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Multilevel Predictors of Smoking Initiation among Adolescents: Findings from the Minnesota Adolescent Community Cohort (MACC) Study

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Abstract

Objective—To understand how factors at multiple levels of influence impact adolescent smoking initiation.

Method—Data from the Minnesota Adolescent Community Cohort, a population-based cohort, were analyzed. Adolescents were recruited from randomly selected geopolitical units (GPUs) in Minnesota at ages 12 to 13 (n=1,953), and were surveyed every six months (2000–2006) until 18. The association between baseline social factors and smoking initiation was analyzed using logistic regression. Linear regression was used to analyze predictors and age of initiation among smokers (n=603).

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Conflict of Interest Statement

The authors declare that there are no conflicts of interest.

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Results—Higher proportion of 15–16 year-olds who smoke at the area-level (GPU) was associated with younger initiation (15.47 vs 15.87, $p<.05$). Higher proportion of the population employed and higher median household income were associated with older initiation (15.90 vs. 15.56 $p<.05$). Parent education, living with parents or siblings who smoke, living in homes that allow smoking, and having friends who smoke at baseline were associated with smoking initiation or younger initiation ($p<.05$). Participants whose parents had less than a high school education were 1.6 times more likely than those with college educated parents to have smoked more than a whole cigarette (CI=1.06, 2.26).

Conclusion—Factors at multiple levels of influence affect adolescent smoking initiation. Smoking by older age peers and lower SES predicts earlier smoking.

Introduction

Over 80% of adult smokers tried smoking before the age 18;(CDC, 2010) two thirds experiment with smoking by age 15. (Johnson and Hoffmann, 2000) The probability of cessation among adults is inversely related to the age of smoking initiation.(Breslau and Peterson, 1996) Given that most initiation of tobacco use occurs in adolescence and cessation is so difficult in adulthood, preventing smoking initiation among adolescents is critical to controlling the public health implications. Most research on predictors of adolescent smoking behaviors has emphasized individual or socio-demographic characteristics. (Griesler, et al., 2002, Kandel, et al., 2004) Yet smoking prevention policies and programs are implemented at a broader level of communities and geographic areas. To best understand prevention requires analyzing influences on multiple intersecting levels and to establish temporal causality of smoking initiation requires using longitudinal prospective cohort studies.(Wakefield and Forster, 2005)

Previous studies have examined individual and proximal environmental level predictors of adolescent smoking initiation. The proximal social environment includes friends' smoking which has been identified as a predictor of both adolescent smoking initiation (Conrad, et al., 1992, Flay, et al., 1994) and susceptibility to smoking (e.g. reported likelihood of accepting a cigarette if offered in the near future). (Bauman, et al., 2001, Gritz, et al., 2003, Miller, et al., 2006) Other proximal risk factors to smoking initiation include living in a single-parent home, exposure to pro-tobacco messages, and living with at least one household smoker.(Gritz, et al., 2003) Adolescents often smoke their first cigarette in the presence of other peers (Johnson and Hoffmann, 2000) and often access cigarettes from social contacts.(J. Forster, 2003) They smoke as a form of stress reduction, to relax, and as an expression of independence.(Nichter, et al., 1997)

Neighborhood-level social variables have statistically significant effects on health behaviors. (Pickett and Pearl, 2001) Specifically, an inverse association was found between neighborhood-level SES and smoking prevalence, after controlling for individual-level SES (Kleinschmidt, 1995); with a relative risk of smoking of 1.2–1.7 in lower SES neighborhoods.(Pickett and Pearl, 2001) Area-level analyses of SES (measured as employment, education, housing values, and income) have also yielded inverse associations with mean smoking prevalence in youth.(Bernat, et al., 2009)

Longitudinal datasets have been used to examine variation in influences on adolescent smoking initiation with particular attention to ethnicity (Griesler and Kandel, 1998, Griesler, et al., 2002); parental influence;(Flay, et al., 1994) and peer influence.(Alexander, 2001, Flay, et al., 1994, Urberg, et al., 1997) While prior research establishes the importance of area-level analyses few have used a multi-level approach to analyze adolescent smoking. (Kandel, et al., 2004, Klein, 2009, Siegel, et al., 2008) No studies reported the influence of

socio-economic variables and prevalence of older adolescent smoking at the area level on adolescent smoking *initiation*, which is the express purpose of our paper.

METHODS

The Minnesota Adolescent Community Cohort (MACC) is a prospective cohort study that began in 2000. The design of the study is detailed elsewhere.(Forster JL, 2011) Participants in the MACC Study were selected in 2000–2001 and 2001–2002 through cluster random sampling. To start, Minnesota was divided into 129 areas, or geopolitical units (GPUs) based on geographic and political boundaries, patterns of local tobacco program activities, and sufficient numbers of teenagers residing in each unit. Sixty GPUs were then randomly selected using modified random digit dialing and a combination of probability and quota sampling methods to obtain an even distribution of participants from ages 12 to 16 in each GPU. Of eligible households, 3636 participants in Minnesota were recruited. An additional cohort of 585 twelve year-olds was recruited from the 60 Minnesota GPUs using the same procedures during 2001–2002, resulting in an overall sample of 4221. Participants were interviewed by phone every six months. The present study included participants who were ages 12 and 13 at baseline and had not yet smoked more than a whole cigarette (n=1963). The study is restricted to data collected before they were 18 years old. The overall retention rate at round 15 was 60.8%.

The University of Minnesota Institutional Review Board approved this study. Parents provided active informed consent at each survey point for their children until participants reached 18 years of age.

Measures

Participants were asked at every round “Have you smoked more than a whole cigarette?” Those who responded “yes” to the question were classified as having initiated smoking. Age of initiation was defined as the participant’s age when he/she first reported smoking a whole cigarette, calculated by date of birth and date of interview.

At the individual level, information was collected on gender, race/ethnicity (white vs. non-white, collapsed from six categories), and parent education using the highest level of two parents, used as a proxy measure for SES.

At the proximal social context level, participants were asked if they lived with a parent or sibling who smoked (yes/no) and whether there was a home smoking policy (yes/no). Participants were asked “How many of your four closest friends smoke cigarettes?” to assess peer smoking. The variable was coded into a dichotomous response of either no smoking friends or one or more friends who smoked.

Data from the United States Census Bureau 2000 Census Summary File 3 (Census Bureau, 2003) was used to derive GPU-level socio-demographic measures. Demographic characteristics shown to be associated with smoking behavior in previous studies were selected for analysis:(Bernat, et al., 2009) percentage of population that was white; urban (living in places with at least 2500 inhabitants);at least a high school education; living above the federal poverty line (income-to-poverty ratio>1.5);employed adults (16 years old or above);households headed by men; median household income; and median house value.

The means of census block group medians within specific GPUs were used to measure GPU – level characteristics. We also calculated prevalence of past month smoking among participants who were 15 and 16 years old at baseline to represent older peer smoking in

each GPU. All GPU-level characteristics were categorized into tertiles (e.g., high, medium, low).

Statistical analysis

The influence of individual, proximal and area (GPU) level predictors on whether the participants, nonsmokers at baseline, reported smoking initiation before age 18 (yes/no) was examined using multilevel logistic regression models. At the individual and proximal levels, we first assessed the bivariate associations between the predictors and the outcome (smoking initiation). Predictors that were associated with the outcomes using a criterion of $p \leq 0.1$ were included in the multivariate analysis, while taking into account clustering by GPU. This assured us the correct sample size ($n=60$) and standard errors. We did not include individual and social-level predictors when estimating the effect of area-level predictors. Since individual and social – level predictors could be mediators in the association between area-level predictors and individual behaviors, their inclusion may lead to underestimation of the effects of area-level predictors. Among those who reported smoking more than a whole cigarette before 18 years of age, we used multilevel linear regression to examine the effect of individual, proximal and area-level predictors on the *age* of initiation.

RESULTS

Almost 31% of participants reported initiating smoking during the study period (Table 1). The average age of initiation was 15.7 years. Participants were mostly white and had parents with at least some college education (Table 1). Approximately 66% lived with parents who did not smoke, and most siblings of participants were nonsmokers (91%) at baseline. Two-thirds of the participants reported a home smoking ban. At baseline, participants had 0.3 friends who smoked. At the GPU level, on average, over 90% of the population was employed and living in households headed by men, and over 80% of the population was white, with at least a high school education. About 66% of the population resided in an urban area. The average median house value and median household income were \$117,600 and \$48,500, respectively.

Table 2 shows the bivariate and adjusted associations between all predictors and smoking initiation. At the proximal level, participants whose parents had less than a high school education were 1.6 times more likely than those with college educated parents to have ever smoked more than a whole cigarette during adolescence (confidence interval=1.06, 2.26). Living with smoking parents, living with smoking siblings, and having at least one friend who smoked were associated with smoking initiation ($p < .05$). Only participants who lived in GPUs with a medium versus low percentage (83.1–90.7 vs. <83.1) of the population with at least a high school education were significantly more likely to have initiated smoking prior to age 18 (odds ratio=1.34, confidence interval=1.05, 1.86).

Table 3 shows the associations between predictors and age of initiation, among participants who initiated smoking. At the individual level, having parents with some college education versus more than a college education was associated with starting smoking earlier (adjusted regression coefficient [ARC] = -0.42 , 95% confidence interval = -0.83 , -0.02). Age of initiation was also influenced by smoking in the adolescents' proximal social environment by peers (ARC = 0.63); parents (ARC = 0.28); and siblings (ARC = 0.18). Participants who lived in GPUs with a high percentage (>96.8) of the adult population employed initiated smoking at a significantly older age than those who lived in GPUs with low percentage employed (<94.8) (age 15.90 vs. 15.56) (regression coefficient=0.37, $p < .05$). Living in GPUs with high ($>20.8\%$) and medium proportions (12.5–20.8%) of 15–16 year-olds who smoked was associated with an earlier age of smoking initiation (15.47 and 15.46 respectively) compared to the mean age (15.87) in GPUs with a low proportion of smoking

15–16 year olds (<12.5%) (regression coefficients= -0.40 and -0.41 , respectively; $p < .05$). Living in GPUs with a higher median house value was associated with later smoking initiation (regression coefficient= 0.37 , $p < .05$).

Attrition Analysis

Only 7 respondents lost to follow-up were known to have not initiated smoking. Since the main outcome was smoking initiation, any responded lost to follow up after initiation did not affect the analysis. Given the relatively small number of non-initiators (7) compared with the number of initiators (603) and the overall sample (1953), attrition did not significantly affect the outcomes of the analysis conducted for this paper. For the overall study, 60% of the sample responded to surveys administered in all 15 initial rounds and for round 17 there was a response rate of 77.7%.

DISCUSSION

Prior research using multi-level analyses and longitudinal datasets to study the influences on adolescent smoking behaviors have emphasized state or community-level policies that restrict smoking in workplaces (Klein, 2009), smoke-free restaurant initiatives (Siegel, et al., 2008), bans on vending machines and state taxes.(Kandel, et al., 2004) Distal social context factors that decreased smoking onset and progression to daily smoking included bans on vending machines (Kandel, et al., 2004) and smoke-free restaurant policies.(Siegel, et al., 2008) In those studies, including individual and proximal contextual factors mitigated the effects of distal factors. Variables measuring the influence of proximal social context were significantly associated with initiation and included living with a smoking parent,(Kandel, et al., 2004, Klein, 2009, Siegel, et al., 2008) peer smoking, (Kandel, et al., 2004, Klein, 2009, Siegel, et al., 2008) and smoking allowed at home.(Klein, 2009) This study adds the effect of distal area-level factors such as GPU-level measures of the proportion of older adolescents smoking and of SES.

A novel finding is that a higher proportion of older teenagers (15–16 years old) who smoked is associated with earlier smoking initiation for adolescents. Higher levels of smoking by older adolescents may yield perceptions of higher prevalence of smoking, which has been positively associated with adolescent smoking prevalence in prior research.(Albers, 2008, Bernat, et al., 2009, Kandel, et al., 2004) Also, older teenage smoking prevalence may make smoking more available given that a primary source of cigarettes for adolescents is social peers.(J. Forster, 2003) Results suggest that reducing or preventing smoking among older adolescents may indirectly prevent or delay smoking initiation among younger adolescents.

Having parents with some college but not a degree was predictive of earlier initiation compared with parental education of college or higher, as well as just high school diploma. Higher employment and median household income associated with initiating smoking at an older age. Both findings support prior research findings on the inverse relationship between SES and the age of smoking initiation.(Bernat, et al., 2009, Gilman, et al., 2003, Soteriades and DiFranza, 2003) Among higher SES groups this may reflect stronger anti-tobacco cultural norms preventing uptake of smoking such as perceived risks of tobacco's harms and more resources to limit the influences on smoking initiation. This includes resources to provide more individualized monitoring of adolescent behavior by parents or caregivers or to involve adolescents in extracurricular activities.

Smoking in adolescents' proximal social context is associated with initiation and age of initiation. Our findings support the influence of peer smoking on initiation (Bauman, et al., 2001, Flay, et al., 1994, Gritz, et al., 2003, Kandel, et al., 2004). Having at least one friend who smoked was predictive of both smoking initiation and earlier initiation. Encouraging

culturally appropriate refusal skills may be an effective intervention to reduce or delay smoking initiation among adolescents.(Duncan, 2000)

Another significant finding is that smoking allowed at home is associated with earlier smoking initiation, regardless of parent smoking. This supports the need for home smoking restrictions, which have reduced the likelihood of experimenting with cigarettes among adolescents even for those whose parents were non-smokers (Albers, 2008, Farkas, 2000, Szabo, 2006).

Study Limitations and Strengths

A limitation of the study is that it includes a Minnesota sample, which may restrict generalizability to other states. Loss to follow-up is a threat to internal validity of prospective studies because of misclassification of outcome status. Potential misclassification may happen among those who never reported smoking more than a whole cigarette and were lost to follow-up before they turned 18 years old. However, only seven participants who never reported having smoked more than a whole cigarette were lost to follow-up before they turned 18 years old, and therefore it is unlikely that our findings were biased because of loss to follow-up. A strength of our study is the large sample size and prospective design, which ensured the temporal sequence between the predictors and outcomes and provided stronger evidence for causal inference.(Wakefield and Forster, 2005)

Conclusion

Factors at multiple levels influence whether and when adolescents initiate smoking. Findings from our study further support the need for multi-level comprehensive tobacco control strategies outlined by the Center for Disease Control's *Best Practice for Comprehensive Tobacco Control*. Since indicators of higher SES are associated with a delayed uptake of smoking, policies and interventions preventing smoking should target lower SES areas. Further, GPUs with higher prevalence of older adolescent smoking may be targeted with anti-smoking policies and programs, specifically for older adolescents.

Due to the influence of smoking in the proximal social context of homes (by parents, siblings or anyone) there is a need for home smoking restrictions to effectively deter or delay adolescent smoking. Finally the number of friends who smoke as a predictor of earlier smoking merits local programs that increase culturally appropriate refusal skills.(Duncan, 2000)

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Highlights

- Multi-level social (distal, proximal, and individual) predictors of adolescent smoking.
- Older smoking initiation associated with area-measured higher Socioeconomic Status.
- Younger smoking initiation associated with proportion of older adolescents who smoke.

Table 1

Individual level and GPU level characteristics of the sample.

Characteristics		Mean (SD)	n (%)
<i>Individual level</i>			
Smoked >1 cigarette by age 18	Yes		603 (30.7)
	No		1360 (69.3)
Attrition (non-initiators lost to follow up)			7(0.4)
Age smoked > 1 cigarettes		15.7 (1.4)	
Gender	Male		965 (49.1)
	Female		999 (50.9)
Race/ethnicity	Non-white		315 (16.2)
	White		1630 (83.8)
Parent education	≤High school		343 (21.3)
	Some college		332 (20.6)
	College graduate		648 (40.2)
	>College graduate		287 (17.8)
<i>Proximal social level</i>			
Living with smoking parents	Yes		676 (34.4)
	No		1287 (65.6)
Living with smoking siblings	Yes		170 (8.7)
	No		1790 (91.3)
Smoking allowed at home	Yes		636 (33.7)
	No		1252 (66.3)
Have at least one friend who smokes	Yes		343 (17.5)
	No		1616 (82.5)
<i>Area (GPU) level</i>			
% white		89.4 (14.0)	
% urban population		65.5 (33.5)	
% with ≥high school education		86.8 (6.0)	
% above poverty line		84.3 (8.7)	
% employed (age ≥16)		95.5 (2.2)	
% household headed by men		91.0 (5.1)	
Median house value (\$1,000s)		117.6 (43.8)	
Median household income (\$1,000s)		48.5 (14.7)	
% 15–16 years old smoke		17.0 (8.0)	

Table 2Bivariate and multivariate analysis on smoking more than a whole cigarette before age 18.¹

Characteristics		OR (95% CI)	AOR (95% CI)
<i>Individual level</i>			
Gender	Male	0.80 (0.66, 0.98)	0.82 (0.66, 1.01)
	Female	Ref.	Ref.
Race/ethnicity	Non-white	1.00 (0.76, 1.31)	
	White	Ref.	
Parent education	≤High school	2.31 (1.62, 3.30)	1.55 (1.06, 2.26)
	Some college	1.79 (1.25, 2.57)	1.34 (0.92, 1.96)
	College graduate	1.24 (0.89, 1.72)	1.09 (0.78, 1.54)
	>College graduate	Ref.	Ref.
<i>Proximal socio-environmental level</i>			
Living with smoking parents	Yes	2.41 (1.97, 2.95)	1.94 (1.53, 2.47)
	No	Ref.	Ref.
Living with smoking siblings	Yes	3.06 (2.22, 4.22)	2.34 (1.67, 3.28)
	No	Ref.	Ref.
Smoking allowed at home	Yes	1.81 (1.47, 2.22)	1.15 (0.90, 1.47)
	No	Ref.	Ref.
Having at least one friend who smokes	Yes	2.90 (2.27, 3.69)	2.41 (1.86, 3.10)
	No	Ref.	Ref.
<i>Area (GPU) level</i>			
% white	High (>95.3)	1.19 (0.87, 1.64)	
	Medium (90.1–95.3)	1.06 (0.78, 1.44)	
	Low (<90.1)	Ref.	
% urban population	High (>96.3)	0.84 (0.61, 1.15)	
	Medium (43.7–96.3)	0.86 (0.63, 1.16)	
	Low (<43.7)	Ref.	
% with ≥high school education	High (>90.7)	0.89 (0.66, 1.20)	
	Medium (83.1–90.7)	1.34 (1.05, 1.86)	
	Low (83.1)	Ref.	
% above poverty line	High (>90.7)	1.00 (0.73, 1.37)	
	Medium (80.1–90.7)	1.07 (0.78, 1.47)	
	Low (<80.1)	Ref.	
% employed (age ≥16)	High (>96.8)	0.95 (0.70, 1.31)	
	Medium (94.8–96.8)	0.96 (0.70, 1.32)	
	Low (<94.8)	Ref.	
% household headed by men	High (>93.2)	0.94 (0.69, 1.30)	
	Medium (91.6–93.2)	0.88 (0.64, 1.20)	
	Low (<91.6)	Ref.	

Characteristics		OR (95% CI)	AOR (95% CI)
Median house value	High (>\$132,000)	0.93 (0.68, 1.27)	
	Medium (\$92–132,000)	0.88 (0.65, 1.20)	
	Low (<\$92,000)	Ref.	
Median household income	High (>\$55,000)	0.92 (0.67, 1.27)	
	Medium (\$37–55,000)	0.91 (0.67, 1.24)	
	Low (<\$37,000)	Ref.	
% 15–16 years old smoke	High (>20.8)	1.06 (0.80, 1.40)	
	Medium (12.5–20.8)	1.26 (0.88, 1.80)	
	Low (<12.5)	Ref.	

¹ OR=odds ratio; AOR=adjusted odds ratio; CI=confidence interval; bolded odds ratios are statistically significant (p<.05). The multivariate analysis only included significant characteristics in the bivariate analysis (p<.10).

Table 3Bivariate and multivariate analysis on age smoked more than a whole cigarette in a lifetime.¹

Characteristics		Mean age (95% CI)	Adjusted Mean age (95% CI)
<i>Individual level</i>			
Gender	Male	15.60 (15.42, 15.77)	
	Female	15.70 (15.54, 15.86)	
Race/ethnicity	Non-white	15.34 (15.05, 15.63)	15.31 (14.97, 15.65)
	White	15.72 (15.58, 15.85)	15.51 (15.27, 15.74)
Parent education	≤High school	15.74 (15.51, 15.97)	15.54 (15.22, 15.86)
	Some college	15.61 (15.35, 15.86)	15.37 (15.04, 15.70)
	College graduate	15.79 (15.59, 16.00)	15.47 (15.16, 15.78)
	>College graduate	16.18 (15.84, 16.51)	15.79 (15.41, 16.18)
<i>Proximal level</i>			
Living with smoking parents	Yes	15.36 (15.19, 15.52)	15.27 (14.98, 15.55)
	No	15.94 (15.77, 16.10)	15.55 (15.27, 15.82)
Living with smoking siblings	Yes	15.36 (15.07, 15.64)	15.32 (14.97, 15.66)
	No	15.71 (15.58, 15.84)	15.50 (15.27, 15.72)
Smoking allowed at home	Yes	15.34 (15.16, 15.52)	15.23 (15.00, 15.46)
	No	15.87 (15.71, 16.03)	15.51 (15.29, 15.73)
Having at least one friend who smokes	Yes	15.11 (14.90, 15.31)	15.09 (14.80, 15.38)
	No	15.87 (15.74, 16.00)	15.72 (15.45, 15.99)
<i>Area (GPU) level</i>			
% white	High (>95.3)	15.52 (15.31, 15.73)	
	Medium (90.1–95.3)	15.71 (15.50, 15.91)	
	Low (<90.1)	15.73 (15.51, 15.95)	
% urban population	High (>96.3)	15.76 (15.53, 15.98)	
	Medium (43.7–96.3)	15.67 (15.46, 15.88)	
	Low (<43.7)	15.54 (15.33, 15.75)	
% with ≥high school education	High (>90.7)	15.82 (15.59, 16.04)	
	Medium (83.1–90.7)	15.64 (15.45, 15.83)	
	Low (83.1)	15.50 (15.28, 15.73)	
% above poverty line	High (>90.7)	15.69 (15.47, 15.90)	
	Medium (80.1–90.7)	15.71 (15.50, 15.92)	
	Low (<80.1)	15.55 (15.32, 15.78)	
% employed (age ≥16)	High (>96.8)	15.90 (15.70, 16.10)	
	Medium (94.8–96.8)	15.48 (15.28, 15.69)	
	Low (<94.8)	15.56 (15.36, 15.76)	
% household headed by men	High (>93.2)	15.72 (15.51, 15.94)	
	Medium (91.6–93.2)	15.63 (15.42, 15.85)	
	Low (<91.6)	15.60 (15.38, 15.82)	
Median house value	High (>\$132,000)	15.84 (15.63, 16.06)	
	Medium (\$92–132,000)	15.65 (15.44, 15.86)	

Characteristics		Mean age (95% CI)	Adjusted Mean age (95% CI)
Median household income	Low (<\$92,000)	15.48 (15.27, 15.68)	
	High (>\$55,000)	15.78 (15.56, 15.99)	
	Medium (\$37–55,000)	15.68 (15.48, 15.89)	
% 15–16 years old smoke	Low (<\$37,000)	15.49 (15.28, 15.71)	
	High (>20.8)	15.47 (15.28, 15.66)	
	Medium (12.5–20.8)	15.46 (15.19, 15.72)	
	Low (<12.5)	15.87 (15.70, 16.04)	

¹ Bolded mean ages are statistically significant (p<.05). The multivariate analysis only included significant characteristics in the bivariate analysis (p<.10).