p < 0.05$).

Table 2. Child's exposure group related to nicotine and cotinine concentrations in wristbands, nicotine in air and urinary cotinine.

Exposure group by classification scheme (#)	n*	7-day Wristband Nicotine Concentration (ng/g), n = 52 Median (p25–p75)	7-day Wristband Cotinine Concentration (ng/g), n = 22 Median (p25–p75), n	Air Nicotine Concentration (ng/m³), n = 53 Median (p25–p75)	Urinary Cotinine Concentration (ng/ml), n = 53 Median (p25–p75)
Recruitment (I)					
NS-Non-exposed at recruitment	15	3.7 (1.6–4.6)	0.34 (0.0–1.0), 5	0.0 (0.0–0.0)	0.1 (0.0–0.1)
EC	19	**28.9 (15.5–55.5)[a]**	**7.4 (3.4-12.7)[a], 10**	0.0 (0.0–14.3)	**0.5 (0.3–1.2)[a]**
CC	19	**233.8 (74.7–429.1)[a,b]**	**36.8 (15.4-56.1)[a,b], 7**	**90.7 (0.0–291.3)[a,b]**	**3.6 (1.4–9.9)[a,b]**
Child's reported exposure (II)					
NS-Non-exposed by caregiver report	24	4.5 (3.1–28.2)	1.5 (0.3-29.4), 11	0.0 (0.0–0.0)	0.1 (0.1–0.3)
EC	14	**27.6 (15.1–58.0)[a]**	6.3 (4.0-10.9), 7	0.0 (0.0–41.4)	**0.5 (0.3–1.2)[a]**
EC+CC	4	**176.2 (55.7–561.3)[a]**	36.9 (- - -)[e], 1	**171.5 (21.2–381.9)[a,b]**	**2.4 (1.9–8.1)[a]**
CC	9	**242.4 (105.9–470.8)[a,b]**	50.7 (- - -), 3	**210.2 (68.0–317.1)[a,b]**	**4.2 (3.2–7.6)[a,b]**
Residents' tobacco product use (III)					
NS-No reported use by residents	14	3.9 (1.6–5.4)	0.3 (0.0-1.0) 5	0.0 (0.0–0.0)	0.1 (0.0–0.2)
EC	14	**27.0 (14.9–53.1)[a]**	**8.6 (4.9-13.4) [a], 9**	0.0 (0.0–0.0)	**0.3 (0.2–0.6)[a]**
EC+CC	13	**73.4 (28.4–214.9)[a]**	**22.4 (4.8-49.4) [a], 4**	0.0 (0.0–55.2)	**1.4 (0.7–2.8)[a]**
CC	12	**243.4 (102.2–510.5)[a,b]**	**43.8 (18.8-66.8) [a], 4**	**187.1 (45.9–294.9)[a,b]**	**4.2 (3.0–10.4)[a,b]**
Detailed residents' tobacco products use (III)					
NS-No reported use by residents	14	3.9 (1.6–5.4)	0.3 (0.0-1.0), 5	0.0 (0.0–0.0)	0.1 (0.0–0.2)
EC, inside or only outside home, no CC[c]	14	**27.0 (14.9–53.1)[a]**	**8.6 (5.0-13.4) [a], 9**	0.0 (0.0–0.0)	**0.3 (0.2–0.6)[a]**
CC outside only, regardless of EC usage[d]	10	**36.7 (23.1–91.2)[a]**	15.4 (- - -) [a], 3	0.0 (0.0–30.5)	**1.1 (0.2–1.5)[a]**
CC and EC inside home	5	**230.3 (65.4–311.6)[a]**	29.4 (- - -), 1	**47.0 (0.0–276.3)[a]**	**2.8 (1.4–8.3)[a]**
CC inside home, no EC	10	**428.4 (173.4–584.6)[a,b]**	**43.8 (18.8-66.8) [a], 4**	**279.5 (77.5–320.7)[a,b]**	**4.8 (3.5–10.8)[a,b]**

NS: no exposure or no use of tobacco products, CC: conventional cigarette; EC: electronic cigarettes. p25-p75: 25th and 75th percentile. Classification I – At recruitment, reported exposure of the child, NS, no EC/CC use by caregivers or residents and home smoking ban, EC exposure to EC inside, CC , exposure to CC inside. Classification II - Exposure of the child in same indoor room based on report of caregiver for 7 day period. Classification III -Residents reported use over 7 day period inside the home whether or not child was present. *sample size for all measures except wristband cotinine. [a] significantly higher levels than NS, (p<0.01); [b] significantly higher levels than EC, (p<0.01); [c] Group includes EC users only outside home (n=2) and EC users inside home (n= 12); [d] Group includes reported exposure to CC outside with no EC users (n= 2), CC outside with EC users outside (n=3), CC outside with EC users inside home (n= 5). [e] percentiles not reported for samples sizes of less than 4. Note: bolded values are significant (p< 0.05). Also note that the overall detection rate for air monitors was 36%; details are given in Table S1 in supporting online materials.

Table 3. Correlations of wristband, urine and air exposure measures in relation to conventional cigarettes (CC) and electronic cigarettes (EC) exposure and usage

Reported tobacco product exposure and use	**Median (p25-p75)**	**7-Day Wristband Nicotine (ng/g silicone) *rho* (n)**	**7-Day Wristband Cotinine (ng/g silicone) *rho* (n)**	**Urinary cotinine (ng/ml) *rho* (n)**	**Air Nicotine (ng/m^3) *rho* (n)**
CC variables					
Child's exposure to CC inside (cigarettes/week)[a]	0.0 (0.0-12.0)	**0.706*** (38)**	**0.560* (15)**	**0.717*** (38)**	**0.723** (38)**
Residents' use of CC inside (cigarettes/week)[b]	0.9 (0.0-12.0)	**0.725*** (29)**	**0.774** (10)**	**0.680*** (29)**	**0.779** (29)**
EC variables					
Child's exposure to EC inside (minutes/week)[c]	0.0 (0.0-14.8)	**0.353* (38)**	0.083 **(18)**	**0.470** (38)**	**0.351* (38)**
Residents' use of EC inside (minutes/week)[d]	0.0 (0.0-17.8)	**0.557** (26)**	0.425 **(13)**	**0.625*** (26)**	**0.455* (26)**
Residents' use of EC inside (mL/week)[d]	0.0 (0.0-3.3)	**0.581** (26)**	0.406 **(13)**	**0.646*** (26)**	**0.500**(26)**

CC: conventional cigarettes; EC: electronic cigarettes. p25-p75: 25th and 75th percentile. Spearman's correlations (*rho*): *(p<0.05), **(p<0.01), ***(p<0.001). [a] Exposure of the child in same indoor room based on report of caregiver for 7 day period, excluding exclusive EC use (a subset of Classification II from Table 2). [b.] Residents reported use of CC over 7 day period inside the home whether or not child was present excluding exclusive EC use; (a subset of classification III from Table 2) [c] Exposure of the child in same indoor room based on report of caregiver for 7 day period, excluding any with CC usage (a subset of Classification II from Table 2).; [d] Reported caregiver use of EC over 7 day period inside the home whether or not child was present, excluding any with CC usage (a subset of classification III from Table 2. Note: bolded values are significant (p< 0.05).

Table 4. Tobacco-specific nitrosamines (TSNAs) in wristbands worn for 7 days in relation to child's exposure classification.

Exposure group by classification scheme (#)	Wristband Total TSNAs n	Wristband Total TSNAs n (%) detected*	Wristband Total TSNAs concentration, ng/g silicone (median, p25-p75)	NNK n (%) detected*	NAT n (%) detected*	NAB n (%) detected*	NNN n (%) detected*
Recruitment (I)							
NS- Non-exposed at recruitment	14	2 (14)	0.10 (0.0-0.10)	0 (0)	0 (0)	2 (14)	0 (0)
EC	19	5 (26)	0.10 (0.0-0.11)	3 (16)	0 (0)	2 (11)	1 (5)
CC	18	13 (72)	**0.20 (0.05-0.53)[a]**	11 (61)	7 (39)	6 (33)	3 (17)
Child's reported exposure (II)							
NS -Non-exposed by caregiver report	23	6 (26)	0.05 (0.04-0.24)	3 (13)	1 (4)	3 (13)	1 (4)
EC	14	3 (21)	0.05 (0.04-0.19)	2 (14)	0, (0)	1 (7)	0 (0)
EC+CC	4	3 (75)	0.09 (0.04-0.53)	2 (50)	2 (50)	1 (25)	0 (0)
CC	9	8 (88)	**0.40 (0.04-0.67)[a]**	7 (78)	4 (44)	5 (56)	3 (33)
Residents' tobacco product use (III)							
NS -No use by residents	13	2 (15)	0.05 (0.04-0.13)	0 (0)	0 (0)	2 (15)	0 (0)
EC	14	3 (21)	0.05 (0.04-0.21)	1 (7)	0 (0)	2 (14)	1 (7)
EC+CC	13	6 (46)	0.06 (0.04-0.53)	6 (46)	3 (23)	2 (15)	1 (8)
CC	11	9 (82)	**0.25 (0.04-0.67)[a,b]**	7 (64)	4 (36)	4 (36)	2 (18)

Abbreviations: NS: no smoking and no e-cigarette use by caregivers or residents and home smoking ban, CC: Conventional Cigarette; EC: electronic cigarettes;; TSNAs: Tobacco-specific nitrosamines; NAT: N′-nitrosoanatabine; NNN: N-nitrosonornicotine; NAB: N-nitrosoanabasine NNK: 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone ; p25-p75: 25th and 75th percentile. LOD: Limit of Detection (0.05 ng/g).Classification I – At recruitment, reported exposure of the child, NS, no smoking and no e-cigarette use by caregivers or residents and home smoking ban, EC exposure to EC inside, CC , exposure to CC inside. Classification II - Exposure of the child in same indoor room based on report of caregiver for 7 day period. Classification III -Residents reported use over 7 day period inside the home whether or not child was present. *n, (%) detected = wristbands that had listed compounds detected in laboratory analysis. [a] significantly higher levels than NS, ($p<0.01$); [b] significantly higher levels than EC, ($p<0.01$); Note: bolded values are significant different values ($p< 0.05$). Also note that one participant did not have a complete reported exposure variable, so n=50 instead of n=51 for this group.

Supplementary Material (online)

List of contents:

1.0 METHODS*: Detailed Methods for Laboratory Analysis*

Personnel performing extraction and analysis were blinded as to exposure status of participants. All sample containers and laboratory tools (scissors, tweezers, pipet tips, syringes, and syringe filters) were rinsed with solvent prior to use. Laboratory personnel wore disposable caps and laboratory coats when processing samples.

Materials. All solvents were LC/MS grade. Chemical standards of nicotine, nicotine-d_4, cotinine, and cotinine-d_3 were purchased from MilliporeSigma. Chemical standards of the tobacco-specific nitrosamines (TSNAs) 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone (NNK), N-nitrosoanatabine (NAT), and N-nitrosoanabasine (NAB) were purchased from Cambridge Isotope Laboratories. N-nitrosonornicotine (NNN) was purchased from MilliporeSigma. The deuterated forms of the four TSNAs were purchased from Toronto Research Chemicals.

Wristband TSNA. Separate WB was used for TSNA. Each silicone wristband was cut into small pieces, and half were placed in a 50 mL centrifuge tube and spiked with 12.5 ng of each of the four internal standards (NNK-d_4, NAB-d_4, NAT-d_4, NNN-d_4). Five mL of acetonitrile was added, and the samples were vortexed for 30 min. The wristband pieces were removed, 300 mg of $MgSO_4$ was added, and the samples were vortexed for 3 min. Samples were centrifuged at 3000 rpm ($900 \times g$) for 5 minutes. The organic layer was transferred to a new tube, evaporated to 1 mL, and added to a 2 mL vial containing the dSPE mixture (Agilent, QuEChERS Dispersive Kit, AOAC method, containing 50 mg primary-secondary amine, 50 mg C_{18}, and 150 mg $MgSO_4$). Samples were vortexed for 1 minute, then centrifuged at 10,000 rpm ($5600 \times g$) for 1 minute. The liquid layer was removed and passed through the syringe filter. The final concentration of each of the deuterated TSNAs was 12.5 ng/mL. The instrumental method is described in [1]

Air Nicotine. Nicotine was extracted from the air badges by placing each badge in a 50 mL centrifuge tube, spiking with 10 ng of nicotine-d_4, and equilibrating for 15 min. Two mL of 0.1% formic acid was added and the samples were vortexed for 1 min. One mL 1M KOH was added and the samples were vortexed for 1 min. Two mL acetonitrile was added and the samples were vortexed for 30 min. The badge was removed, 2 g $MgSO_4$ and 0.5 g NaCl were added, and the samples vortexed for 1 min. Samples were then centrifuged at 3000 rpm ($900 \times g$) for 5 min. One mL of the top (organic) layer was removed and passed through the syringe filter. The final concentration of nicotine-d_4 was 5 ng/mL. The instrumental method and calibration procedure described for wristband nicotine was used for quantification. The LOQ was 0.2 ng/badge, and the MDL was 0.13 ng/badge. Field blank values ranged from 0.7 - 4.4 ng nicotine (average 2.77), so the detection limit was more driven by field blank levels than LOQ of the method.

1. Matt GE, Quintana PJE, Zakarian JM, et al. When smokers quit: exposure to nicotine and carcinogens persists from thirdhand smoke pollution. Tobacco control. 2016;26(5):548-556.

2.0 RESULTS: Supplementary Tables

Table S1. Detection frequency and concentrations in wristbands, air and urine samples.

Analyte / measure	Detected n (%)	p25	p50	p75	p95
Urine Cotinine (ng/ml), n = 53	50 (94)	0.14	0.49	2.82	10.88
Air Nicotine (ng/m^3), n = 53	19 (36)	0.00	0.00	65.85	399.97
2-Day Wristband Nicotine (ng/g), n = 53	53 (100)	4.43	22.80	94.40	405.28
2 Day Wristband Cotinine (ng/g), n=22	21 (95)	0.52	3.98	9.05	39.72
7-Day Wristband Nicotine (ng/g), n = 52	52 (100)	5.44	31.63	107.71	562.37
7 Day Wristband Cotinine (ng/g), n=22	20 (91)	1.12	9.75	31.04	69.74
2 Day Wristband cotinine/nicotine ratio, (ng/g) n = 22	21 (95)	0.09	0.37	0.62	1.78
7 Day Wristband cotinine/nicotine ratio, (ng/g) n = 22	20 (91)	0.13	0.43	0.68	1.25
7 Day Wristband Total TSNAs (ng/g), n= 51	20 (39)	0.05	0.05	0.13	0.53
7 Day Wristband NAT, n =51	7 (14)	0.05	0.05	0.06	0.10
7 Day Wristband NAB, n=51	10 (20)	0.05	0.05	0.06	0.13
7 Day Wristband NNN, n = 51	4 (8)	0.05	0.05	0.05	0.07
7 Day Wristband NNK, n = 51	14 (27)	0.05	0.05	0.12	0.31

TSNAs: Tobacco-specific nitrosamines; NAT: N′-nitrosoanatabine; NNN: N-nitrosonornicotine; NAB: N-nitrosoanabasine NNK: 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone; Note: only 22 (7-day) and 22 (2-day) wristbands were analyzed for cotinine. .p25 = 25th percentile, etc.

Table S2. Detection frequency and concentrations in wristbands (ng/wristband) - not adjusted by wristband weight.

Wristband measure	Detected n (%)	p25	p50	p75	p95
2-Day Wristband Nicotine (ng/WB), n = 53	53 (100)	16.30	85.96	362.25	1665.45
2-day Wristband Cotinine (ng/WB), n=22	21 (95)	1.95	15.21	34.20	151.44
7-Day Wristband Nicotine (ng/WB), n = 52	52 (100)	21.88	127.13	437.44	2162.48
7-day Wristband Cotinine (ng/WB), n=22	20 (91)	4.18	34.96	118.83	264.75

Table S3. Child's exposure group related to nicotine and cotinine concentrations in wristbands worn for two days, nicotine in air and urinary cotinine.

Exposure group by classification scheme (#)	n (%)*	2-day Wristband Nicotine Concentration (ng/g), n = 53 Median (p25–p75)	2-day Wristband Cotinine Concentration (ng/g), n = 22 Median (p25–p75), n	Urinary Cotinine Concentration (ng/ml), n = 53 Median (p25–p75)
Recruitment groups (I)				
NS-Non-exposed at recruitment	15 (28.3)	3.1 (1.3-4.4)	0.2 (0.1-0.9), 5	0.1 (0.0–0.1)
EC	19 (35.8)	**24.8 (11.2-36.9)[a]**	**4.0 (0.9–7.0) [a], 10**	**0.5 (0.3–1.2)[a]**
CC	19 (35.8)	**149.9 (65.3-245.5)[a,b]**	**14.6 (7.6–18.7) [a,b], 7**	**3.6 (1.4–9.9)[a,b]**
Child's reported exposure (II) (n=50)				
NS -Non-exposed by caregiver report	23 (46.0)	4.4 (1.9-25.5)	1.6 (0.2–7.6), **11**	0.1 (0.1–0.3)
EC	14 (28.0)	14.9 (11.1-34.3)	3.6 (1.0–6.4), **7**	**0.5 (0.3–1.2)[a]**
EC+CC	4 (8.0)	**136.8 (55.3-241.7)[a]**	16.2 (- - -)[e], **1**	**2.4 (1.9–8.1)[a]**
CC	9 (18.0)	**180.9 (109.1-391.1)[a,b]**	18.7 (- - -), **3**	**4.2 (3.2–7.6)[a,b]**
Residents' tobacco product use (III)				
NS -No reported use by residents	14 (26.4)	3.2 (1.2-4.4-26.3)	0.2 (0.1–0.9) **5**	0.1 (0.0–0.2)
EC	14 (26.4)	**17.4 (11.1-34.3)[a]**	**4.0 (1.0-7.3) [a], 9**	**0.3 (0.2–0.6)[a]**
EC+CC	13 (24.5)	**47.1 (13.9-132.6)[a]**	**4.4 (1.2-10.8) [a], 4**	**1.4 (0.7–2.8)[a]**
CC	12 (22.6)	**180.9 (81.2-242.9)[a,b]**	**17.4 (14.9–37.2)[a,b], 4**	**4.2 (3.0–10.4)[a,b]**
Detailed residents' tobacco products use				
NS -No reported use by residents	14 (26.4)	3.2 (1.2-4.4)	0.2 (0.1–0.9), **5**	0.1 (0.0–0.2)
EC, inside or only outside home, no CC[c]	14 (26.4)	**17.4 (11.1-34.3)[a]**	**4.4 (1.0–7.2)[a], 9**	**0.3 (0.2–0.6)[a]**
CC outside only, regardless of EC usage[d]	10 (18.9)	**20.9 (11.5-48.6)[a]**	**3.3 (0.5–11.9)[a], 3**	**1.1 (0.2–1.5)[a]**
CC and EC inside home	5 (9.4)	**115.2 (49.2-286.6)[a]**	7.6 (- - -), **1**	**2.8 (1.4–8.3)[a]**
CC inside home, no EC	10 (18.9)	**196.6 (137.3-334.9)[a,b]**	**17.4 (14.9–37.2)[a,b], 4**	**4.8 (3.5–10.8)[a,b]**

NS: no exposure or no use of tobacco products, CC: conventional cigarette; EC: electronic cigarettes; Classification I – At recruitment, reported exposure of the child, NS, no smoking and no e-cigarette use by caregivers or residents and home smoking ban, EC exposure to EC inside, CC , exposure to CC inside. Classification II - Exposure of the child in same indoor room based on report of caregiver for 7-day period. Classification III -Residents reported use over 7-day period inside the home whether or not child was present. *n refers to all measures except wristband cotinine. [a] significantly higher levels than NS, ($p<0.01$); [b] significantly higher levels than EC, ($p<0.01$); [c] Group includes EC users only outside home (n=2) and EC users inside home (n= 12); [d] Group includes reported exposure to CC outside with no EC users (n= 2), CC outside with EC users outside (n=3), CC outside with EC users inside home (n= 5). [e]percentiles not reported for samples sizes of less than 4. Note: bolded values are significant ($p< 0.05$).

Table S4. Individual tobacco-specific nitrosamines (TSNAs) in wristbands worn for 7 days in relation to child's exposure classification.

Exposure group by classification scheme (#)	n (%)	NNK (ng/g)		NAT (ng/g)		NAB (ng/g)		NNN (ng/g)	
		Detected (%)	Median (min-max)	Detected (%)	(Median; min-max)	Detected (%)	(Median; min-max)	Detected (%)	(Median; min-max
Recruitment groups (I)									
NS-Non-exposed at recruitment	14 (27.4)	0	< LOD	0	< LOD	15	LOD (LOD -0.12)	0	<LOD
EC	19 (37.3)	15	LOD (LOD-0.06)	0	< LOD	11	LOD (LOD -0.10)	5	LOD (LOD -0.06)
CC	18 (35.3)	61	0.15 (LOD-0.43)	39	0.06 (LOD-0.15)	33	LOD (LOD -0.13)	17	LOD (LOD -0.08)
Child's reported exposure (II)									
NS -Non-exposed by caregiver report	23 (46.0)	0	< LOD	0	< LOD	9	LOD (LOD -0.25)	0	<LOD
EC	14 (28.0)	14	LOD (LOD-0.19)	7	LOD (LOD -0.06)	7	LOD (LOD -0.10)	0	<LOD
EC+CC	4 (8.0)	25	0.09	50	0.06 (LOD -0.09)	25	0.05	0	<LOD
CC	9 (18.0)	77	0.25 (LOD-0.43)	44	0.06 (LOD -0.15)	33	LOD (0.04-0.14)	33	LOD (LOD -0.43)
Residents' tobacco product use (III)									
NS -No use by residents	14 (27.5)	0	< LOD	0	< LOD	14	LOD (LOD-0.13)	0	<LOD
EC	14 (27.5)	7	0.13	0	< LOD	14	LOD (LOD-0.10)	7	0.07
EC+CC	13 (25.5)	46	0.06 (LOD-0.31)	23	LOD (LOD-0.09)	25	LOD (LOD-0.14)	7	LOD (LOD-0.06)
CC	12 (23.5)	70	0.24 (LOD -0.43)	40	LOD (LOD-0.15)	40	LOD (LOD-0.14)	20	LOD (LOD-0.08)

NS: no exposure or no use of tobacco products, CC: conventional cigarette; EC: electronic cigarettes; Classification I – At recruitment, reported exposure of the child, NS, no smoking and no e-cigarette use by caregivers or residents and home smoking ban, EC exposure to EC inside, CC , exposure to CC inside. Classification II - Exposure of the child in same indoor room based on report of caregiver for 7-day period, Classification III -Residents reported use over 7-day period inside the home whether or not child was present. [a] significantly higher levels than NS, ($p<0.01$); [b] significantly higher levels than EC, ($p<0.01$); TSNAs: Tobacco-specific nitrosamines; NAT: N′-nitrosoanatabine; NNN: N-nitrosonornicotine; NAB: N-nitrosoanabasine NNK: 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone ; LOD: Limit of Detection (approximately 0.05 ng/g, varies by wristband size).

Table S5. Spearman correlations (*rho*) among analytes in wristband, urine and air samples.

Environmental and Biomarker Samples	Urinary Cotinine (ng/ml), n = 53	Air Nicotine (ng/m^3), n = 53	2-Day Wristband Nicotine (ng/g), n=53	2 Day Wristband Cotinine (ng/g), n=22	7-Day Wristband Nicotine (ng/g), n = 52	7 Day Wristband Cotinine (ng/g), n=22	7 Day Wristband Total TSNAs (ng/g), n= 51
Urinary Cotinine (ng/ml), n = 53	-	**0.72*****	**0.91*****	**0.87*****	**0.92*****	**0.84*****	**0.64*****
Air Nicotine (ng/m^3), n = 53		-	**0.66****	**0.56****	**0.71*****	**0.48***	**0.46*****
2-Day Wristband Nicotine (ng/g), n = 53			-	**0.89*****	**0.94*****	**0.86*****	**0.60*****
2 Day Wristband Cotinine (ng/g), n=22				-	**0.91*****	**0.90*****	**0.48***
7-Day Wristband Nicotine (ng/g), n = 52					-	**0.93*****	**0.59*****
7 Day Wristband Cotinine (ng/g), n=22						-	**0.44***
7 Day Wristband Total TSNAs (ng/g), n= 51							-

*(p<0.05) **(p<0.01) ***(p<0.001) TSNAs: Tobacco-specific nitrosamines, Note: bolded values are significant different values (p< 0.05). The sample size for correlations is the lower number of the pair.

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Table S6. Cotinine to nicotine ratio in wristbands, ng/g silicone, n=22

Exposure group by classification scheme (#)	**n (%)**	**7-day wristband cotinine/ nicotine ratio (median, p25-p75)**	***p*-value**
Recruitment (I)			
NS-Non-exposed at recruitment	5 (19.0)	0.74 (0.3-1.11)	
EC	10 (47.6)	0.50 (0.3-0.71)	0.158
CC	7 (33.4)	0.20 (0.1-0.42)	
Child's reported exposure (II)			
NS-Non-exposed by caregiver report	11 (48.0)	0.60 (0.21-0.89)	
EC	7 (33.3)	0.30 (0.11-0.58)	0.391
EC+CC	1 (4.7)	0.092	
CC	3 (14.0)	0.20 (0.11-0.22)	
Residents' tobacco product use (III)			
NS-No reported use by residents	5 (19.0)	0.74 (0.0-1.27)	
EC	9 (43.0)	0.45 (0.09-1.14)	0.424
EC+CC	4 (19.0)	0.32 (0.13-0.61)	
CC	4 (19.0)	0.16 (0.09-0.66)	

Abbreviations: NS Child not exposed to tobacco smoke or electronic cigarette vapor, CC: conventional cigarette ; EC: electronic cigarettes;