Nicotine dependence symptoms among young never-smokers exposed to secondhand tobacco smoke

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Abstract

Background—To extend previous observations that secondhand tobacco smoke (SHS) is associated with nicotine markers in children, we investigated if SHS exposure is associated with self-reports of nicotine dependence (ND) symptoms among young never-smokers.

Method—Data on number of persons who smoke inside the home, number of days exposed to SHS in a motor vehicle in the past week, number of parents, siblings, and friends who smoke, and ND symptoms, were collected from 10–12 year-old students in self-report questionnaires. The association between SHS and ND symptoms among young never-smokers was assessed in logistic regression models.

Results—Sixty-nine of 1488 never-smokers (5%) reported one or more ND symptom. After controlling for sibling and peer smoking, and susceptibility to initiating smoking, exposure to SHS in a motor vehicle was independently associated with ND symptoms (OR, 95% CI=1.2, 1.0–1.4). The OR for number of persons who smoke inside the home was 1.1 (0.9–1.4).

Conclusion—SHS exposure in motor vehicles may be associated with ND symptoms among young never-smokers. If replicated, this finding provides support for interventions that promote non-smoking in motor vehicles.

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Keywords

Tobacco; Passive smoking; Nicotine dependence; Children

1. Introduction

Among the numerous psychosocial factors related to the initiation and persistence of tobacco use among youth, parental influences are among the strongest and most consistent (Kandel & Wu, 1995; Tyas & Pederson, 1998; Vitaro, Wanner, Brendgen, Gosselin & Gendreau, 2004), although the effects may not be equivalent across age groups (Avenevoli & Merikangas, 2003). It is generally thought that parents who smoke exert influence on youth smoking through social role modeling (Fleming, Kim, Harachi, & Catalano, 2002), as well as through heritable personality and biological characteristics (Sullivan & Kendler, 1999). However, because parental smoking is a major source of secondhand tobacco smoke (SHS) in children, it may also represent a pathway of influence on health or behaviour through physiological processes (Anthonisen & Murray, 2005; Becklake, Ghezzo, & Ernst, 2005).

Nicotine is the chemical component in tobacco that is primarily responsible for addictive outcomes (US Department of Health and Human Services, 1998), and the large area for absorption in lung alveoli enables nicotine to be extracted from cigarette smoke and delivered quickly to the brain (US Department of Health and Human Services, 1998). Passive smoking results in the absorption of up to 60–80% of the nicotine content in SHS (Iwase, Aiba, & Kira, 1991), making SHS a non-negligible source of exposure to nicotine. Urinary nicotine markers have been reported in infants exposed to tobacco smoke in their home or in the family vehicle (Hetch et al., 2006), and marked nicotine levels have also been found in the blood plasma (Pacifi et al., 1995) and hair (Al-Delaimy, Fraser, & Woodward, 2001; Dimich-Ward, Gee, Brauer, & Leung, 1997), of non-smoking adults exposed to SHS. Becklake et al. (2005) reported that higher concentrations of salivary cotinine in non-smoking children were associated with greater susceptibility to smoking initiation two years later.

Initial models of the smoking onset process suggested that lengthy and regular tobacco use was necessary for developing nicotine dependence (US Department of Health and Human Services, 1994). However recent studies suggest that nicotine dependence symptoms can occur very soon after the initiation of cigarette smoking in some adolescents at very low exposures to cigarettes (DiFranza, Savageau, Rigotti et al., 2002; O'Loughlin et al., 2003), and early conversion to nicotine dependence in this young age group coincides with rapid intensification of smoking (Karp, O'Loughlin, Paradis, Hanley & DiFranza, 2005). We hypothesized that SHS exposure may lead to the development of nicotine dependence symptoms in the absence of tobacco use among young never-smokers. In this analysis, we investigated if young never-smokers self-report nicotine dependence symptoms, and if SHS exposure is associated with reports of nicotine dependence symptoms.

2. Methods

AdoQuest is an ongoing prospective cohort investigation of 1843 students initially aged 10–12 years, designed to investigate the natural course of the co-occurrence of health-compromising behaviours in children. A stratified random sample of 40 schools was selected from among all French-language schools with more than 90 grade 5 students, located in the greater Montreal area. Schools were stratified based on an indicator of socioeconomic status (SES) (Ministère de l'éducation du Québec, 2003) to assure equal representation of students from high, middle, and low SES levels. Seven schools could not be recruited because of a province-wide teacher labour dispute; three because of other ongoing studies and one because the school principal did not respond to repeated contact attempts. Students were recruited from all grade 5 classes in the 29 participating schools. All participants provided assent and their parents/guardians provided written informed consent. The study received ethics approval from the McGill University Institutional Review Board and the Concordia University Human Research Ethics Committee.

Baseline data on health related-behaviours and psychosocial characteristics related to these behaviours were collected in spring 2004–5 in classroom administered self-report questionnaires. Participants were reminded both verbally and in writing that their responses were completely confidential.

Nicotine dependence symptoms were measured among all subjects, whether or not they smoked. The seven items measuring nicotine dependence symptoms were drawn from the Nicotine Dependence Scale for Adolescents (Nonnemaker et al., 2004), the Hooked on Nicotine Checklist (DiFranza, Savageau, Fletcher et al., 2002), and the ICD-10 criteria for tobacco dependence (O'Loughlin, Kishchuk, Tremblay, & Paradis, 2002), and included (i) How often do you have cravings to smoke cigarettes? (sometimes/often/very often vs never/almost never); (ii) How physically addicted to smoking cigarettes are you? (very/somewhat/a bit vs not at all); (iii) How mentally addicted to smoking cigarettes are you? (very/somewhat/a bit vs not at all); (iv) How often have you felt like you really need a cigarette? (often/sometimes/rarely vs never); (v) Do you find it difficult not to smoke in places where it is not allowed (at a movie theatre, at home if your parents don't know you smoke)? (very/a bit vs not at all); (vi) When you see other kids your age smoking cigarettes, how easy is it for you not to smoke? (very/a bit difficult vs pretty/very easy); and (vii) How true is this statement for you? "I sometimes have strong cravings for cigarettes where it feels like I am in the grip of a force that I cannot control." (very/fairly true vs not very/not at all true). Items were translated into French by a Francophone physician and a Francophone pharmacist on the Tobacco Control Team at the Direction de sante publique in Montreal. Items in French were then back-translated into English. The few disagreements in the French translations were resolved through consensus. The meaning and understanding of items (i), (iv), (v) and a version of items (ii) and (iii) were tested in focus group interviews of Francophone and Anglophone smokers aged 14–17 years, and showed evidence of content validity (O'Loughlin, Kishchuk et al., 2002). All (or very similar) items showed good to excellent 1–2 week test–retest reliability, as well as strong convergent construct validity against smoking intensity in adolescent smokers aged 13–19 years (O'Loughlin, Tarasuk, DiFranza, & Paradis, 2002). The reliability coefficients obtained in this previous work are reported in

Appendix A. A “nicotine dependence symptom score” was computed as the sum of the seven items endorsed as positive. If the participant did not respond to a specific item, we assigned a null value.

Self-perceived “susceptibility to initiating smoking” was assessed in three items: (i) Do you think you might try smoking cigarettes in the future?; (ii) If one of your best friends was to offer you a cigarette, would you smoke it?; and (iii) At any time during the next year, do you think you will smoke a cigarette? (Pierce, Choi, Gilpin, Farkas & Merritt, 1996). Response choices included definitely not, probably not, probably yes, and definitely yes. Participants who responded “definitely not” to all three questions were categorized as “not susceptible to initiating smoking”. All other participants were categorized as “susceptible to initiating smoking”.

Exposure to SHS in the home was ascertained in one item that measured number of persons who smoke inside the home: “Excluding yourself, how many people smoke inside your home everyday or almost everyday? Do not count those who smoke outside.” Response choices included none, 1, 2, 3, 4, and 5 or more people. Exposure to SHS in a car was ascertained by: “During the past 7 days, on how many days did you ride in a car with someone who was smoking cigarettes?” Responses choices included 0, 1 or 2, 3 or 4, 5 or 6, all 7 days.

The smoking behaviour of parents was measured in two items: (i) Does your father, or the person who is like your father, smoke cigarettes?; and (ii) Does your mother, or the person who is like your mother, smoke cigarettes? Response choices included I do not live with a father/mother or anyone who is like a father/mother, he/she has never smoked, he/she used to smoke, he/she smokes now, I do not know. Sibling smoking was measured in two items: (i) Do any of your sisters smoke cigarettes?; and (ii) Do any of your brothers smoke cigarettes? Response choices included I do not have any sisters/brothers, none of my sisters/brothers smokes, at least 1 of my sisters/brothers used to smoke, at least 1 of my sisters/brothers smoke now, I do not know. Peer smoking was measured in one item: Your closest friends are the friends you like to spend the most time with. How many of your closest friends smoke cigarettes? (none, 1, 2, 3, 4, 5 or more).

2.1. Data analysis

The current analysis pertains to data collected at baseline. Participants retained for analysis included those who responded “no” to the two questions: “Have you ever tried smoking, even just a few puffs?”, and “Have you ever smoked a whole cigarette?”, and in addition, responded “none” to the question: “On how many of the last 30 days did you smoke one or more cigarettes?” Participants with incomplete data on SHS exposure were excluded. To correct for clustering within schools, all analyses were conducted within a generalized estimating equations (GEE) framework with an exchangeable correlation structure of residuals. Multivariate logistic regression models were developed to test the hypothesis that SHS exposure is independently associated with nicotine dependence symptoms. Separate models were created for SHS exposure in the home and in a car. Because parental smoking likely causes SHS exposure (i.e., it is in the causal pathway), it was not included as a covariate in the multivariate models. Other items not included in multivariate models were

variables not attaining univariate statistical significance level of $p < 0.1$. All analyses were conducted using the SAS statistical package version 9.1.

3. Results

Of 2946 eligible students in the 29 schools, 1801 (61%) completed questionnaires at baseline. Table 1 compares selected characteristics of AdoQuest participants with those of grade 5 students in Quebec who participated in the 2005 Youth Smoking Survey (YSS), which included a provincially representative sample (Health Canada, 2005). Compared to the YSS sample, higher proportions of AdoQuest participants reported exposure to SHS, proportionately more were susceptible to initiating smoking, and more had ever tried smoking.

The average age of AdoQuest participants was 10.7 (SD=0.5) years; 56% were girls. The distributions of subjects across exposures and covariates are presented in Table 2. Of 1488 never-smokers, 69 (4.6%) self-reported at least one nicotine dependence symptom ($n=41$, 15, 8, 3, and 2 reported 1, 2, 3, 4, and 6 symptoms, respectively). The most frequently reported symptoms included mental ($n=29$) and physical addiction ($n=23$), difficulty not smoking when others smoke ($n=25$), and feeling the need to have a cigarette ($n=23$). Having difficulty not smoking where it is not allowed ($n=2$), and experiencing cravings ($n=13$) or very strong cravings ($n=4$) were endorsed less frequently.

Univariately, increases in level of exposure to SHS, both in the home and in a car, were associated with an increased likelihood of reporting nicotine dependence symptoms (Table 3). Cigarette smoking among family members and friends, and susceptibility to initiating smoking, were also univariately associated with a higher odds of reporting at least one nicotine dependence symptom.

The odds ratios adjusted for potential confounders for home and car SHS exposure did not vary substantially from the unadjusted odds ratios (Table 3: Models 1 and 2, respectively). These results upheld in a secondary analysis that excluded all participants categorized as being susceptible to initiating smoking (data not shown). Removing the variable representing number of siblings who smoke from Models 1 and 2 did not change the estimated odds ratios of home and car SHS (data not shown), and none of several interaction terms tested (sex $\times$ SHS exposure; sibling smoking $\times$ SHS exposure; friends smoking $\times$ SHS exposure; susceptible to initiating smoking $\times$ SHS exposure) was statistically significant (p -values all > 0.2). Finally the estimated effects of SHS exposure at home or in a car were similar when the number of nicotine dependence symptoms reported was modeled as a continuous variable in linear regression models (data not shown).

4. Discussion

According to conventional understanding, a person who does not smoke cigarettes cannot experience nicotine dependence. Yet in this study, 5% of grade 5 children who had never smoked a cigarette reported at least one symptom of nicotine dependence. Further, exposure to SHS was associated with a higher probability of reporting these symptoms. This finding could reflect that, even beyond being detectable through nicotine markers, SHS may

potentiate physiologic mechanisms that cause symptoms of nicotine dependence in young never-smokers (Okoli, Kelly, & Hahn, 2007). It is of course possible that participants misinterpreted the questions on nicotine dependence or that either social role modeling or expectations about what participants should experience (rather than what they actually experience) influenced reports of nicotine dependence symptoms. However we did take susceptibility to initiating smoking and peer smoking into account in this analysis, which presumably took at least some of the effects of social role modeling and expectation into account. Overall, these data suggest an interesting and potentially important hypothesis — that exposure to SHS may potentiate nicotine dependence symptoms in young never-smokers.

The sensitization-homeostasis model of nicotine addiction (DiFranza & Wellman, 2005) posits that nicotine is addictive because it sensitizes neural pathways that suppress cravings thereby causing an excessive inhibition in neurons that generate craving. As homeostatic measures develop to balance the resulting inhibition of nicotine, the craving neurons activate and function autonomously. This model of nicotine addiction may explain some of the nicotine dependence symptoms (particularly ‘mental addiction’, ‘physical addiction’, ‘difficulty not smoking when others are smoking’ and ‘cravings to smoke’) endorsed by the children in our study. In relation to this model, it is possible that involuntary nicotine exposure from SHS could sensitize neural pathways in young never-smokers, resulting in reports of cravings and other nicotine dependence symptoms. Indeed, a recent report showed that biomarkers of SHS exposure are associated with symptoms similar to nicotine withdrawal among non-smoking adults, such as reporting depressed mood, trouble sleeping, irritability, anxiety, trouble concentrating, restlessness and increased appetite (Okoli, Rayens, & Hahn, 2007). These findings in conjunction with our results provide support for the hypothesis that SHS exposure in some youth may result in the development of psychobehavioural symptoms believed until now to occur only among smokers.

Of the nicotine dependence symptoms reported, mental and physical addiction were among those most frequently reported by young never-smokers. Gervais, O’Loughlin, Meshefedjian, Bancej, and Tremblay (2006) recently reported that mental and physical addiction are the first nicotine dependence symptoms experienced by novice smokers. Further, some novice smokers experience these symptoms very early in the natural course of smoking onset (within 2–5 months of first puff) at very low exposures to smoking. Because younger age is associated with increased vulnerability to the effects of tobacco (Kandel & Chen, 2000), it is plausible that exposure to nicotine at low doses through intermittent and sporadic cigarette use or through exposure to SHS could result in nicotine dependence symptoms. Indeed, the onset of nicotine dependence was recently observed among novice smokers with nicotine biomarker levels that were comparable to levels of passive smokers and well below levels normally used to distinguish smokers from SHS exposed non-smokers (DiFranza et al., 2007).

Limitations of this analysis include that the temporal relationship between SHS exposure and nicotine dependence symptoms could not be established because of the cross-sectional study design. However it is unlikely that nicotine dependence symptoms in 10–12 year-old children result in SHS exposure in the home or in motor vehicles. Second the number of

participants who reported at least one nicotine dependence symptom was small, limiting the power to detect the associations of interest. Third, there are no “gold standard” measures of nicotine dependence symptoms in children. Although the items used in this study are psychometrically strong and show content as well as convergent construct validity, it is possible that they do not measure nicotine dependence symptoms. Never-smokers could report symptoms they expect by simply smelling cigarette smoke or observing others smoking, rather than those they actually experience (Upadhyaya, Drobes, & Thomas, 2004). Our measures of SHS exposure were not validated with biomarkers. However non-differential misclassification of exposure and nicotine dependence symptoms in this study would likely result in attenuation of the odds ratios.

In summary this study suggests that SHS exposure may relate to self-reports of nicotine dependence symptoms among young never-smokers. If replicated, these findings support public health interventions that promote non-smoking in the presence of children, and more specifically uphold policy interventions to restrict non-smoking in motor vehicles in which children are present.

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Appendix A. Test–retest reliability coefficients for items included in the nicotine dependence score

Item included in nicotine dependence score (response choices)	Items tested in previous research ^a	
	Item (response choices)	1–2 week test–retest reliability
How often do you have cravings to smoke cigarettes? (sometimes/often/very often vs never/almost never)	Did you ever have strong cravings to smoke? (yes, no)	Kappa coefficient (95% CI) = 0.85 (0.70–0.99)
How physically addicted to smoking cigarettes are you? (very/somewhat/a bit vs not at all)	Have you ever felt like you were addicted to tobacco? (yes, no)	Kappa coefficient (95% CI) = 0.93 (0.83–1.0)
	On a scale from 0 to 10, how physically addicted to smoking are you?	ICC ^c (lower 95% CI) = 0.81 (0.69)
	On a scale from 0 to 10, how dependent on smoking are you?	ICC (lower 95% CI) = 0.89 (0.81)
	On a scale from 0 to 10, how addicted to tobacco/nicotine are you?	ICC (lower 95% CI) = 0.88 (0.80)
How mentally addicted to smoking cigarettes are you? (very/somewhat/a bit vs not at all)	On a scale from 0 to 10, how mentally addicted to smoking are you	ICC (lower 95% CI) = 0.87 (0.77)
How often have you felt like you really need a cigarette? (often/sometimes/rarely vs never)	Have you ever felt like you really need a cigarette? (yes, no)	Kappa coefficient (95% CI) = 0.80 (0.63–0.97)
Do you find it difficult not to smoke in places where it is not allowed (at a movie theatre, at home if your parents don't know you smoke)? (very/a bit vs not at all)	Is it hard for you to keep from smoking in places where you are not supposed to, like school? (yes, no)	Kappa coefficient (95% CI) = 0.75 (0.55–0.96)
	When you are in a place where smoking is forbidden, is it difficult for you not to smoke? (very difficult, difficult, somewhat difficult, slightly difficult, not at all difficult)	ICC (lower 95% CI) = 0.72 (0.56)
When you see other kids your age smoking cigarettes, how easy is it for you not to smoke? (very/a bit difficult vs pretty/very easy)	On a scale from 0 to 10, how easy is it for you not to smoke when you see others smoking? (yes, no)	ICC (lower 95% CI) = 0.81 (0.68)
How true is this statement for you? "I sometimes have strong cravings for cigarettes where it feels like I am in the grip of a force that I cannot control." (very/fairly true vs not very/not at all true)	Do you feel a strong need or urge to smoke? (yes, no)	Kappa coefficient (95% CI) = 0.81 (0.66–0.97)

^aData drawn from O'Loughlin J, Tarasuk J, DiFranza J, et al. Measurement of nicotine dependence: Reliability of selected measures of nicotine dependence among adolescents. *Ann Epidemiol* 2002;12:353–62.

^bCI = Confidence interval.

^cICC = Intraclass correlation coefficient.

Table 1

Comparison of selected characteristics of AdoQuest participants with those of grade 5 students in Quebec who participated in the Youth Smoking Survey (YSS) 2005

	YSS (<i>n</i> =851) %	AdoQuest (<i>n</i> =1801) ^a %
People smoke inside the home	34	37
Rode in a car with someone smoking	22	26
Ever tried smoking	10	13
Susceptible to initiating smoking	36	41

^a Includes 251 students who reported smoking, and 62 with missing data on secondhand tobacco smoke exposure.

Table 2

Distribution of never-smokers according to symptoms of nicotine dependence

	Nicotine dependence symptoms	
	None (n=1419) %	1 (n=69) %
Age, years		
9	0.2	0.0
10	29.7	27.5
11	66.5	63.8
12	3.5	8.7
13	0.1	0.0
Sex, male	44.6	36.2
No. of persons who smoke inside the home		
0	67.2	59.4
1	19.0	18.8
2	10.5	15.9
3	2.3	2.9
4	0.6	1.5
5	0.4	1.5
No. of days rode in car with someone smoking		
0	77.5	68.1
1–2	12.3	8.7
3–4	4.2	10.1
5–6	2.5	4.4
7	3.6	8.7
No. of parents who smoke		
0	67.2	60.9
1	23.5	21.7
2	9.2	17.4
No. of siblings who smoke		
0	93.0	84.1
1	6.3	11.6
2	0.6	4.4
Friends who smoke	8.8	23.2
Susceptible to initiating smoking	34.4	59.7
School socioeconomic status		
Low	24.6	30.4
Middle	32.8	39.1
High	42.6	30.4

Table 3

Crude and adjusted odds ratios (OR) and 95% confidence intervals (CI) for indicators of exposure to secondhand tobacco smoke, for reporting at least one nicotine dependence symptom among never-smokers ($n=1488$)

	Crude OR (95% CI)	Model 1 (home) adjusted OR (95% CI)	Model 2 (car) adjusted OR (95% CI)
No. of persons who smoke inside the home	1.3 (1.0, 1.6)	1.1 (0.9, 1.4)	<i>a</i>
No. of days rode in car with someone smoking	1.3 (1.1, 1.6)	<i>a</i>	1.2 (1.0, 1.4)
Age, years	1.3 (0.8, 2.1)	<i>a</i>	<i>a</i>
Male	0.7 (0.4, 1.2)	<i>a</i>	<i>a</i>
No. of parents who smoke	1.3 (1.0, 1.9)	<i>a</i>	<i>a</i>
No. of siblings who smoke	2.4 (1.4, 4.1)	1.8 (1.1, 3.0)	1.8 (1.1, 2.9)
Friends who smoke	3.1 (1.7, 5.6)	2.3 (1.2, 4.3)	2.2 (1.2, 4.1)
Susceptible to initiating smoking	2.8 (1.7, 4.7)	2.5 (1.5, 4.1)	2.4 (1.4, 4.0)
School socioeconomic status			
Low	Ref	<i>a</i>	<i>a</i>
Middle	1.0 (0.5, 1.7)	<i>a</i>	<i>a</i>
High	0.6 (0.3, 1.1)	<i>a</i>	<i>a</i>

^aVariable not included in the model.