Reactions to thirdhand smoke are associated with openness to smoking in young never smoking children

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Abstract

Objective: To investigate the associations between reactions to thirdhand smoke (THS) and openness to smoking in young children.

Methods: In a school-based survey in Hong Kong, 4762 Chinese primary school students reported their reactions to THS (one or more of 'pleasant/happy', 'nausea', 'excited', 'heart beat faster', 'relaxed', 'dislike the smell', 'like the smell', 'dizzy', 'coughing/choking', 'eye uncomfortable' and 'none of the above'), smoking status and openness to smoking (lack of a firm intention not to smoke). Factor structure of reactions to THS was investigated with factor scores calculated and categorised. Logistic regression yielded adjusted odds ratio (AOR) of openness to smoking for reactions to THS.

Results: Factor analysis yielded two factors including 5 and 4 reactions, which were generally deemed negative and positive, respectively. The proportions of students with factor scores ≥1 for negative and positive reactions were 51.3% and 6.3%, respectively. In never smokers, openness to smoking was negatively associated with 'dislike the smell' (AOR 0.52, 95% CI 0.39-0.68), 'coughing/choking' (0.53, 0.38-0.75), 'eye uncomfortable' (0.62, 0.40-0.95) and negative reaction factor score of 2-5 (vs 0) (0.59, 0.40-0.88), and was positively associated with 'pleasant/happy' (2.80, 1.54-5.09), 'excited' (2.83, 1.17-6.87), 'like the smell' (3.06, 1.49-6.26) and positive reaction factor score of 1-4 (vs 0) (2.86, 1.83-4.48). In experimental or former smokers, fewer associations reached statistical significance.

Conclusions: Negative and positive reactions to THS were negatively and positively associated with openness to smoking, respectively, in young never smoking children.

Keywords: Children; Reactions; Thirdhand smoke; Openness to smoking

1. Introduction

Childhood and adolescence is a critical period for smoking prevention. The 2014 Report of the Surgeon General showed that, among the daily smokers in the United States, 90.3% initiated smoking and 72.2% started daily smoking on or before 19 years of age (1). In Hong Kong, the most westernized and developed city of China with the lowest smoking prevalence in the developed world (10.7%), the Thematic Household Survey in 2013 showed that 65.7% of daily smokers had become weekly smokers by the age of 19 (2).

Child and adolescent's reactions to initial cigarette smoking are a well-established risk factor of their subsequent smoking behaviour (3). Positive reactions predict continuation and progression to more regular smoking, while negative reactions generally predict decreased risk of continued smoking (4-10).

Lessov-Schlaggar et al. studied the cross-sectional associations between reactions to secondhand smoke (SHS) and smoking susceptibility in a sample of non-smoking preteens and found that 'unpleasant/gross' was associated with lower smoking susceptibility, whereas 'liked the smell' was associated with higher smoking susceptibility (11). Such findings were replicated in the follow-up study of this sample that showed the associations of reactions to SHS with smoking susceptibility trajectory (12).

Thirdhand smoke (THS) is the residual pollutants of tobacco smoke that remain in dust and on surfaces after combustion of tobacco, which can be re-emitted into the gas phase, or react with other compounds in the environment to produce secondary pollutants (13). Young children are more likely to be exposed to THS because they are typically closer to those contaminated surfaces (13). Young children are also more sensitive to THS because of their high respiratory rate to body weight ratio and immature metabolic capacity (14). However, there was no report on the reaction to THS in young children. Given the predictive ability of reactions to initial cigarette smoking and SHS for smoking, we hypothesised that reactions to THS likewise predict smoking in young children.

The present study tested this hypothesis by investigating children's reactions to THS and their associations with openness to smoking, defined as a lack of firm intention not to smoke, by using cross-sectional data from primary school students in Hong Kong. Understanding such associations may help identify children at increased risk of smoking and thus inform future smoking prevention programmes.

2. Methods

2.1. Sampling and ethics statement

Each year, the Hong Kong Council on Smoking and Health invites all primary schools in Hong Kong (about 500) to enrol for an anti-smoking educational theatre stage performance and accepts the first 99 schools to respond. In 2013-2014, 36 of the 99 enrolled schools were randomly selected for invitation to participate in a cross-sectional survey on Primary 2-4 (equivalent to Grades 2–4 in the United States) students and 33 schools agreed to participate. Written parental consent was not required and declining parents were to ask their children to return a blank questionnaire during the survey. Student participation remained voluntary even with parental consent. Ethics approval including the consent procedures was granted by the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster. Of the 5275 Primary 2-4 students in the 33 schools, 4762 students (90.3%) returned a valid questionnaire.

2.2. Measurement

An anonymous, self-administered questionnaire in simple Chinese was used. To study reactions to THS, students were asked 'when you can smell cigarette from objects or people, yet no one smokes around, which of the following reactions/feelings do you have?' Students were allowed to choose one or more from the following options: 'pleasant/happy', 'nausea', 'excited', 'heart beat faster', 'relaxed', 'dislike the smell', 'like the smell', 'dizzy', 'coughing/choking', 'eye uncomfortable' and 'none of the above'. These options have been used to study reactions to SHS and initial cigarette smoking in children and adolescents (4, 11, 12). Our study used these options for THS because of the overlap of constituents between THS,

SHS and tobacco smoke, such as nicotine, which causes euphoric sensation and increased heart rate (15, 16), and some irritants (e.g. formaldehyde) (17-19). Moreover, nasal and eye irritation can be caused by a very low concentration of tobacco pollutants, which corresponds to a fresh air dilution volume above 3000 m^3 per cigarette (20).

Openness to smoking was defined as choosing any response options of 'definitely yes', 'probably yes', 'not certain', or 'probably no' rather than 'definitely no' for the question 'will you smoke, if a good friend offers you a cigarette'. A lack of firm intention not to smoke predicts future smoking in both never smokers and those with other levels of past smoking experience (21-23). A sensitivity analysis was also conducted in which openness to smoking was defined as choosing any options of 'definitely yes', 'probably yes' or 'not certain' rather than 'probably no' or 'definitely no'.

To measure smoking status, students were asked to choose from the following options: (1) I have never smoked, (2) I have smoked once or a few times (for fun or to try a puff), (3) I used to smoke but have stopped now, (4) I smoke occasionally but less than one cigarette per week, (5) I smoke one to six cigarettes per week and (6) I smoke more than six cigarettes per week. Students choosing the first four options were classified as never, experimental, former and occasional smokers, respectively, and those choosing the fifth or sixth were classified as regular smokers.

THS exposure at home was measured by 'How many days in the past 7 days did you smell cigarette from objects or people at home, yet no one smoked around nor was smoke in the air', with options of 0 to 7 days/week. SHS exposure at home was measured by 'How many days in the past 7 days did someone smoke near you at home?', with options of 0 to 7 days/week. Students also reported their age (in years), sex, number of bedrooms at home (0/1/2/3/4/≥5) and smoking status of father (yes/no) and mother (yes/no). The number of bedrooms should be apparent to young students and is a good indicator of socioeconomic status (SES) in Hong Kong, where housing price is the highest in the world (24).

2.3. Statistical analysis

Occasional (n=31) and regular (n=26) smokers, who were few and likely to be open to smoking, as well as those with smoking status missing (n=276) were excluded. For the question on reactions to THS, students who did not respond (n=72) or chose 'none of the above' in addition to any of the reactions (n=33) were excluded, leaving 4324 for analysis.

Following the precedent of exploring the underlying dimensions of reactions to initial cigarette smoking and SHS (11, 12, 25), factor analysis with promax rotation (allowing correlated factors) was used to explore the factor structure of students' reactions to THS. Factors were identified based on the following guidelines: (1) an eigenvalue greater than 1.0; (2) the point of discontinuity of the scree plot; (3) a factor had to include two or more items (26). An item was included in a factor if its factor loading was above 0.3 (26). Factor scores were calculated as the total number of items included in a factor and were then recoded into categorical variables.

Logistic regression yielded odds ratios (OR) of openness to smoking in relation to each reaction to THS and each categorised factor score in never smokers (n=4150) adjusting for age, sex, number of bedrooms at home, father smoking, mother smoking, SHS exposure at home and THS exposure at home. The same analyses were conducted in experimental or former smokers (n=174) with additional adjustment of smoking status, i.e. experimental/former smoking. The above analyses stratified by smoking status were to control for any confounding by smoking experience.

Among never smokers, 20% had missing values in one or more variables in the regression model: openness to smoking (15%) and covariates (7%). Among experimental or former smokers, the corresponding percentage was 33%: openness to smoking (22%) and covariates (16%). Missing values in the outcome variable and the covariates were imputed 10 times by multiple imputation using the method of multivariate imputation by chained equations with an imputation model incorporating openness to smoking, categorised factor scores and the covariates in the logistic regression model. Results were derived from the 10 imputed datasets separately and then combined based on Rubin's rule (27).

Complete-case analyses were also conducted as sensitivity analyses. All statistical analyses were conducted using STATA 13.0.

3. Results

The sample for analysis had a mean age (standard deviation) of 8.5 (0.9) years (not shown in tables). Table 1 shows that the sample had 54.3% boys, 96.0% never smokers, 2.6% experimental smokers, 1.4% former smokers and 6.9% who were open to smoking. Table 2 shows that the more commonly reported reactions towards THS were 'dislike the smell' (57.5%), 'coughing/choking' (31.1%), 'nausea' (20.8%), 'dizzy' (16.5%), 'eye uncomfortable' (15.5%) and 'heart beat faster' (6.3%). Other reactions, 'pleasant/happy' (3.2%), 'relaxed' (2.2%), 'liked the smell' (1.8%) and 'excited' (1.3%), were less common.

Table 2 also shows the two factors yielded by factor analysis. Factor 1 included 'nausea', 'heart beat faster', 'dizzy', 'coughing/choking' and 'eye uncomfortable', which were generally negative reactions. Factor 2 included 'pleasant/happy', 'excited', 'relaxed' and 'like the smell', which were generally positive reactions. 'Dislike the smell' was not included in either of the factors. The factors representing negative and positive reactions explained 84% and 77% of the total variance (not shown in tables).

The factor scores for negative reactions ranged from 0 to 5 and were recoded into 2 (0/1-5) and 3 categories (0/1/2-5). The proportion of students reporting 1-5, 1 and 2-5 negative reactions was 51.3%, 28.1% and 23.3%, respectively (Table 1). The factor scores for positive reactions ranged from 0 to 4 and were recoded into 2 categories (0/1-4). The proportion of students reporting 1-4 positive reactions was 6.3% (Table 1). The uncategorised factor scores for positive and negative reactions were negatively correlated (r = -0.18; P < 0.001), only 1.0% of students had factor scores ≥1 for both negative and positive reactions (not shown in tables).

Table 1 shows that boys were more likely to report positive reactions and less likely to report negative reactions, and younger students were less likely to report negative reactions (Ps < 0.001). Generally,

students with father smoking, mother smoking, more SHS exposure at home, or more THS exposure at home were more likely to report positive or negative reactions, although such association between father smoking and negative reactions was non-significant. Students who were open to smoking were more likely to report positive reactions and less likely to report negative reactions (Ps < 0.05). Experimental and former smokers were more likely to report positive reactions (P < 0.001).

Table 3 shows that, in never smokers, 'dislike the smell' (adjusted OR 0.52, 95% CI 0.39-0.68), 'coughing/choking' (0.53, 0.38-0.75) and 'eye uncomfortable' (0.62, 0.40-0.95) were associated with decreased adjusted ORs for openness to smoking. In contrast, 'pleasant/happy' (2.80, 1.54-5.09), 'excited' (2.83, 1.17-6.87) and 'like the smell' (3.06, 1.49-6.26) were associated with increased adjusted ORs for openness to smoking. Similarly, in never smokers, a negative reaction factor score of 2-5 (vs 0) was associated with a decreased adjusted OR (0.59, 0.40-0.88) for openness to smoking and a positive reaction factor score of 1-4 (vs 0) was associated with an increased adjusted OR (2.86, 1.83-4.48). The corresponding adjusted OR for the negative reaction factor score of 1-5 was marginally significant (0.77, 0.57-1.02; P = 0.07). Among experimental or former smokers, the corresponding point estimates were broadly similar in magnitude to those in never smokers, although statistical significance was found only for 'dislike the smell' (adjusted OR 0.36, 95% CI 0.17-0.74), 'eye uncomfortable' (0.28, 0.08-0.97) and positive reaction factor score of 1-4 (vs 0) (4.77, 1.33-17.09). Both the complete-case analyses and the sensitivity analyses using the alternative definition of openness to smoking produced results (available upon request) similar with the above.

4. Discussion

Our study, the first to investigate children's reaction to THS, found that reactions to THS that are generally considered to be negative (e.g. 'nausea') were much more common than those considered positive (e.g. 'pleasant/happy'). The factor analysis yielded two factors which included 5 negative and 4 positive reactions. The factor scores ≥ 1 for negative and positive reactions constituted about 1/2 and 1/20,

respectively, of the sample for analysis. Children with factor scores ≥ 1 for both negative and positive reactions were few.

We found that children with father smoking, mother smoking, more SHS exposure at home, or more THS exposure at home were generally more likely to report positive or negative reactions. More exposure to THS may facilitate children's recall of their reactions towards THS and thus increase the report of positive or negative reactions. This may also explain the associations of parental smoking and SHS exposure with reactions to THS because both parental smoking and SHS exposure should be closely correlated with THS exposure.

Parental smoking and SHS exposure predict smoking initiation in children (28) and were also found to be associated with reactions to THS in the present study. Therefore, parental smoking and SHS may influence the associations between reactions to THS and openness to smoking. However, these associations were generally consistent after adjusting for parental smoking, SHS and several other covariates.

Our study, the first to investigate the associations between reactions to THS and openness to smoking, found that, in never smoking children, 'dislike the smell', 'coughing/choking', 'eye uncomfortable' and factor score of 2-5 compared with 0 for negative reactions were negatively associated with openness to smoking, whereas 'pleasant/happy', 'excited', 'like the smell' and factor score of 1-4 compared with 0 for positive reactions were positively associated with openness to smoking. These results suggest that never smoking children who have negative and positive reactions to THS are at decreased and increased risk of smoking initiation, respectively. On the other hand, among experimental or former smokers, statistical significance was found for fewer of the associations of interest. Nonetheless, the similar point estimates between never and experimental or former smokers suggest that the non-significance could be due to small sample size (n=174), and reactions to THS may also predict future smoking among experimental or former smokers.

It is possible that the mechanisms of the associations between reactions to THS and openness to smoking involve unmeasured social influences. For example, if children hear their parents or peers describe tobacco smoke as enjoyable or watch movies in which actors appear to enjoy cigarettes, they may be more likely to describe the smell of residual tobacco smoke in a positive way. Such social influence may also affect children's openness to smoking (11). Nonetheless, adjusting for parental smoking, which should be an important source of social influence, did not meaningfully attenuate the associations we found.

Although the mechanisms of the associations between reactions to THS and openness to smoking are unclear, the present study suggests that reactions to THS may be a novel risk factor of smoking initiation. This may particularly be the case in places where the other, often more important, risk factors such as low price, advertising, smoking in public, and peer smoking have largely been dealt with. If this association is confirmed in longitudinal studies, future smoking prevention programme should consider using reactions to THS for classifying risk levels. Future studies may also try to modify children's reactions to THS by exploring and hence modifying their determinants, e.g. knowledge toward the harm of THS, and test whether such strategy reduces smoking initiation.

5. Conclusions

Negative and positive reactions to THS were negatively and positively associated with openness to smoking, respectively, in young never smoking children. Reactions to THS may be a novel risk factor of smoking initiation.

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Conflict of interest

None.

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Table 1. Positive and negative reactions to thirdhand smoke (THS) by basic characteristics (n=4324)

		Positive reactions to THS		Negative reactions to THS		
		Factor score 1 - 4 (n=273, 6.3%)		Factor score 1 (n=1213, 28.1%)	Factor score 2 - 5 (n=1007, 23.3%)	
	n (%)	%	P[a]	%	%	P[a]
Sex			<0.001			<0.001
Boys	2297 (54.3)	7.3		26.8	22.0	
Girls	1935 (45.7)	4.7		29.8	25.2	
Age			0.74			<0.001
<=8	2535 (59.0)	6.3		28.3	20.9	
>=9	1759 (41.0)	6.0		27.8	26.9	
Number of bedrooms at home			<0.001			0.90
1 or none	707 (16.5)	7.9		27.9	22.1	
2	3037 (70.8)	4.9		28.3	23.6	
3 or more	548 (12.8)	11.1		27.9	23.7	
Father smoking			0.001			0.09
No	2859 (66.1)	5.4		27.5	22.7	
Yes	1465 (33.9)	8.1		29.2	24.4	
Mother smoking			<0.001			0.04
No	3943 (91.2)	5.8		27.8	23.0	
Yes	381 (8.8)	11.6		31.0	26.5	
SHS exposure at home			<0.001			<0.001
None	2897 (69.7)	4.7		26.1	22.3	
1-4 days/week	600 (14.4)	9.2		31.2	23.8	

5-7 days/week	659 (15.9)	8.7		31.1	28.2	
THS exposure at home			<0.001			<0.001
None	2831 (66.1)	5.0		25.7	21.4	
1-4 days/week	884 (20.7)	8.0		33.1	24.9	
5-7 days/week	566 (13.2)	9.5		32.0	30.2	
Openness to Smoking			<0.001			0.03
No	3427 (93.1)	4.5		27.8	24.5	
Yes	254 (6.9)	16.1		28.4	17.3	
Smoking status			<0.001			0.17
Never	4150 (96.0)	5.8		28.2	23.2	
Experimental	114 (2.6)	16.7		24.6	31.6	
Former	60 (1.4)	20.0		26.7	16.7	

[a] Chi-square test was used.

Table 2. Prevalence and factor analysis of reactions to thirdhand smoke (n=4324)

		Factor loadings	
Reactions	Prevalence (%)	Factor 1 (Negative reactions)	Factor 2 (Positive reactions)
Dislike the smell	57.5	0.07	-0.23
Coughing/choking	31.1	**0.47**	-0.05
Nausea	20.8	**0.45**	-0.01
Dizzy	16.5	**0.55**	0.01
Eye uncomfortable	15.5	**0.48**	0.01
Heart beat faster	6.3	**0.41**	0.04
Pleasant/happy	3.2	-0.04	**0.51**
Relaxed	2.2	0.02	**0.35**
Like the smell	1.8	0.01	**0.53**
Excited	1.3	0.00	**0.52**

Rotation method: Promax

A factor loading in bold indicates that the reaction was included one of the factors

Table 3. Odds ratios (ORs) of openness to smoking in relation to reactions to thirdhand smoke in never smokers and in experimental or former smokers[a]

	Never smokers, n=4150		Experimental or former smokers, n=174	
	Crude ORs (95% CI)	Adjusted ORs (95% CI)[b]	Crude ORs (95% CI)	Adjusted ORs (95% CI)[c]
Pleasant/happy[d]	2.97 (1.64-5.38)***	2.80 (1.54-5.09)**	3.22 (0.66-15.81)	3.08 (0.58-16.40)
Nausea	0.88 (0.62-1.26)	0.87 (0.61-1.25)	0.62 (0.24-1.61)	0.53 (0.20-1.44)
Excited	3.31 (1.39-7.88)**	2.83 (1.17-6.87)**	N/A[e]	N/A[e]
Heart beat faster	1.52 (0.90-2.56)	1.42 (0.84-2.42)	0.79 (0.28-2.25)	0.72 (0.24-2.15)
Relaxed	0.96 (0.30-3.07)	0.80 (0.25-2.59)	3.74 (0.72-19.47)	4.99 (0.82-30.31)
Dislike the smell	0.51 (0.39-0.67)***	0.52 (0.39-0.68)***	0.39 (0.20-0.79)**	0.36 (0.17-0.74)**
Like the smell	3.54 (1.75-7.15)***	3.06 (1.49-6.26)**	2.57 (0.60-10.92)	2.42 (0.51-11.51)
Dizzy	0.95 (0.66-1.38)	0.93 (0.64-1.36)	0.68 (0.28-1.65)	0.69 (0.27-1.77)
Coughing/choking	0.56 (0.40-0.77)**	0.53 (0.38-0.75)***	0.47 (0.22-1.01)	0.46 (0.21-1.02)
Eye uncomfortable	0.64 (0.42-0.98)*	0.62 (0.40-0.95)*	0.35 (0.10-1.14)	0.28 (0.08-0.97)*
Positive reactions				
0	1	1	1	1
1 – 4[f]	3.16 (2.03-4.92)***	2.86 (1.83-4.48)***	4.44 (1.34-14.71)*	4.77 (1.33-17.09)*
Negative reactions				
0	1	1	1	1
1	0.95 (0.67-1.33)	0.91 (0.65-1.28)	0.70 (0.30-1.65)	0.74 (0.29-1.86)
2 – 5	0.63 (0.43-0.93)*	0.59 (0.40-0.88)*	0.50 (0.21-1.23)	0.46 (0.19-1.15)
1 – 5[g]	0.80 (0.60-1.07)	0.77 (0.57-1.02)	0.60 (0.29-1.20)	0.60 (0.29-1.22)

*P<0.05; **P<0.01; ***P<0.001

[a] After multiple imputation

[b] Adjusted for age, sex, number of bedrooms at home, father smoking, mother smoking, secondhand smoke exposure at home, thirdhand smoke exposure at home.

[c] Adjusted for smoking status (experimental/ former smokers) in addition to the same set of covariates in b.

[d] The reference group for each individual reaction was the subjects without such reaction

[e] Before multiple imputation, all experimental or former smokers who reported 'excited' were open to smoking.

[f] Including 'pleasant/happy', 'excited', 'relaxed' and 'like the smell'.

[g] Including 'nausea', 'heart beat faster', 'dizzy', 'coughing/choking' and 'eye uncomfortable'.