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## Early Emerging Nicotine-Dependence Symptoms: A Signal of Propensity for Chronic Smoking Behavior in Adolescents

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### Abstract

**Objective**—To evaluate the predictive validity of nicotine-dependence symptoms in 9th- and 10th-grade adolescents.

**Study design**—A total of 594 adolescents who had not smoked more than 100 cigarettes in their lifetime and 152 adolescents who had smoked more than 100 cigarettes in their lifetime were included in the analysis. The predictive validity of 10 nicotine-dependence items administered at baseline was evaluated at the 24-month follow-up assessment.

**Results**—For those who smoked fewer than 100 cigarettes, higher levels of experienced nicotine-dependence symptoms at baseline, as well as individual symptoms, predicted current and daily smoking behavior at the 24-month follow-up, over and above baseline smoking. For adolescents who had smoked more than 100 cigarettes at baseline, the level of nicotine dependence and individual symptom endorsement did not predict smoking behavior at the 24-month follow-up.

**Conclusions**—Our findings demonstrate that early emerging dependence symptoms reported at low levels of smoking exposure signal a greater propensity for continued smoking behavior not accounted for by current or past smoking exposure. Screening for these early emerging symptoms among novice adolescent smokers represents an important and unused tool in tobacco control efforts aimed at preventing the development of chronic smoking patterns.

Over the past several decades, public health interventions have been very successful in reducing smoking in the United States by encouraging higher rates of quitting and decreased uptake. This has been achieved largely through “universal” approaches that have increased the knowledge of deleterious effects of smoking and exposure to second-hand smoke and influenced major antismoking legislation that has increased prices, reduced access, and limited smoking in both public and private areas.<sup>1-3</sup> But despite the success of these universal, population-based initiatives, national monitoring surveys suggest that the prevalence of cigarette smoking remains high.<sup>4</sup> Currently, more than 20% of US high school students report smoking in the past 30 days,<sup>4</sup> and 12.3% of high school seniors smoke daily.<sup>5</sup> Many more are at continued risk for establishing daily smoking patterns.<sup>6</sup>

Given the heavy public health burden associated with smoking despite substantial environmental restrictions, a “hardening hypothesis” has been posited in which mainly “hard-core” smokers (ie, those with a greater propensity for heavy, dependent smoking) remain in the wake of population-based intervention.<sup>7-9</sup> Based on the belief that new

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smokers who progress beyond initiation and experimentation may have a propensity for heavy dependent use, recent work has begun to focus on identifying individual differences in patterns of early smoking behavior and emerging dependence symptoms. Prospective studies have evaluated the development of smoking and nicotine dependence among novice adolescent smokers, and despite their use of different measures of dependence and different lags between follow-up assessment, each has clearly demonstrated that for some youth, symptoms of nicotine dependence emerge soon after smoking initiation, at relatively low levels of smoking exposure and well before the establishment of daily smoking patterns.<sup>10-15</sup> Although this and other accumulating evidence based on cross-sectional reports of novice smokers clearly documents individual differences in the number and type of nicotine dependence symptoms experienced to date,<sup>16</sup> it remains largely unclear whether these early emerging symptoms represent a substantial risk for sustained, chronic smoking behavior and, if so, whether that risk may be better accounted for by individual differences in smoking exposure than by the presence of nicotine dependence symptoms per se.

Based on a report from the Development and Assessment of Nicotine Dependence in Youth Study, endorsement of one or more dependence symptoms by youth recruited in the 7th grade was linked to continued smoking, daily smoking, and failed quitting attempts 3 years later.<sup>11</sup> The potential influence of previous smoking exposure was not controlled for in these analyses, however. The present study was designed to examine the independent association between nicotine dependence and future smoking behavior based on a prospective study designed to map the natural history of smoking and nicotine dependence across adolescence.

## Methods

The University of Illinois, Chicago School of Medicine, Institutional Review Board, approved all procedures. Consent/assent for participation was collected from the parent and the adolescent participant. The sample was drawn from the Social and Emotional Contexts of Adolescent Smoking Patterns Study. The goal of sampling was to develop a cohort of adolescents that mirrored the racial and ethnic diversity of the greater Chicago metropolitan area and that were at high risk for smoking. High schools were selected for recruitment based on geographic location, size, ethnic/racial diversity, willingness to work with research staff in gaining parental consent, and willingness to provide a school liaison to the study, along with space for recruitment and data collection activities. Approximately 35 schools were invited to participate in the study, from which a final sample of 16 high schools was selected. All 9th- and 10th-grade students at these 16 Chicago-area high schools completed a brief screener survey of smoking behavior ( $n = 12\,970$ ). All students who reported smoking in the past 90 days and smoking  $<100$  cigarettes in their lifetime were invited to participate, as were all those who reported smoking in the past 30 days and smoking  $>100$  cigarettes in their lifetime. In addition, random samples of youth reporting having never smoked, or smoking  $<100$  cigarettes in their lifetime but not smoking in the past 90 days, also were invited to participate. Of the 3654 students invited, 1344 agreed to participate (36.8%). Of these, 1263 (94.0%) completed the baseline measurement wave.

Retention at 24 months was excellent, with 90.8% ( $n = 1147$ ) of the cohort completing the 24-month assessment. Participants and nonparticipants at 24 months did not differ in terms of age or race/ethnicity; however, nonparticipation was significantly higher in boys than in girls (11.5% vs 7.4%;  $P = .013$ ). Nonparticipation also was higher in youths with a parent who did not participate in the study (parents were asked to complete extensive questionnaires at baseline) ( $P < .0001$ ). Compared with completers, noncompleters reported higher 7-day smoking rates at baseline ( $0.78 \pm 1.86$  cigarettes per day vs  $0.45 \pm 1.50$  cigarettes per day;  $P = .03$ ), a greater number of days smoked in the past 30 ( $5.79 \pm 9.18$  days vs  $3.66 \pm 7.51$  days;  $P = .004$ ), and higher numbers of cigarettes smoked on days

smoked in the past 30 ( $1.38 \pm 2.90$  vs  $0.84 \pm 1.85$ ;  $P < .01$ ). Noncompleters also had a lower grade point average at baseline than completers ( $3.53 \pm 0.70$  vs  $3.73 \pm 0.75$ ;  $P < .01$ ). Although adolescents who failed to complete the 24-month follow-up tended to have somewhat higher rates of smoking at baseline, the overwhelming majority of high-risk youths were retained. A total of 594 adolescents who smoked in the past 90 days but had not smoked >100 cigarettes in their lifetime and 152 adolescents who had smoked in the past 30 days, had smoked >100 cigarettes in their lifetime, but were smoking <5 cigarettes per day at baseline were the focus of the present analyses. Demographic and smoking characteristics for each group are presented in Table I.

## Measures

Current smoking was assessed with 2 items at the baseline assessment administered approximately 2 months after screening. Participants were asked how many days they smoked cigarettes in the past 30 days (frequency) and how many cigarettes they smoked in the past 7 days (quantity). These same quantity and frequency questions were used to assess current cigarette smoking at the 24-month follow-up. The number of days smoked in the past 30 was dichotomized to daily (30 days) versus nondaily (<30 days), and the number of cigarettes smoked in the past 7 days was dichotomized to any smoking in the past 7 days (yes/no).

Nicotine dependence was assessed with a shortened version of the Nicotine Dependence Syndrome Scale (NDSS),<sup>17</sup> modified for use with adolescents. The full NDSS scale was reduced to 10 items based on psychometric analyses conducted on an adolescent sample,<sup>18</sup> retaining those items reflecting mainly drive and tolerance from the original NDSS. Research supports the reliability, stability, construct validity, and predictive validity of the NDSS for use with adolescents,<sup>19,20</sup> and the modified version demonstrated strong internal consistency with the current sample (coefficient alpha = 0.93). Items in the current study were answered on a 4-point Likert-type scale, ranging from 0 (not at all true) to 3 (very true). A total nicotine-dependence score was obtained by averaging the responses to all items. Individual symptoms were included in the analyses. The 3 response options of “sometimes true” to “very true” were collapsed into a single category to generate a dichotomous variable for symptom endorsement (no, not at all true vs yes, any of the 3 positive responses).

Other tobacco use was measured by the following questions: During the past 30 days, on how many days did you (1) use chewing tobacco, snuff, or dip; (2) smoke cigars, cigarillos, or little cigars; (3) smoke bidis; or (4) smoke kreteks? Reports were dichotomized into any other tobacco use versus no other tobacco use.

## Analyses

Logistic regression analyses were performed to test the association between nicotine dependence (both the NDSS total score and endorsement of individual symptoms) measured at baseline and smoking behavior (past week smoking and past month daily smoking) measured at the 24-month follow-up for each smoking group. Covariates included baseline smoking exposure indices (number of days smoked in the past 30 days and number of cigarettes smoked in the past 7 days), other tobacco use in the past 30 days, and sex. Models were built by individually adding sex, smoking quantity, smoking frequency, and other tobacco use.

## Results

For adolescents entering the study with lifetime exposure to smoking of <100 cigarettes, those who were current smokers at the 24-month follow-up and those who were smoking daily at the 24-month follow-up had higher NDSS total scores at baseline than noncurrent smokers (mean NDSS of  $0.51 \pm 0.54$  in current smokers vs  $0.23 \pm 0.36$  in nonsmokers) and nondaily smokers (mean NDSS of  $0.66 \pm 0.61$  in daily smokers vs  $0.30 \pm 0.43$  in nondaily smokers). Logistic regression analysis examining the association between the NDSS total score at baseline and smoking behavior at 24 months revealed that higher levels of nicotine dependence predicted smoking behavior 24 months later, and that this association was significant after controlling for baseline smoking (quantity and frequency), sex, and other tobacco use (outcome, past week smoking at 24 months: odds ratio [OR] = 2.4, 95% confidence interval [CI] = 1.39-4.03 outcome, daily smoking at 24 months: OR = 2.2; 95% CI = 1.11-4.45).

At the symptom level, baseline reports of “willingness to go out in a rainstorm to get cigarettes” and that “it is worth it to be able to smoke a cigarette even in cold or rainy weather” predicted both past week smoking and daily smoking at 24 months. After controlling for sex, smoking quantity and frequency, and other tobacco use, symptoms of withdrawal (ie, restlessness and irritability when not smoking and smoking to keep from experiencing discomfort) and reporting better functioning in the morning after having a cigarette predicted past week smoking at 24 months. Baseline reports of craving also predicted daily smoking behavior at 24 months.

When examining corresponding models based on the sample of smokers who had smoked in the past 30 days, smoked >100 cigarettes in their lifetime, but were smoking <5 cigarettes per day, the level of nicotine dependence and individual symptom endorsement at baseline were not significantly associated with smoking at the 24-month follow-up. Building the models to include covariates demonstrated that in many cases, the only significant predictor of future smoking for those who had smoked >100 cigarettes was baseline smoking frequency (ie, number of days smoked in the past month). Tables II and III present the final models examining the association between nicotine dependence measured at baseline and current smoking behavior at the 24-month follow-up for each smoking group.

## Discussion

Although smoking initiation typically occurs in adolescence and represents a behavior that has been studied extensively in this population, surprisingly little research has examined the importance of emerging dependence in novice smokers and its potential role in smoking maintenance across adolescence and into young adulthood.<sup>10,21-23</sup> To begin to fill this gap, the present study examined the 2-year predictive validity of early emerging nicotine dependence symptoms among novice adolescent smokers. For adolescents smoking <100 cigarettes in their lifetime, higher levels of nicotine dependence at baseline as well as individual symptoms of craving, withdrawal, and perceived functioning predicted past week and/or daily smoking 2 years later—associations that were not better accounted for by baseline smoking quantity or frequency. In contrast, among those who had smoked >100 cigarettes in their lifetime, smoking frequency, rather than nicotine dependence, predicted smoking behavior at the 2-year follow-up. Taken together, these findings suggest that measurement of nicotine dependence during the earliest exposures to smoking may be an important, yet unused tool in predicting smoking behavior before the development of more established smoking patterns, but that as more regular smoking patterns emerge, nicotine-dependence symptoms may no longer uniquely predict future smoking.

Despite the absence of directly comparable research in terms of the continuum of smoking exposure represented in the present sample, our findings generally confirm those of Sledjeski et al,<sup>20</sup> who reported that nicotine dependence as measured by a continuous scale of *Diagnostic and Statistical Manual of Mental Disorders IV* items in a sample of first-year college students predicted future smoking quantity over and above smoking exposure, but only when baseline smoking quantity was low (ie,  $\leq 5$  cigarettes per week). When smoking quantity was high (ie,  $\geq 60$  cigarettes per week), nicotine dependence did not predict future smoking over and above baseline smoking quantity and frequency, confirming that in a young adult smoking sample, more regular smoking patterns may drive continued smoking, and individual differences in nicotine dependence may drive lower levels of use.<sup>20</sup>

Although more than 70% of people in the United States try a cigarette sometime during their lifetime, only 67% of this group transitions to daily smoking, and only 40% ever meet the criteria for nicotine dependence.<sup>24</sup> Our study demonstrates that dependence symptoms experienced by adolescents who have smoked  $< 100$  cigarettes signal a greater propensity for continued smoking behavior above and beyond smoking quantity and frequency. These findings have important implications for tobacco control efforts, in that they provide information on who may be more likely to progress to chronic dependent smoking and who may engage in smoking but not make this transition. A hardening hypothesis has been proposed, suggesting that individuals with high susceptibility to nicotine dependence may explain the difficulty encountered in reducing the prevalence of daily smoking much below 25% over the past decade.<sup>7-9</sup> Notably, although most smoking interventions target preventing the first smoking experience<sup>25</sup> or treating heavily dependent chronic smokers,<sup>26</sup> our findings suggest that smokers reporting symptoms of nicotine dependence during their earliest exposure to nicotine represent an important target for intervention. Even though the malleability of smoking behavior during this period is unknown, this potentially pivotal stage in the course of smoking behavior merits evaluation.<sup>27</sup>

Despite the strengths of this study—including recruitment of adolescent smokers across the continuum of smoking behavior, measurement of nicotine dependence, and longitudinal assessment—our findings should be interpreted within the context of the study's limitations. First, the sample was geographically restricted. Further, measurement of nicotine dependence was limited to a shortened version of the NDSS, modified for use with adolescents.<sup>18</sup> Additional prospective studies using multiple measures of nicotine dependence are needed to both replicate and extend the present findings by identifying dependence features that consistently predict smoking persistence in this population. Although emerging item response theory work based on a nationally representative sample of novice smokers has demonstrated that several of the NDSS items discriminate well between levels of nicotine dependence (J. Rose and L. Dierker, unpublished data), the lack of longitudinal data for this population currently impedes our ability to more comprehensively evaluate their predictive capacity. Finally, whether these reports of emerging symptoms at low levels of smoking can be linked to more objective measures of physiological dependence is unclear. This information would better allow us to contribute to theory surrounding the development of chronic smoking behavior. But regardless of whether individual differences in nicotine dependence are driven by systematic differences in subjective evaluations of symptoms or by physiologic differences in sensitivity, we have shown that above and beyond smoking quantity and frequency, these differences do forecast future smoking and as such are worthwhile targets of intervention.

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## Glossary

<b>CI</b>	Confidence interval
<b>NDSS</b>	Nicotine Dependence Syndrome Scale
<b>OR</b>	Odds ratio

**Table I**  
**Demographic and smoking characteristics by smoking group**

Baseline characteristic*	Smokers <100 cigarettes <sup>†</sup> (n = 594)	Smokers >100 cigarettes <sup>‡</sup> (n = 152)
Male sex, n (%)	344 (57.9)	71 (46.7)
Age, years, mean (SD)	15.6 (0.62)	15.8 (0.63)
Caucasian ethnicity, n (%)	413 (69.5)	121 (79.6)
Smoked in past 24 hours, n (%)	70 (11.8)	93 (61.6)
Smoked in past 7 days, n (%)	230 (39.7)	123 (83.7)
Any other tobacco use in past 30 days, n (%)	189 (31.8)	71 (46.7)
Ever smoked daily in lifetime, n (%)	90 (15.2)	119 (79.3)
Smoked daily in the past month, n (%)	4 (0.68)	45 (29.6)
Age of initiation (puff or more), years, mean (SD)	12.7 (2.03)	11.7 (1.91)
Number of days smoked in past month, mean (SD)	3.2 (5.4)	18.24 (11.06)
Number of cigarettes smoked in past week, mean (SD)	2.0 (5.61)	19.5 (23.6)
NDSS score, mean (SD) of 10 items on a scale of 0-3	0.4 (0.48)	1.3 (0.82)
24-month outcome, n (%)		
Positive for past week smoking	205 (38.7)	97 (77.6)
Positive for daily smoking	51 (9.6)	57 (44.5)

\* Percentages based on valid responses.

<sup>†</sup> Based on the screening phase of the study, youth who indicated smoking in the past 90 days and who have smoked less than 100 cigarettes in their lifetime.

<sup>‡</sup> Based on the screening phase of the study, youth who smoked in the past 30 days, smoked more than 100 cigarettes in their lifetime, but smoke 5 or fewer cigarettes a day.



**Table II**  
**Association between baseline nicotine-dependence symptoms and smoking at the 24-month follow-up by smoking group\***

	Smokers <100 cigarettes (n = 538) <sup>†</sup>		Smokers >100 cigarettes (n = 129) <sup>†</sup>	
	Yes, %	No, %	OR (CI)	OR (CI)
Compared to when I first started smoking, I need to smoke a lot more now to be satisfied.				
Positive for past week smoking at 24 months	51.5	34.2	1.2 (0.73-1.82)	79.4
Positive for daily smoking at 24 months	15.2	7.4	1.1 (0.52-2.22)	47.0
Since I started smoking, I have increased how much I smoke.				
Positive for past week smoking at 24 months	51.2	31.4	1.5 (0.96-2.24)	80.2
Positive for daily smoking at 24 months	14.4	6.7	1.3 (0.66-2.70)	49.5
After not smoking for awhile, I need to smoke to relieve feelings of restlessness and irritability.				
Positive for past week smoking at 24 months	52.5	31.2	<b>1.7* (1.15-2.62)</b>	82.5
Positive for daily smoking at 24 months	14.4	7.0	1.4 (0.71-2.78)	50.0
After not smoking for awhile, I need to smoke to keep myself from experiencing any discomfort.				
Positive for past week smoking at 24 months	60.2	32.5	<b>1.9* (1.20-3.02)</b>	83.3
Positive for daily smoking at 24 months	17.3	7.3	1.4 (0.72-2.85)	48.3
I can function much better in the morning after I've had a cigarette.				
Positive for past week smoking at 24 months	73.0	36.8	<b>2.3* (1.01-5.47)</b>	84.5
Positive for daily smoking at 24 months	29.7	8.3	2.3 (0.92-5.90)	60.7

Boldface *P* < .05.

\* ORs and 95% CIs adjusted for baseline smoking frequency (days smoked in past 30), quantity (number of cigarettes smoked in past week), other tobacco use (any on the past 30 days), and sex.

<sup>†</sup> Percentages based on valid responses.

**Table III**  
**Association between baseline nicotine dependence symptoms and smoking at the 24-month follow-up by smoking group\***

	Smokers <100 cigarettes <sup>†</sup>			Smokers >100 cigarettes <sup>†</sup>		
	Yes, %	No, %	OR (95% CI)	Yes, %	No, %	OR (95% CI)
Whenever I go without a smoke for a few hours, I experience craving.						
Positive for past week smoking at 24 months	57.5	35.9	1.3 (0.75-2.36)	84.5	67.4	1.8 (0.60-5.55)
Positive for daily smoking at 24 months	21.3	7.5	<b>2.2* (1.02-4.57)</b>	54.8	28.0	1.9 (0.74-4.98)
When I'm craving a cigarette it feels like I'm in the grip of some unknown force that I can't control.						
Positive for past week smoking at 24 months	54.8	36.6	1.3 (0.74-2.17)	80.9	73.2	0.7 (0.24-1.94)
Positive for daily smoking at 24 months	20.0	7.9	1.7 (0.84-3.61)	53.5	33.9	1.1 (0.47-2.71)
If there were no cigarettes in the house and there was a big rainstorm, I would still go out of the house and find a cigarette.						
Positive for past week smoking at 24 months	69.5	35.6	<b>3.1* (1.60-5.82)</b>	85.5	71.0	1.26 (0.43-3.68)
Positive for daily smoking at 24 months	23.3	8.1	<b>2.2* (1.04-4.79)</b>	53.5	37.7	0.9 (0.37-2.23)
In situations where I need to go outside to smoke, it's worth it to be able to smoke a cigarette, even in cold or rainy weather.						
Positive for past week smoking at 24 months	60.3	32.5	<b>1.9* (1.16-3.08)</b>	81.7	68.3	0.9 (0.27-2.70)
Positive for daily smoking at 24 months	20.5	6.3	<b>2.4* (1.18-4.82)</b>	52.9	29.3	1.2 (0.44-3.49)
If I'm low on money, I'll spend it on buying cigarettes instead of buying lunch.						
Positive for past week smoking at 24 months	65.5	36.4	1.5 (0.76-3.03)	84.1	68.5	1.3 (0.48-3.77)
Positive for daily smoking at 24 months	21.8	8.4	1.2 (0.46-2.97)	52.8	35.2	1.0 (0.37-2.42)

\* ORs and 95% CIs adjusted for baseline smoking frequency (days smoked in past 30), quantity (number of cigarettes smoked in past week), other tobacco use (any on the past 30 days) and sex.

<sup>†</sup> Percentages based on valid responses.