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A comparison of individual versus community influences on youth smoking behaviors: A cross-sectional study

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ABSTRACT

Objectives To compare individual versus community risk factors for adolescent smoking.

Design A cross-sectional observational study.

Setting National telephone survey.

Participants 3646 US adolescents aged 13-18 years in 2007 recruited through a random digit-dial survey; 50% female.

Outcome measures Ever tried smoking and smoking intensity.

Results Approximately one-third (35.6%, N=1297) had tried smoking. Neither tobacco outlet density nor proximity were associated with tried smoking or smoking intensity in adjusted models. In contrast, age (OR = 1.23, 95% CI 1.16, 1.31), lower socioeconomic status (OR = 0.82, 95% CI 0.74, 0.91), sibling smoking (OR=2.13, 95% CI 1.75, 2.59), friend smoking (OR = 2.60, 95% CI 2.19, 3.10 for some and OR = 7.01, 95% CI 5.05,9.74 for most), movie smoking exposure (OR = 2.66, 95% CI 1.95, 3.63), team sports participation (OR = 0.69, 95% CI 0.54, 0.89) and sensation seeking (OR = 7.72, 95% CI 5.26, 11.34) were associated with trying smoking. Among experimental smokers, age (OR = 1.33, 95% CI 1.20, 1.48), minority status (OR = 0.42, 95% CI 0.22, 0.81 for Black; OR = 0.50, 95% CI 0.30, 0.83 for Hispanic), friend smoking (OR = 6.38, 95% CI 3.29,12.39 for some; OR = 32.98, 95% CI 16.43,66.19 for most), team sports participation (OR = 0.46, 95% CI 0.30, 0.72), and sensation seeking (OR = 6.89, 95% CI 3.42, 13.88) were associated with smoking intensity.

Conclusions Public health campaigns to prevent and reduce youth smoking should emphasize individual risk factors for smoking rather than tobacco outlet density and proximity. The finding does not rule out that other community risk factors, such as neighborhood smoking or social capital, may be important.

INTRODUCTION

Preventing adolescent smoking is a key public health imperative. Individual risk factors for youth smoking include exposure to tobacco marketing,[1] exposure to smoking in entertainment media,[2] personality factors such as sensation seeking,[3, 4] and extracurricular activities such as team sports participation.[5] Approaches to preventing youth smoking risk have included interventions to minimize adolescents' responsiveness to these risk factors[6] and policies to minimize adolescent's exposure to them.[7]

In addition to the influence of individual risk factors, community influences, such as access to tobacco outlets, may play a role in youth smoking. For example, frequent exposure to tobacco outlets[8] and tobacco outlet density[9, 10] has been associated with youth smoking. Owing to these community-level influences, Cohen et al. have proposed policies to limit tobacco outlet density to reduce youth smoking.[11]

When jointly considered, which has the greater potential to influence youth smoking – individual or community level factors? The evidence for community influence is still emerging; studies to date have been limited to regions, have not controlled for individual characteristics outside of sociodemographics, and have applied varying approaches to density measurement.[10, 12-14] In addition, community influences, such as tobacco outlet density and proximity, could be confounded by social influences like sibling and friend smoking.

Another area to consider in the context of tobacco outlet density and proximity is their association with neighborhood characteristics that may also pose risk. Here the evidence is mixed, but with many studies showing an association between tobacco outlet density and neighborhoods characterized by high percentages of minorities[10, 13, 15-18] and low income,[10, 13, 16-18] although one study found a surprising relationship between tobacco outlet density and higher median income in adults.[15] Paul et al. found that tobacco outlet proximity was not associated with socioeconomic status in adults,[19] whereas West et al. found that proximity was associated with neighborhood poverty in youth.[14] Thus, the finding that tobacco outlet density is related to youth smoking could also be confounded by other community factors.

This study examines the role of access to tobacco outlets compared to individual risk factors on youth smoking. It is the first to consider the role of community-level factors on adolescent smoking nationwide, the first to jointly examine individual risk factors with community-level factors, and the first to examine these factors in the context of individual and community measures of race and ethnicity. The intent of this work is to inform policies related to tobacco control efforts directed at youth.

METHODS

Theoretical Framework

This study is guided by Bronfenbrenner's Ecological Systems Theory,[20-22] which posits that development, health and well-being are situated within and shaped by the interactions that occur between the individual and the four systems: microsystem (immediate environment),

mesosystem (connections between immediate environments, e.g., tobacco outlet density and proximity), exosystem (indirect external environmental settings), and macrosystem (larger cultural context).[20-22] This theory suggests that empirical approaches to studying risk of tobacco behavior should include individual and community-level variables. The individual-level variables included in this study are all well-established risk factors for smoking: gender, race/ethnicity, socioeconomic status, friend smoking, sibling smoking, exposure to smoking in movies, team sports participation, and the personality characteristic of sensation seeking. The community-level variables include tobacco outlet density, distance to closest tobacco outlet, proportion population Black, proportion population Hispanic, and proportion of families with income below the poverty level.

Sample Recruitment

A detailed description of the recruitment methods for study participants has been published previously.[23] Briefly, between June and October 2003, 6522 U.S. adolescents aged 10-14 years were recruited through a random digit-dial telephone survey, which captured a representative sample of U.S. adolescents. Five follow-up surveys were conducted at 8-month intervals. This study involves the fifth follow-up survey conducted in the fall of 2007. Interviewers successfully contacted 3055 (47%) of the original 6522 adolescents for this round. Loss to follow up was higher among Blacks, older adolescents, those of lower socioeconomic status, baseline smokers and higher sensation seekers. To address the minority attrition, a sample of 598 Black adolescents (in the same age range) were recruited through lists of residential numbers for U.S. census tracts for which African-Americans represented 20% or more of the population, resulting in available sample of 3653 for this study. Parental consent and adolescent

assent were required for participation. The study was approved by the Committee for the Protection of Human Subjects at Dartmouth Medical School. The 3653 subjects lived in 3456 unique census tracts, of which the majority (95.5%) contained only 1 subject; 144 tracts (4.2%) contained two subjects, and 11 tracts (0.3%) contained three subjects. When possible, the adolescent's location was geocoded to their home street address (N=3167) or to their ZIP code centroid (N=479), resulting in a final sample size of N=3646 for this study.

Outcome Variables

Ever tried smoking: Respondents were asked, "Have you ever tried smoking a cigarette, even just a puff? (Yes, No)" which was used to employ branching logic – respondents who answered yes were categorized as ever smokers and then asked about smoking intensity.

Smoking intensity: Among ever smokers, assessment of smoking intensity was based on a composite measure using three items that assessed past 30-day smoking (alpha = 0.87): "During the past 30 days, on how many days did you smoke cigarettes?" (none, 1-10 days, 11-29 days, or every day); "During the past 30 days, on the weekdays that you smoked, how many cigarettes did you usually smoke per day?" (1 to 5, 6 to 10, 11 to 20, more than 20); "During the past 30 days, on the weekends that you smoked, how many cigarettes did you usually smoke per day?" (1 to 5, 6 to 10, 11 to 20, more than 20).

Individual risk factors

Sociodemographics: Individual measures of age, race and ethnicity were included. Socioeconomic status was assessed using a standardized composite measure based on parent reports of their own education and household income (alpha = 0.69).

Sibling smoking: Sibling smoking was assessed with the question, "Do any of your older brothers or sisters smoke cigarettes?"

Friend smoking: Friend smoking was assessed with the question, "How many of your friends smoke cigarettes? Your choices are none, some, or most."

Exposure to movie smoking: Adolescents' exposure to movie smoking was estimated using the Beach method[24] for top U.S. box-office hits from 2000-2006 (n = 384). Movies were content-coded for smoking using previously validated methods.[24] Each adolescent survey was programmed to randomly select 50 movie titles from the larger pool of 384 movies; respondents were asked whether they had ever seen each movie title. To create a measure of exposure to movie smoking, the number of smoking occurrences in films each adolescent had seen from his/her unique list of 50 movies were summed. A proportion was generated by dividing this number by the number of smoking occurrences that the adolescent would have seen had all 50 movies in the unique list been viewed and this proportion was multiplied by the number of smoking occurrences in the entire parent sample of 384 movies.

Team sports participation: Team sports participation was assessed with a single item, "Now I'd like you to think about all the sports teams you played on during the past 12 months, including

all school, community or recreational teams. How many sports teams did you play on in the past 12 months?" The answer was a continuous measure, based on the adolescent's response.

Sensation seeking: Sensation seeking propensity was assessed using a short 5-item measure: "I would like to explore strange places," "I like to do frightening things," "I like new and exciting experiences, even if I have to break the rules," "I like to listen to loud music," "I like to do dangerous things." Each of these items had the following response categories for each statement: Strongly Agree, Disagree, Agree, Strongly Agree. These items had a Cronbach's alpha (α) of 0.70.

Community influences

Tobacco outlets: To obtain a national dataset for tobacco outlets, we reviewed North American Industry Classification System (NAICS) codes and selected establishments that were likely to sell tobacco products. The Office of Management and Budget (OMB) developed NAICS for use by Federal statistical agencies in classifying all business establishments based on their primary activity. We selected the 306,695 establishments coded as tobacco stores, grocery stores, gas stations, and convenience stores and obtained geocoded data from the NAICS Association. Although some businesses classified as department stores, liquor stores, and pharmacies may sell tobacco as well (e.g. Wal-Mart, Costco, CVS), they were not classified as tobacco outlets because they also include many stores that do not sell tobacco (e.g. Sears, Dollar Stores, hospital pharmacies), and the NAICS categories do not allow differentiation between sub-classes of stores that do or do not sell tobacco.

Tobacco outlet density using adaptive bandwidth kernel density estimation: A nationwide density surface of the tobacco outlets using adaptive bandwidth kernel density estimation (KDE)[25, 26] and the LandScan™ Global Population Database[27] was produced. Adaptive bandwidth KDE accounts for the underlying population density by limiting the bandwidth of each tobacco outlet to the surrounding population of 1000 people. Setting a limit constrains the influence of a single outlet to a small spatial extent where the population density is high (urban areas) while in rural areas the reach of the tobacco outlet is geographically larger. For sparsely populated regions, the bandwidth of each tobacco outlet was limited to a 25 km radius to prevent the density calculation from expanding to a spatially unreliable distance. The resultant density surface covers the continental U.S. with pixels that are ~0.5 miles on each side and have a density value in units of tobacco outlets per 1000 people. Each adolescent was assigned the density value based on the pixel at their geocoded location.

Distance to closest tobacco outlet: ArcGIS Network Analyst (ESRI, Redlands, CA) was used to compute the distance along the road network from the adolescent's geocoded location to the closest tobacco outlet. Street data was obtained from the 2008 edition of StreetMap North America,[28] which was created in 2005 and based on the ground conditions in 2003. Other methods of measuring proximity were also considered, including Euclidian distance and driving time. A sensitivity analysis demonstrated no difference between methods in the final model (data not shown).

Census tract measures of race/ethnicity and poverty: Community characteristics that might be confounders for tobacco outlet density and proximity were included. Using the U.S. Census 2000 data, the proportion population Black, the proportion population Hispanic, and the proportion of families with income below the poverty level for each adolescent's census tract were calculated.

Statistical analysis

Pearson correlation coefficients were used to describe the association among community influences. Multiple logistic regression was used to assess the association between individual and environmental risk factors and ever tried smoking, and multiple ordered logistic regression was used to assess the odds of being higher on the frequency of smoking scale among smokers. Because the majority of the sample resided in unique census tracts, it was not necessary to fit hierarchical models. Instead, the environmental variables were entered as individual-level risk indicators of the adolescent's environment. Some variables (movie smoking exposure, tobacco outlet density, distance to the closest outlet, proportion population Black, proportion population Hispanic, and proportion families with incomes below the poverty level) were skewed right. In order to limit the influence of high outliers, values higher than the 95th percentile were trimmed to the 95th percentile. Additionally, to allow a comparison of effect size among the variables, friend smoking, movie smoking exposure, tobacco outlet density, proportion of families with incomes below the poverty level, and sensation seeking were rescaled so that the lowest value was 0 and the highest value was 1. This scaling procedure allowed a comparison between the dose-response between individual/community measures and adolescent smoking. Ninety-five percent confidence intervals were assessed based on two-tailed hypothesis assumptions.

RESULTS

Individual and community characteristics: Table 1 describes the characteristics of the adolescents and their correlation with the two smoking outcomes. Thirty-six percent had tried smoking, and this percentage increased across age categories from 18 to 56 percent in 13 and 18 year olds respectively. Among smokers, mean smoking intensity also increased with age. There were no large differences in tried smoking prevalence across gender or race, but smoking intensity was much lower among Black and Hispanic smokers compared with Whites and those of mixed race. The correlation between community variables and smoking was an order of magnitude lower than correlations with individual characteristics. Whereas tobacco outlet density was positively correlated with smoking onset, it was negatively correlated with smoking intensity. The largest correlation for community predictors was -0.13, between proportion population Black and smoking intensity, also consistent with lower smoking intensity among minorities at the individual level.

Table 1. Individual and community risk factors and smoking outcomes (N=3646).

Variable	n	Proportion of Sample	Tried Smoking (mean)	Smoking Intensity (mean)
Individual descriptors				
Categorical				
Age				
13	114	0.03	0.18	0.30
14	722	0.20	0.24	0.23
15	827	0.23	0.29	0.34
16	804	0.22	0.37	0.39
17	769	0.21	0.43	0.51
18	410	0.11	0.56	0.81
Gender				
Male	1,810	0.50	0.38	0.49
Female	1,836	0.50	0.34	0.43
Race/ethnicity				
White	2,091	0.57	0.36	0.59
Black	818	0.22	0.32	0.20
Hispanic	481	0.13	0.41	0.29
Mixed race/other	256	0.07	0.38	0.57
Sibling smokes				
No	2,924	0.80	0.31	0.43
Yes	720	0.20	0.56	0.55
Friend smoking				
None	1,615	0.44	0.17	0.05
Some	1,711	0.47	0.45	0.35
Most	316	0.09	0.78	1.29
Ever smoked				
No	2,349	0.64		
Yes	1,297	0.36		
	Median	Interquartile Range	(correlation)	(correlation)
Continuous				
Smoking Intensity (among smokers)	0	0,1		
Socioeconomic status	0.08	-0.65,0.65	-0.12	-0.03
Friend Smoking	2	1,2	0.21	0.45
Movie smoking exposure	558	285,883	0.21	0.04
Team sports participation	1	0,2	-0.08	-0.14
Sensation seeking	12	10,14	0.31	0.25
Community descriptors				
Tobacco outlet density (per 1000 people)	0.34	0.03,1.12	0.03	-0.05

Distance (mi) to nearest outlet	0.59	0.29,1.19	0.001	0.03
Proportion population Black	0.03	0.01,0.21	-0.03	-0.13
Proportion population Hispanic	0.03	0.01,0.09	0.02	-0.08
Poverty[a]	0.06	0.03,0.11	0.02	-0.07

[a]Proportion of families with income below the poverty level

The community characteristics were also correlated with each other. Higher tobacco outlet density was associated with larger proportions of families with incomes below the poverty level, proportion of the population that was Black and Hispanic (Table 2). Tobacco outlet density decreased as distance to nearest outlet increased (correlation = -0.32), but the relationship was not linear. There was a wide range for distance to closest outlet among adolescents living in low tobacco outlet density areas, and a wide range of densities among adolescents living close to an outlet, justifying the consideration of both factors as being independently associated with smoking behavior.

Table 2. Correlation among the environmental descriptors.

	Correlation				
Environmental descriptor	1	2	3	4	5
1 Tobacco outlet density (per 1000 people)	1.00				
2 Distance (mi) to nearest outlet	-0.32	1.00			
3 Proportion population Black	0.27	-0.17	1.00		
4 Proportion population Hispanic	0.26	-0.13	-0.10	1.00	
5 Poverty[a]	0.39	-0.12	0.52	0.38	1.00

[a]Proportion of families with income below the poverty level

Relation with ever tried smoking: Being male, being Hispanic, having sibling(s) who smoke, being of lower socioeconomic status, having friends who smoke, being older, having more exposure to movie smoking, not playing team sports, being higher in sensation seeking, and living in a neighborhood with higher tobacco outlet density were all significantly associated with ever trying smoking in the unadjusted models (Table 3). Two types of multivariate models were built to test these associations with ever trying smoking. In the first, only community-level factors were included; it showed a significant inverse association with proportion of the population that was Black and a significant association with census tract poverty. In the second

multivariate model, individual characteristics were added, which substantially improved model fit. Whereas most individual characteristics (sibling smoking, socioeconomic status, friend smoking, age, movie smoking exposure, team sports participation, and sensation seeking) were significantly associated with ever trying smoking in the second model, none of the community characteristics were significantly associated with ever trying smoking. Notably, the coefficient for tobacco outlet density changed little across models and, although small, remained close to statistical significance, in contrast to the other community predictors.

Table 3. Crude and multivariate association with ever tried smoking.

		Community only[a] n = 3,621		All variables[b] n = 3,543	
Variable	Crude Odds Ratio	Adj Odds Ratio	95% CI	Adj Odds Ratio	95% CI
Individual characteristics					
Categorical					
Gender					
Male	Ref				
Female	0.84*			1.03	0.88,1.21
Race/ethnicity					
White	Ref				
Black	0.85			0.85	0.62,1.18
Hispanic	1.24*			1.18	0.88,1.59
Mixed race/other	1.13			1.08	0.77,1.50
Sibling smokes					
No	Ref				
Yes	2.85*			2.13*	1.75,2.59
Friend smoking					
None	Ref				
Some	3.93*			2.60*	2.19,3.10
Most	17.14*			7.01*	5.05,9.74
Continuous					
Age (for each additional year)	1.39*			1.23*	1.16,1.31
Socioeconomic status	0.76*			0.82*	0.74,0.91
Movie smoking exposure	5.14*			2.66*	1.95,3.63
Team sports participation	0.59*			0.69*	0.54,0.89
Sensation seeking	20.71*			7.72*	5.26,11.34
Community characteristics					
Tobacco outlet density (per 1000 people)	1.30*	1.28	0.97,1.70	1.27	0.92,1.76
Tobacco outlet proximity (distance in miles to nearest outlet)	0.86	0.94	0.69,1.27	0.96	0.67,1.36
Proportion population Black	0.80	0.59*	0.42,0.83	0.93	0.53,1.61
Proportion population Hispanic	1.47	0.87	0.49,1.55	0.88	0.41,1.87
Poverty[c]	2.06	3.66*	1.07,12.42	0.74	0.17,3.22

*p<0.05

[a]Pseudo R^2 = 0.003

[b]Pseudo R^2 = 0.20

[c]Proportion of families with income below the poverty level

Relation with smoking intensity: Similar multivariate models were built for smoking intensity among the experimental smokers (Table 4). Minority status, sibling smoking friend smoking, age, team sports participation, sensation seeking, proportion population Black and Hispanic, and poverty, were all associated with smoking intensity at the bivariate level. In the community-only multivariate model, proportion population Black and Hispanic retained a significant inverse relation with smoking intensity. In the full model, friend smoking, age, and sensation seeking were all associated with higher intensity and being Black or Hispanic and participating in team sports associated with lower intensity. None of the community characteristics retained a statistically significant association with smoking intensity.

Table 4. Crude and multivariate association with smoking intensity among experimental smokers.

		Community only[a] n = 1,289		All variables[b] n = 1,263	
Variable	Crude Odds Ratio	Adj Odds Ratio	95% CI	Adj Odds Ratio	95% CI
Individual characteristics					
Categorical					
Gender					
Male	Ref				
Female	0.89			0.99	0.75,1.30
Race/ethnicity					
White	Ref				
Black	0.29*			0.42*	0.22,0.81
Hispanic	0.47*			0.50*	0.30,0.83
Mixed race/other	0.85			0.85	0.50,1.42
Sibling smokes					
No	Ref				
Yes	1.33*			1.08	0.81,1.45
Friend smoking					
None	Ref				
Some	9.11*			6.38*	3.29,12.39
Most	57.89*			32.98*	16.43,66.19
Continuous					
Age (for each additional year)	1.37*			1.33*	1.20,1.48
Socioeconomic status	0.98			0.98	0.82,1.17
Movie smoking exposure	1.14			0.81	0.49,1.34
Team sports participation	0.35*			0.46*	0.30,0.72
Sensation seeking	14.55*			6.89*	3.42,13.88
Community characteristics					
Tobacco outlet density (per 1000 people)	0.69	1.03	0.62,1.71	1.15	0.66,2.03
Tobacco outlet proximity (distance in miles to nearest outlet)	1.27	0.83	0.49,1.40	0.82	0.46,1.46
Proportion population Black	0.23*	0.18*	0.09,0.37	0.97	0.33,2.84
Proportion population Hispanic	0.24*	0.16*	0.05,0.45	0.35	0.09,1.42
Poverty[c]	0.06*	2.31	0.25,21.15	0.78	0.05,11.43

*p<0.05

[a]Pseudo R^2 = 0.01

[b]Pseudo R^2 = 0.14

[c]Proportion of families with income below the poverty level

DISCUSSION

This study highlights the much stronger association between individual health risk factors and youth smoking behavior compared to community risk factors, with an emphasis on tobacco outlets. The two studies that have examined this to date have suggested that tobacco outlet density (but not proximity) is associated with youth smoking.[10, 12] This study confirms the finding of no relation between tobacco outlet proximity and youth smoking. Also consistent with the two other studies, in the unadjusted model, we saw an association between tobacco outlet density and youth smoking. However, unlike those studies, we also accounted for other individual risk factors for youth smoking. After accounting for these other individual risk factors, the relation with tobacco outlet density was no longer statistically significant. More importantly, community estimates for effect size were small compared to individual risk factors. Thus, regardless of whether the association of tobacco outlet density reached accepted standards for statistical significance, the small effect across a broad range of tobacco outlet densities suggests that policies designed to lower density would have only a small impact on youth smoking onset. In contrast, the association with movie smoking is large enough to suggest that policies aiming to reduce movie exposure could impact youth smoking onset.

Smoking onset is a different behavior with different risk factors compared to progression to higher levels of intensity. Smoking onset tends to be influenced by social risk factors (sibling smoking, friend smoking, movie smoking). Smoking progression continues to be associated with smoking by peers and exposure to tobacco marketing,[29, 30] but is also is predominantly driven by addiction processes[31, 32]. In this study, sensation seeking was a risk factor for both

smoking onset and smoking progression, which is consistent with other research.[33] Sensation seeking level probably captures, in part, biological characteristics that promote experience seeking[34] and tolerance of deviance,[35] but it may also be associated with higher sensitivity to the addictive influence of nicotine.[36] Given its large association with both smoking outcomes in this study, research suggesting that identifying sensation seeking can be used to either target high risk adolescents,[37] or even that sensation seeking characteristics could be raised or lowered by environmental circumstances,[38] deserve greater emphasis.

Consistent with other studies that have distinguished between smoking onset and progression,[39] some characteristics were associated with one outcome but not the other. Exposure to smoking in movies was associated with smoking onset but not smoking intensity, consistent with some other reports.[29, 30] Minority youth tried smoking at rates similar to White youth, but minority ever smokers had much lower smoking intensity than Whites. This finding is not surprising, given that minority adolescents have lower rates of smoking compared with Whites,[40, 41] with larger temporal declines in smoking among Black adolescents[42] and lower rates of progression to regular use.[43] Studies of smoking onset have been inconsistent, with some confirming lower rates among minorities,[44]whereas others,[45] including this one, did not. Why minority youth that try smoking have lower smoking intensity than Whites deserves further research, given that the finding holds across studies;[40, 43] minority adolescents could be less susceptible to nicotine addiction in its earliest stages.

This study was limited in that it relied on cross-sectional data and therefore cannot address temporality. However, it would be an unusual to see a correlation that is weak in a cross-

sectional study to become a key predictor in a longitudinal one. The national scope of the study could be viewed as a strength, but it precluded us from directly measuring tobacco outlet density. Instead, we relied on available data, which is subject to higher levels of error than direct measurement. Although this limitation could have widened confidence intervals due to random error, we have no reason to believe that the error is larger in some neighborhoods than others, which would lead to biased estimates. We suggest that, even if the results were statistically significant, the estimates were still small for tobacco outlet density.

We would like to mention a few other limitations. We assessed only a small subset of community characteristics. This study does not rule out the possibility that other neighborhood characteristics, such as measures of social capital or neighborhood smoking, may have an important impact on youth smoking. In fact, one study using the Brofenbrenner model found that neighborhood rates of youth smoking affected adolescent smoking trajectories, over and above individual risk factors.[46] Our study did not explicitly measure exposure to tobacco storefront advertising in the context of community-level influences and therefore cannot address this issue explicitly. Tobacco outlet density should be a proxy for exposure to storefront advertising but would not capture individual differences in how adolescents respond to or remember it, which could explain differences between our findings and those of others who directly measured recollection of storefront advertising at the individual level.[47] Our study also could not determine whether some types of team sports confer more protection from established smoking than others, because it did not elaborate on the nature of the sport played. We did not examine peer influences, for which many approaches are possible,[48] in detail. Finally, we assessed tobacco density and proximity at the home, not the school. Future studies should consider the

role of school density and proximity to tobacco outlets around schools in context of individual risk factors.

This study adds to the growing body of evidence that public health campaigns to prevent and reduce youth smoking should emphasize individual risk factors for smoking, including supporting participation in team sports, minimizing exposure to movie smoking, addressing the social influence of friend smoking, and addressing experience seeking among high sensation-seekers. In terms of policy implications, this study supports the need for explicit policies to minimize youth exposure to movie smoking such as the recommendation to eliminate smoking from youth-rated movies, and to rate movies R if they contain smoking.[49] Without policies in place to minimize youth smoking exposure to movie content, parents should be strongly encouraged to make an effort to minimize their child's exposure to smoking in movies by using online tools such as www.commonsensemedia.org which offer information about movie smoking content in individual movies.

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

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Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
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Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
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Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
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Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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A comparison of individual versus community influences on youth smoking behaviors: A cross-sectional observational study

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A comparison of individual versus community influences on youth smoking behaviors: A cross-sectional observational study

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ABSTRACT

Objectives To compare individual with community risk factors for adolescent smoking.

Design A cross-sectional observational study with multivariate analysis.

Setting National telephone survey.

Participants 3646 US adolescents aged 13-18 years in 2007 recruited through a random digit-dial survey.

Outcome measures Ever tried smoking and, among experimental smokers, smoking intensity (based on smoking in past 30 days).

Results One-third of participants (35.6%, N=1297) had tried smoking. After controlling for individual risk factors, neither tobacco outlet density nor proximity were associated with tried smoking or smoking intensity. Associations with trying smoking included age (Adjusted Odds Ratio [AOR] = 1.23, 95% CI 1.16, 1.31), lower socioeconomic status (AOR = 0.82, 95% CI 0.74, 0.91), sibling smoking (AOR=2.13, 95% CI 1.75, 2.59), friend smoking (AOR = 2.60, 95% CI 2.19, 3.10 for some and AOR = 7.01, 95% CI 5.05,9.74 for most), movie smoking exposure (AOR = 2.66, 95% CI 1.95, 3.63), team sports participation (AOR = 0.69, 95% CI 0.54, 0.89) and sensation seeking (AOR = 7.72, 95% CI 5.26, 11.34). Among experimental smokers, age (AOR = 1.33, 95% CI 1.20, 1.48), minority status (AOR = 0.42, 95% CI 0.22, 0.81 for Black; AOR = 0.50, 95% CI 0.30, 0.83 for Hispanic), friend smoking (AOR = 6.38, 95% CI 3.29,12.39 for some; AOR = 32.98, 95% CI 16.43,66.19 for most), team sports participation (AOR = 0.46, 95% CI 0.30, 0.72), and sensation seeking (AOR = 6.89, 95% CI 3.42, 13.88) were associated with smoking intensity.

Conclusions The study suggests that interventions and policies to prevent and reduce youth smoking should focus on individual risk factors for smoking, including supporting participation

in team sports, minimizing exposure to movie smoking, addressing the social influence of friend smoking, and addressing experience seeking among high sensation-seekers.

INTRODUCTION

Preventing adolescent smoking is a key public health imperative. Individual risk factors for youth smoking have been studied for decades. They include personality factors such as sensation seeking,(1, 2) and other social influences like parent(3-6) and friend(7, 8) smoking. They also include exposure to tobacco marketing(9) and smoking in entertainment media(10), which were both considered causal risk factors in a recent (2012) Surgeon General's report on smoking in adolescents and young adults.(11) Research has shown that extracurricular activities, such as team sports participation, are associated with preventing youth smoking.(12-16) Knowledge about these risk factors has informed interventions aiming to minimize adolescents' responsiveness to social risk factors(17) and policies to minimize adolescent's exposure to tobacco marketing and movies.(18)

In addition to individual risk factors, community influences such as frequent exposure to tobacco outlets(19) and tobacco outlet density,(20, 21) have been associated with youth smoking. Compared to the compelling research on individual risk factors, evidence for community influence is mixed. Studies to date have been regional, have not extensively controlled for individual characteristics, and have applied varying approaches to density measurement.(21-24) To our knowledge, studies have not yet tested whether the association between tobacco outlet density and proximity is confounded by race or social influences like sibling and friend smoking. One study that controlled for individual sociodemographics failed to find an association between tobacco outlet density and youth smoking.(25)

Another area to consider in the context of tobacco outlet density and proximity is their association with neighborhood characteristics, such as poverty, that may also pose a community risk factor for smoking. Many studies show an association between tobacco outlet density and neighborhoods characterized by high percentages of minorities(21, 23, 26-29) and low income,(21, 23, 27-29) although this finding has not been consistent across regions.(26) Thus, the finding that tobacco outlet density is related to youth smoking could also be confounded by community factors. Nevertheless, the literature was robust enough for Cohen et al. to propose policies to limit tobacco outlet density to reduce youth smoking,(30) raising the question of whether individual or community-level factors have greater potential to prevent youth smoking.

This study examines the role of access to tobacco outlets on youth smoking in a national sample of U.S. adolescents. By access, we mean approaching, entering, exiting, and having exposure to information imparted to potential customers about tobacco products, including visibility of in-store and storefront advertising. Our focus is twofold—to assess the multivariate association with youth smoking after controlling for other individual and community risk factors, and to compare the sizes of these associations. It is the first to consider the role of community-level factors on adolescent smoking in the U.S. nationwide, and the first to jointly examine individual social and media influence risk factors with community-level factors. The intent of this work is to inform interventional research and policies related to tobacco control efforts directed at youth.

METHODS

Theoretical Framework

This study is guided by Bronfenbrenner's Ecological Systems Theory,(31-33) which posits that development, health and well-being are situated within and shaped by the interactions that occur between the individual and the four systems: microsystem (immediate environment), mesosystem (connections between immediate environments, e.g., tobacco outlet density and proximity), exosystem (indirect external environmental settings), and macrosystem (larger cultural context).(31-33) For this study, we include individual-level variables that are well-established risk factors for smoking: gender, race/ethnicity, socioeconomic status, and the personality characteristic of sensation seeking. We also include the microsystem variables of friend smoking, sibling smoking, exposure to smoking in movies, and team sports participation. Our mesosystem variables include tobacco outlet density and distance to closest tobacco outlet. Our exosystem variables include proportion population Black, proportion population Hispanic, and proportion of families with income below the poverty level.

Sample Recruitment

A detailed description of the recruitment methods for study participants has been published previously.(34) Briefly, between June and October 2003, 6522 U.S. adolescents aged 10-14 years were recruited through a random digit-dial telephone survey, which captured a representative sample of U.S. adolescents. Five follow-up surveys were conducted at 8-month intervals. This study involves the fifth follow-up survey conducted in the fall of 2007. Interviewers successfully contacted 3055 (47%) of the original 6522 adolescents for this round. Loss to follow up was higher among Blacks, older adolescents, those of lower socioeconomic status, baseline smokers and higher sensation seekers. To address the minority attrition, a sample of 598 Black adolescents (in the same age range) were recruited through lists of residential

numbers for U.S. census tracts for which African-Americans represented 20% or more of the population, resulting in available sample of 3653 for this study. Parental consent and adolescent assent were required for participation. The study was approved by the Committee for the Protection of Human Subjects at Dartmouth Medical School. The 3653 subjects lived in 3456 unique census tracts, of which the majority (95.5%) contained only 1 subject; 144 tracts (4.2%) contained two subjects, and 11 tracts (0.3%) contained three subjects. Most adolescent residential locations were geocoded to their home street address (N=3167). When home street address was not available, they were geocoded to their ZIP code centroid (N=479), resulting in a final sample size of N=3646 for this study. We used a complete case analysis approach because only 110 subjects (3%) were missing data from one or more variables. The dependent and independent variables include dichotomous, polychotomous and continuous variables. Three variables (smoking intensity, socioeconomic status, and sensation seeking) are scales derived from two or more items, constructed using the "alpha, gen(varlist)" command in Stata 12. The sections below describe how we ascertained the information, constructed the variables, handled outliers, and rescaled the variables in order to compare the associations in our analytical models.

Outcome Variables

Ever tried smoking: Respondents were asked, "How many cigarettes have you smoked in your life" and those who responded "none" were categorized as ever smokers. Those who responded in a category that indicated lifetime smoking were then asked about past 30 day smoking intensity.

Smoking intensity: Smoking intensity was based on a composite measure using three items (alpha = 0.87): "During the past 30 days, on how many days did you smoke cigarettes?" (none, 1-10 days, 11-29 days, or every day); "During the past 30 days, on the weekdays that you smoked, how many cigarettes did you usually smoke per day?" (1 to 5, 6 to 10, 11 to 20, more than 20); "During the past 30 days, on the weekends that you smoked, how many cigarettes did you usually smoke per day?" (1 to 5, 6 to 10, 11 to 20, more than 20).

Individual risk factors

Sociodemographics: Individual measures of age, race and ethnicity were included. Socioeconomic status (SES) was assessed using a standardized composite measure based on parent reports of their own education and household income (alpha = 0.69). The variable was centered around zero and a 1-point increase corresponded to a 1 standard deviation increase in SES.

Sibling smoking: Sibling smoking was assessed with the question, "Do any of your older brothers or sisters smoke cigarettes? (Yes, No)"

Friend smoking: Friend smoking was assessed with the question, "How many of your friends smoke cigarettes? Your choices are none, some, or most."

Exposure to movie smoking: Adolescents' exposure to movie smoking was estimated using the Beach method(35) for top U.S. box-office hits from 2000-2006 (n = 384). Movies were content-

coded for smoking using previously validated methods.(35) Each adolescent survey was programmed to randomly select 50 movie titles from the larger pool of 384 movies; respondents were asked whether they had ever seen each movie title. To create a measure of exposure to movie smoking, the number of smoking occurrences in films each adolescent had seen from his/her unique list of 50 movies were summed. A proportion was generated by dividing this number by the number of smoking occurrences that the adolescent would have seen had all 50 movies in the unique list been viewed and this proportion was multiplied by the number of smoking occurrences in the entire parent sample of 384 movies.

Team sports participation: Team sports participation was assessed with a single item, "Now I'd like you to think about all the sports teams you played on during the past 12 months, including all school, community or recreational teams. How many sports teams did you play on in the past 12 months?" Team sports participation was skewed right, with responses ranging up to 12, with 4 at the 95th percentile.

Sensation seeking: Sensation seeking propensity was assessed using a short 5-item measure: "I would like to explore strange places," "I like to do frightening things," "I like new and exciting experiences, even if I have to break the rules," "I like to listen to loud music," "I like to do dangerous things." Each of these items had the following response categories for each statement: Strongly Agree, Disagree, Agree, Strongly Agree. These items had a Cronbach's alpha (α) of 0.70. The sensation seeking scale ranged from 0 to 15 with 12 at the 95th percentile.

Community influences

Tobacco outlets: To obtain a national dataset for tobacco outlets, we reviewed North American Industry Classification System (NAICS) codes and selected establishments that were likely to sell tobacco products. The Office of Management and Budget (OMB) developed NAICS for use by Federal statistical agencies in classifying all business establishments based on their primary activity. We selected the 306,695 establishments coded as tobacco stores, grocery stores, gas stations, and convenience stores and obtained geocoded data from the NAICS Association. Although some businesses classified as department stores, liquor stores, and pharmacies may sell tobacco as well (e.g. Wal-Mart, Costco, CVS), they were not classified as tobacco outlets because they also include many stores that do not sell tobacco (e.g. Sears, Dollar Stores, hospital pharmacies), and the NAICS categories do not allow differentiation between sub-classes of stores that do or do not sell tobacco.

Tobacco outlet density using adaptive bandwidth kernel density estimation: A nationwide density surface of the tobacco outlets using adaptive bandwidth kernel density estimation (KDE)(36, 37) and the LandScan™ Global Population Database(38) was produced. Adaptive bandwidth KDE accounts for the underlying population density by limiting the bandwidth of each tobacco outlet to the surrounding population of 1000 people. Setting a limit constrains the influence of a single outlet to a small spatial extent where the population density is high (urban areas) while in rural areas the reach of the tobacco outlet is geographically larger. For sparsely populated regions, the bandwidth of each tobacco outlet was limited to a 25 km radius to prevent the density calculation from expanding to a spatially unreliable distance. The resultant density surface covers the continental U.S. with pixels that are ~0.5 miles on each side and have a

density value in units of tobacco outlets per 1000 people. Each adolescent was assigned the density value based on the pixel at their geocoded location.

Distance to closest tobacco outlet: ArcGIS Network Analyst (ESRI, Redlands, CA) was used to compute the distance along the road network from the adolescent's geocoded location to the closest tobacco outlet. Street data was obtained from the 2008 edition of StreetMap North America,(39) which was created in 2005 and based on the ground conditions in 2003. Other methods of measuring proximity were also considered, including Euclidian distance and driving time. A sensitivity analysis demonstrated no difference between methods in the final model (data not shown).

Census tract measures of race/ethnicity and poverty: Community characteristics that might be confounders for tobacco outlet density and proximity were included. Using the U.S. Census 2000 data, the proportion population Black, the proportion population Hispanic, and the proportion of families with income below the poverty level for each adolescent's census tract were calculated.

Statistical analysis

Pearson correlation coefficients were used to describe the association among community influences. Multiple logistic regression was used to assess the association between individual and environmental risk factors and ever tried smoking, and multiple ordered logistic regression was used to assess the odds of being higher on the frequency of smoking scale among smokers. Because the majority of the sample resided in unique census tracts, it was not necessary to fit hierarchical models. Instead, the environmental variables were entered as individual-level risk

indicators of the adolescent's environment. Some variables (movie smoking exposure, sensation seeking, team sports participation, tobacco outlet density, distance to the closest outlet, proportion population Black, proportion population Hispanic, and proportion families with incomes below the poverty level) were skewed right. In order to limit the influence of high outliers, values higher than the 95th percentile were trimmed to the 95th percentile. Additionally, to allow a comparison of effect size among the variables, friend smoking, movie smoking exposure, tobacco outlet density, proportion of families with incomes below the poverty level, sensation seeking, and team sports participation were rescaled so that the lowest value was 0 and the highest value was 1. This scaling procedure allowed a comparison between the dose-response between individual/community measures and adolescent smoking. Ninety-five percent confidence intervals were assessed based on two-tailed hypothesis assumptions.

RESULTS

Individual and community characteristics: Table 1 describes the characteristics of the adolescents and their correlation with the two smoking outcomes. Thirty-six percent had tried smoking, and this percentage increased across age categories from 18 to 56 percent in 13 and 18 year olds respectively. Among smokers, mean smoking intensity also increased with age. There were no large differences in tried smoking prevalence across gender or race, but smoking intensity was much lower among Black and Hispanic smokers compared with Whites and those of mixed race. The correlation between community variables and smoking was an order of magnitude lower than correlations with individual characteristics. Whereas tobacco outlet density was positively correlated with trying smoking, it was negatively correlated with smoking

intensity. The largest correlation for community predictors was -0.13, between proportion population Black and smoking intensity, also consistent with lower smoking intensity among minorities at the individual level.

Table 1. Individual and community risk factors and smoking outcomes (N=3646).

Variable	n	Proportion of Sample	Proportion Who Have Tried Smoking	Smoking Intensity Scale Mean
Individual descriptors				
Categorical				
Age				
13	114	0.03	0.18	0.30
14	722	0.20	0.24	0.23
15	827	0.23	0.29	0.34
16	804	0.22	0.37	0.39
17	769	0.21	0.43	0.51
18	410	0.11	0.56	0.81
Gender				
Male	1,810	0.50	0.38	0.49
Female	1,836	0.50	0.34	0.43
Race/ethnicity				
White	2,091	0.57	0.36	0.59
Black	818	0.22	0.32	0.20
Hispanic	481	0.13	0.41	0.29
Mixed race/other	256	0.07	0.38	0.57
Sibling smokes				
No	2,924	0.80	0.31	0.43
Yes	720	0.20	0.56	0.55
Friend smoking				
None	1,615	0.44	0.17	0.05
Some	1,711	0.47	0.45	0.35
Most	316	0.09	0.78	1.29
Ever smoked				
No	2,349	0.64		
Yes	1,297	0.36		
	Median	Quartiles 1 and 3	(correlation)	(correlation)
Continuous				
Smoking Intensity (among smokers)	0	0,1		
Socioeconomic status	0.08	-0.65,0.65	-0.12	-0.03
Movie smoking exposure	558	285,883	0.21	0.04
Team sports participation	1	0,2	-0.08	-0.14
Sensation seeking	12	10,14	0.31	0.25

Community descriptors				
Tobacco outlet density (per 1000 people)	0.34	0.03,1.12	0.03	-0.05
Distance (mi) to nearest outlet	0.59	0.29,1.19	0.001	0.03
Proportion population Black[a]	0.03	0.01,0.21	-0.03	-0.13
Proportion population Hispanic[a]	0.03	0.01,0.09	0.02	-0.08
Poverty[a,b]	0.06	0.03,0.11	0.02	-0.07

[a]For each adolescent's census tract.

[b]Proportion of families with income below the poverty level.

The community characteristics were also correlated with each other. Higher tobacco outlet density was associated with larger proportions of families with incomes below the poverty level, proportion of the population that was Black and Hispanic (Table 2). Tobacco outlet density decreased as distance to nearest outlet increased (correlation = -0.32), but the relationship was not linear. There was a wide range for distance to closest outlet among adolescents living in low tobacco outlet density areas, and a wide range of densities among adolescents living close to an outlet, justifying the consideration of both factors as being independently associated with smoking behavior.

Table 2. Correlation among the environmental descriptors.

	Correlation				
Environmental descriptor	1	2	3	4	5
1 Tobacco outlet density (per 1000 people)	1.00				
2 Distance (mi) to nearest outlet	-0.32	1.00			
3 Proportion population Black[a]	0.27	-0.17	1.00		
4 Proportion population Hispanic[a]	0.26	-0.13	-0.10	1.00	
5 Poverty[a,b]	0.39	-0.12	0.52	0.38	1.00

[a]For each adolescent's census tract.

[b]Proportion of families with income below the poverty level.

Relation with ever tried smoking: Overall, 35.6 percent of respondents reported ever having tried a cigarette. Being male, being Hispanic, having sibling(s) who smoke, being of lower socioeconomic status, having friends who smoke, being older, having more exposure to movie smoking, not playing team sports, being higher in sensation seeking, and living in a neighborhood with higher tobacco outlet density were all significantly associated with ever trying smoking in the unadjusted models (Table 3). Two types of multivariate models were built to test these associations with ever trying smoking. In the first, only community-level factors

were included; it showed a significant inverse association with proportion of the population that was Black and a significant association with census tract poverty. In the second multivariate model, individual characteristics were added, which substantially improved model fit. Whereas most individual characteristics (sibling smoking, socioeconomic status, friend smoking, age, movie smoking exposure, team sports participation, and sensation seeking) were significantly associated with ever trying smoking in the second model, none of the community characteristics were significantly associated with ever trying smoking. Notably, the coefficient for tobacco outlet density changed little across models and, although small, remained close to statistical significance, in contrast to the other community predictors.

Table 3. Crude and multivariate association with ever tried smoking.

Variable	Crude Odds Ratio	Community only[a] n = 3,621 Adj Odds Ratio	95% CI	All variables[b] n = 3,543 Adj Odds Ratio	95% CI
Individual characteristics					
Categorical					
Gender					
Male	Ref				
Female	0.84*			1.03	0.88,1.21
Race/ethnicity					
White	Ref				
Black	0.85			0.85	0.62,1.18
Hispanic	1.24*			1.18	0.88,1.59
Mixed race/other	1.13			1.08	0.77,1.50
Sibling smokes					
No	Ref				
Yes	2.85*			2.13*	1.75,2.59
Friend smoking					
None	Ref				
Some	3.93*			2.60*	2.19,3.10
Most	17.14*			7.01*	5.05,9.74
Continuous					
Age (for each additional year)	1.39*			1.23*	1.16,1.31
Socioeconomic status	0.76*			0.82*	0.74,0.91
Movie smoking exposure	5.14*			2.66*	1.95,3.63
Team sports participation	0.59*			0.69*	0.54,0.89
Sensation seeking	20.71*			7.72*	5.26,11.34
Community characteristics					
Tobacco outlet density (per 1000 people)	1.30*	1.28	0.97,1.70	1.27	0.92,1.76
Tobacco outlet proximity (distance in miles to nearest outlet)	0.86	0.94	0.69,1.27	0.96	0.67,1.36
Proportion population Black[c]	0.80	0.59*	0.42,0.83	0.93	0.53,1.61
Proportion population Hispanic[c]	1.47	0.87	0.49,1.55	0.88	0.41,1.87
Poverty[c,d]	2.06	3.66*	1.07,12.42	0.74	0.17,3.22

*p<0.05

[a]Pseudo R^2 = 0.003

[b]Pseudo R^2 = 0.20

[c]For each adolescent's census tract

[d]Proportion of families with income below the poverty level

Relation with smoking intensity: Most of the respondents who had tried smoking (73%) reported no smoking in the past 30 days. Multivariate model results for smoking intensity among the experimental smokers are reported in Table 4. Minority status, sibling smoking friend smoking, age, team sports participation, sensation seeking, proportion population Black and Hispanic, and poverty, were all associated with smoking intensity at the bivariate level. In the community-only multivariate model, proportion population Black and Hispanic retained a significant inverse relation with smoking intensity. In the full model, friend smoking, age, and sensation seeking were all associated with higher intensity and being Black or Hispanic and participating in team sports associated with lower intensity. None of the community characteristics retained a statistically significant association with smoking intensity.

The tobacco outlet density—smoking association was not significantly different for those 18 years and older in either the tried smoking or the smoking intensity model. Additionally, excluding subjects for whom Zip Code centroid was used as a proxy for home address had little impact on the results.

Table 4. Crude and multivariate association with smoking intensity among experimental smokers.

		Community only[a] n = 1,289		All variables[b] n = 1,263	
Variable	Crude Odds Ratio	Adj Odds Ratio	95% CI	Adj Odds Ratio	95% CI
Individual characteristics					
Categorical					
Gender					
Male	Ref				
Female	0.89			0.99	0.75,1.30
Race/ethnicity					
White	Ref				
Black	0.29*			0.42*	0.22,0.81
Hispanic	0.47*			0.50*	0.30,0.83
Mixed race/other	0.85			0.85	0.50,1.42
Sibling smokes					
No	Ref				
Yes	1.33*			1.08	0.81,1.45
Friend smoking					
None	Ref				
Some	9.11*			6.38*	3.29,12.39
Most	57.89*			32.98*	16.43,66.19
Continuous					
Age (for each additional year)	1.37*			1.33*	1.20,1.48
Socioeconomic status	0.98			0.98	0.82,1.17
Movie smoking exposure	1.14			0.81	0.49,1.34
Team sports participation	0.35*			0.46*	0.30,0.72
Sensation seeking	14.55*			6.89*	3.42,13.88
Community characteristics					
Tobacco outlet density (per 1000 people)	0.69	1.03	0.62,1.71	1.15	0.66,2.03
Tobacco outlet proximity (distance in miles to nearest outlet)	1.27	0.83	0.49,1.40	0.82	0.46,1.46
Proportion population Black[c]	0.23*	0.18*	0.09,0.37	0.97	0.33,2.84
Proportion population Hispanic[c]	0.24*	0.16*	0.05,0.45	0.35	0.09,1.42
Poverty[c,d]	0.06*	2.31	0.25,21.15	0.78	0.05,11.43

*p<0.05

[a]Pseudo R^2 = 0.01

[b]Pseudo R^2 = 0.14

[c]For each adolescent's census tract.

[d]Proportion of families with income below the poverty level

DISCUSSION

This study highlights the much stronger association between individual health risk factors and youth smoking behavior compared to community risk factors. Two studies that have examined the relationship between tobacco outlet density or proximity and youth smoking have suggested that tobacco outlet density (but not proximity) is associated with youth smoking.(21, 22) Consistent with those studies, in the unadjusted model we saw a statistically significant association between tobacco outlet density and youth smoking, but not after accounting for additional community and individual risk factors for youth smoking. More importantly, the magnitudes of the community associations with youth smoking were small compared to individual risk factors. Thus, regardless of whether the association of tobacco outlet density reached accepted standards for statistical significance, the small potential effect across a broad range of tobacco outlet densities suggests that policies designed to lower density would have only a small impact on adolescent smoking. In contrast, the associations between team sports participation and both smoking outcomes were large enough to suggest that interventions and policies aiming to support those activities could help prevent adolescent smoking.

This study used Bronfenbrenner's Ecological Systems Theory to frame the possible joint effects of individual-level, microsystem, mesosystem, and exosystem variables on youth smoking. When variables were scaled so as to compare effect sizes, our findings indicated a relative importance of individual-level variables compared to the community variables we studied. We

suggest empirical multi-level studies pay attention to estimating effects that allow for such comparisons, in addition to focusing on statistical significance. Although we found no strong associations with smoking for the community variables studied, this study does not rule out the possibility that other neighborhood characteristics, such as measures of social capital or neighborhood smoking, may have an important impact on youth smoking. In fact, one study using the Brofenbrenner model found that neighborhood rates of youth smoking affected adolescent smoking trajectories, over and above individual risk factors.(40)

The association between some risk factors and smoking was present for trying smoking but not smoking intensity among experimental smokers, underlying the importance of modeling different smoking transitions separately. Trying smoking is strongly influenced by social risk factors (sibling smoking, friend smoking, movie smoking, and team sports participation). Among experimental smokers, smoking intensity continues to be associated with smoking by some social influence factors—peers, team sports, and exposure to tobacco marketing,(41, 42) but is also is predominantly driven by addiction processes.(43, 44) In this study, sensation seeking was a risk factor for both trying smoking and higher smoking intensity, consistent with other research.(45) Sensation seeking level probably captures, in part, biological characteristics that promote experience seeking(46) and tolerance of deviance,(47) but it may also be associated with higher sensitivity to the addictive influence of nicotine.(48) Given its large association with both smoking outcomes in this study, research on using sensation seeking to target high risk adolescents,(49) modifying risk factors that affect sensation seeking deserve greater emphasis. For example, one study suggested that higher exposure to adult-rated movies resulted in higher growth in sensation seeking during adolescence.(50)

Consistent with other studies that have distinguished between trying smoking and smoking intensity,(51) some characteristics were associated with one outcome but not the other. Exposure to smoking in movies was associated with trying smoking but not smoking intensity, consistent with some other reports.(41, 42) Minority youth tried smoking at rates similar to White youth, but minority ever smokers had much lower smoking intensity than Whites. This finding is not surprising, given that minority adolescents have lower rates of smoking compared with Whites,(52, 53) with larger temporal declines in smoking among Black adolescents(54) and lower rates of progression to regular use.(55) Studies of trying smoking have been inconsistent, with some confirming lower rates among minorities,(56)whereas others,(57) including this one, did not. Why minority youth that try smoking have lower smoking intensity than Whites deserves further research, given that the finding holds across studies;(52, 55) minority adolescents could be less susceptible to nicotine addiction in its earliest stages or social or family circumstances could reduce the likelihood of progression of experimental smoking during adolescence.

This study was limited in that it relied on cross-sectional data and therefore cannot address temporality. However, it would be an unusual to see a weak correlation in a cross-sectional study become a key predictor in a longitudinal one. The national scope of the study could be viewed as a strength but precluded us from directly assessing where tobacco outlets were in each community. Instead, we relied on available commercial data, subject to higher levels of error. Although this limitation could have widened confidence intervals due to random error, we have no reason to believe that the error is larger in some neighborhoods than others, which would lead

to biased estimates. We suggest that, even if the results were statistically significant, the size of the associations were still small for tobacco outlet density and the other community characteristics we measured.

Compared to individual risk factors, tobacco outlet density might be less relevant for minors who are legally constrained in their purchase of tobacco. One previous study of adolescent smoking found no association for tobacco outlet density but a positive association between access—the proportion of stores that illegally sell to minors—and youth smoking.(25) This suggests that tobacco outlet density could be more important in determining smoking patterns among adults, who are less constrained in their purchase of tobacco at retail outlets. Although we found no evidence for that in the small number of adults present in this sample, further study in adult samples may be indicated. Our study did not explicitly measure exposure to tobacco storefront advertising in the context of community-level influences and therefore cannot address this issue explicitly—we cannot rule out a storefront advertising influence without more elaborate measurements of access to this particular aspect of tobacco retailing. Tobacco outlet density should be a proxy for exposure to storefront advertising but would not capture individual differences in how adolescents respond to or remember it, which could explain differences between our findings and those of others who assessed recollection of storefront advertising.(58) Finally, we studied tobacco density and proximity at the home, not the school. McCarthy et al. looked at the relationship between tobacco retail density near schools and youth tobacco use and found that the effects were limited to trying smoking (not established smoking), and only among high school students in urban areas.(59) However, their work did not include the depth of individual-level variables presented in this analysis. Future studies should consider the role of

school density and proximity to tobacco outlets around schools in context of individual risk factors.

This study adds to the growing body of evidence that public health campaigns to prevent and reduce youth smoking should emphasize individual risk factors for smoking, including supporting participation in team sports, minimizing exposure to movie smoking, addressing the social influence of friend smoking, and addressing experience seeking among high sensation-seekers.

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A comparison of individual versus community influences on youth smoking behaviors: A cross-sectional observational study

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ABSTRACT

Objectives To compare individual with community risk factors for adolescent smoking.

Design A cross-sectional observational study with multivariate analysis.

Setting National telephone survey.

Participants 3646 US adolescents aged 13-18 years in 2007 recruited through a random digit-dial survey.

Outcome measures Ever tried smoking and, among experimental smokers, smoking intensity (based on smoking in past 30 days).

Results One-third of participants (35.6%, N=1297) had tried smoking. After controlling for individual risk factors, neither tobacco outlet density nor proximity were associated with tried smoking or smoking intensity. Associations with trying smoking included age (Adjusted Odds Ratio [AOR] = 1.23, 95% CI 1.16, 1.31), lower socioeconomic status (AOR = 0.82, 95% CI 0.74, 0.91), sibling smoking (AOR=2.13, 95% CI 1.75, 2.59), friend smoking (AOR = 2.60, 95% CI 2.19, 3.10 for some and AOR = 7.01, 95% CI 5.05,9.74 for most), movie smoking exposure (AOR = 2.66, 95% CI 1.95, 3.63), team sports participation (AOR = 0.69, 95% CI 0.54, 0.89) and sensation seeking (AOR = 7.72, 95% CI 5.26, 11.34). Among experimental smokers, age (AOR = 1.32, 95% CI 1.21, 1.44), minority status (AOR = 0.48, 95% CI 0.30, 0.79 for Black; AOR = 0.46, 95% CI 0.31, 0.69 for Hispanic; AOR = 0.53, 95% CI 0.43, 0.85 for Mixed race/other), friend smoking (AOR = 3.37, 95% CI 2.37,4.81 for some; AOR = 20.27, 95% CI 13.22,31.08 for most), team sports participation (AOR = 0.38, 95% CI 0.26, 0.55), and sensation seeking (AOR = 6.57, 95% CI 3.71, 11.64) were associated with smoking intensity.

Conclusions The study suggests that interventions and policies to prevent and reduce youth smoking should focus on individual risk factors for smoking, including supporting participation

in team sports, minimizing exposure to movie smoking, addressing the social influence of friend smoking, and addressing experience seeking among high sensation-seekers.

INTRODUCTION

Preventing adolescent smoking is a key public health imperative. Individual risk factors for youth smoking have been studied for decades. They include personality factors such as sensation seeking,(1, 2) and other social influences like parent(3-6) and friend(7, 8) smoking. They also include exposure to tobacco marketing(9) and smoking in entertainment media(10), which were both considered causal risk factors in a recent (2012) Surgeon General's report on smoking in adolescents and young adults.(11) Research has shown that extracurricular activities, such as team sports participation, are associated with preventing youth smoking.(12-16) Knowledge about these risk factors has informed interventions aiming to minimize adolescents' responsiveness to social risk factors(17) and policies to minimize adolescent's exposure to tobacco marketing and movies.(18)

In addition to individual risk factors, community influences such as frequent exposure to tobacco outlets(19) and tobacco outlet density,(20, 21) have been associated with youth smoking. Compared to the compelling research on individual risk factors, evidence for community influence is mixed. Studies to date have been regional, have not extensively controlled for individual characteristics, and have applied varying approaches to density measurement.(21-24) To our knowledge, studies have not yet tested whether the association between tobacco outlet density and proximity is confounded by race or social influences like sibling and friend smoking. One study that controlled for individual sociodemographics failed to find an association between tobacco outlet density and youth smoking.(25)

Another area to consider in the context of tobacco outlet density and proximity is their association with neighborhood characteristics, such as poverty, that may also pose a community risk factor for smoking. Many studies show an association between tobacco outlet density and neighborhoods characterized by high percentages of minorities(21, 23, 26-29) and low income,(21, 23, 27-29) although this finding has not been consistent across regions.(26) Thus, the finding that tobacco outlet density is related to youth smoking could also be confounded by community factors. Nevertheless, the literature was robust enough for Cohen et al. to propose policies to limit tobacco outlet density to reduce youth smoking,(30) raising the question of whether individual or community-level factors have greater potential to prevent youth smoking.

This study examines the role of access to tobacco outlets on youth smoking in a national sample of U.S. adolescents. By access, we mean approaching, entering, exiting, and having exposure to information imparted to potential customers about tobacco products, including visibility of in-store and storefront advertising. Our focus is twofold—to assess the multivariate association with youth smoking after controlling for other individual and community risk factors, and to compare the sizes of these associations. It is the first to consider the role of community-level factors on adolescent smoking in the U.S. nationwide, and the first to jointly examine individual social and media influence risk factors with community-level factors. The intent of this work is to inform interventional research and policies related to tobacco control efforts directed at youth.

METHODS

Theoretical Framework

This study is guided by Bronfenbrenner's Ecological Systems Theory,(31-33) which posits that development, health and well-being are situated within and shaped by the interactions that occur between the individual and the four systems: microsystem (immediate environment), mesosystem (connections between immediate environments, e.g., tobacco outlet density and proximity), exosystem (indirect external environmental settings), and macrosystem (larger cultural context).(31-33) For this study, we include individual-level variables that are well-established risk factors for smoking: gender, race/ethnicity, socioeconomic status, and the personality characteristic of sensation seeking. We also include the microsystem variables of friend smoking, sibling smoking, exposure to smoking in movies, and team sports participation. Our mesosystem variables include tobacco outlet density and distance to closest tobacco outlet. Our exosystem variables include proportion population Black, proportion population Hispanic, and proportion of families with income below the poverty level.

Sample Recruitment

A detailed description of the recruitment methods for study participants has been published previously.(34) Briefly, between June and October 2003, 6522 U.S. adolescents aged 10-14 years were recruited through a random digit-dial telephone survey, which captured a representative sample of U.S. adolescents. Five follow-up surveys were conducted at 8-month intervals. This study involves the fifth follow-up survey conducted in the fall of 2007. Interviewers successfully contacted 3055 (47%) of the original 6522 adolescents for this round. Loss to follow up was higher among Blacks, older adolescents, those of lower socioeconomic status, baseline smokers and higher sensation seekers. To address the minority attrition, a sample of 598 Black adolescents (in the same age range) were recruited through lists of residential

numbers for U.S. census tracts for which African-Americans represented 20% or more of the population, resulting in available sample of 3653 for this study. Parental consent and adolescent assent were required for participation. The study was approved by the Committee for the Protection of Human Subjects at Dartmouth Medical School. The 3653 subjects lived in 3456 unique census tracts, of which the majority (95.5%) contained only 1 subject; 144 tracts (4.2%) contained two subjects, and 11 tracts (0.3%) contained three subjects. Most adolescent residential locations were geocoded to their home street address (N=3167). When home street address was not available, they were geocoded to their ZIP code centroid (N=479), resulting in a final sample size of N=3646 for this study. We used a complete case analysis approach because only 110 subjects (3%) were missing data from one or more variables. The dependent and independent variables include dichotomous, polychotomous and continuous variables. Three variables (smoking intensity, socioeconomic status, and sensation seeking) are scales derived from two or more items, constructed using the "alpha, gen(varlist)" command in Stata 12. The sections below describe how we ascertained the information, constructed the variables, handled outliers, and rescaled the variables in order to compare the associations in our analytical models.

Outcome Variables

Ever tried smoking: Respondents were asked, "How many cigarettes have you smoked in your life" and those who responded "none" were categorized as never smokers. Those who responded in a category that indicated lifetime smoking were then asked about past 30 day smoking intensity.

Smoking intensity: Smoking intensity was based on a composite measure using two items (alpha = 0.82): "During the past 30 days, on how many days did you smoke cigarettes?" (none, 1-10 days, 11-29 days, or every day); "How many cigarettes have you smoked in your life?" (none, a few puffs, one to 19 cigarettes, 20-100 cigarettes, more than 100 cigarettes). This measure had whole number values ranging from 1 to 7. We have used this measure in previously published work.(35)

Individual risk factors

Sociodemographics: Individual measures of age, race and ethnicity were included. Socioeconomic status (SES) was assessed using a standardized composite measure based on parent reports of their own education and household income (alpha = 0.69). The variable was centered around zero and a 1-point increase corresponded to a 1 standard deviation increase in SES.

Sibling smoking: Sibling smoking was assessed with the question, "Do any of your older brothers or sisters smoke cigarettes? (Yes, No)"

Friend smoking: Friend smoking was assessed with the question, "How many of your friends smoke cigarettes? Your choices are none, some, or most."

Exposure to movie smoking: Adolescents' exposure to movie smoking was estimated using the Beach method(36) for top U.S. box-office hits from 2000-2006 (n = 384). Movies were content-

coded for smoking using previously validated methods.(36) Each adolescent survey was programmed to randomly select 50 movie titles from the larger pool of 384 movies; respondents were asked whether they had ever seen each movie title. To create a measure of exposure to movie smoking, the number of smoking occurrences in films each adolescent had seen from his/her unique list of 50 movies were summed. A proportion was generated by dividing this number by the number of smoking occurrences that the adolescent would have seen had all 50 movies in the unique list been viewed and this proportion was multiplied by the number of smoking occurrences in the entire parent sample of 384 movies.

Team sports participation: Team sports participation was assessed with a single item, "Now I'd like you to think about all the sports teams you played on during the past 12 months, including all school, community or recreational teams. How many sports teams did you play on in the past 12 months?" Team sports participation was skewed right, with responses ranging up to 12, with 4 at the 95th percentile.

Sensation seeking: Sensation seeking propensity was assessed using a short 5-item measure: "I would like to explore strange places," "I like to do frightening things," "I like new and exciting experiences, even if I have to break the rules," "I like to listen to loud music," "I like to do dangerous things." Each of these items had the following response categories for each statement: Strongly Agree, Disagree, Agree, Strongly Agree. These items had a Cronbach's alpha (α) of 0.70. The sensation seeking scale ranged from 0 to 15 with 12 at the 95th percentile.

Community influences

Tobacco outlets: To obtain a national dataset for tobacco outlets, we reviewed North American Industry Classification System (NAICS) codes from 2007 and selected establishments that were likely to sell tobacco products. The Office of Management and Budget (OMB) developed NAICS for use by Federal statistical agencies in classifying all business establishments based on their primary activity. We selected the 306,695 establishments coded as tobacco stores, grocery stores, gas stations, and convenience stores and obtained geocoded data from the NAICS Association. Although some businesses classified as department stores, liquor stores, and pharmacies may sell tobacco as well (e.g. Wal-Mart, Costco, CVS), they were not classified as tobacco outlets because they also include many stores that do not sell tobacco (e.g. Sears, Dollar Stores, hospital pharmacies), and the NAICS categories do not allow differentiation between sub-classes of stores that do or do not sell tobacco.

Tobacco outlet density using adaptive bandwidth kernel density estimation: A nationwide density surface of the tobacco outlets using adaptive bandwidth kernel density estimation (KDE)(37, 38) and the LandScan™ Global Population Database(39) was produced. Adaptive bandwidth KDE accounts for the underlying population density by limiting the bandwidth of each tobacco outlet to the surrounding population of 1000 people. Setting a limit constrains the influence of a single outlet to a small spatial extent where the population density is high (urban areas) while in rural areas the reach of the tobacco outlet is geographically larger. For sparsely populated regions, the bandwidth of each tobacco outlet was limited to a 25 km radius to prevent the density calculation from expanding to a spatially unreliable distance. The resultant density surface covers the continental U.S. with pixels that are ~0.5 miles on each side and have a

density value in units of tobacco outlets per 1000 people. Each adolescent was assigned the density value based on the pixel at their geocoded location.

Distance to closest tobacco outlet: ArcGIS Network Analyst (ESRI, Redlands, CA) was used to compute the distance along the road network from the adolescent's geocoded location to the closest tobacco outlet. Street data was obtained from the 2008 edition of StreetMap North America,(40) which was created in 2005 and based on the ground conditions in 2003. Other methods of measuring proximity were also considered, including Euclidian distance and driving time. A sensitivity analysis demonstrated no difference between methods in the final model (data not shown).

Census tract measures of race/ethnicity and poverty: Community characteristics that might be confounders for tobacco outlet density and proximity were included. Using the U.S. Census 2000 data, the proportion population Black, the proportion population Hispanic, and the proportion of families with income below the poverty level for each adolescent's census tract were calculated.

Statistical analysis

Pearson correlation coefficients were used to describe the association among community influences. Multiple logistic regression was used to assess the association between individual and environmental risk factors and ever tried smoking, and multiple ordered logistic regression was used to assess the odds of being higher on the frequency of smoking scale among smokers. Because the majority of the sample resided in unique census tracts, it was not necessary to fit hierarchical models. Instead, the environmental variables were entered as individual-level risk

indicators of the adolescent's environment. Some variables (movie smoking exposure, sensation seeking, team sports participation, tobacco outlet density, distance to the closest outlet, proportion population Black, proportion population Hispanic, and proportion families with incomes below the poverty level) were skewed right. In order to limit the influence of high outliers, values higher than the 95th percentile were trimmed to the 95th percentile. Additionally, to allow a comparison of effect size among the variables, friend smoking, movie smoking exposure, tobacco outlet density, proportion of families with incomes below the poverty level, sensation seeking, and team sports participation were rescaled so that the lowest value was 0 and the highest value was 1. This scaling procedure allowed a comparison between the dose-response between individual/community measures and adolescent smoking. Ninety-five percent confidence intervals were assessed based on two-tailed hypothesis assumptions.

RESULTS

Individual and community characteristics: Table 1 describes the characteristics of the adolescents and their correlation with the two smoking outcomes. Thirty-six percent had tried smoking, and this percentage increased across age categories from 18 to 56 percent in 13 and 18 year olds respectively. Among smokers, mean smoking intensity also increased with age. There were no large differences in tried smoking prevalence across gender or race, but smoking intensity was much lower among Black and Hispanic smokers compared with Whites and those of mixed race. The correlation between community variables and smoking was an order of magnitude lower than correlations with individual characteristics. Whereas tobacco outlet density was positively correlated with trying smoking, it was negatively correlated with smoking

intensity. The largest correlation for community predictors was -0.19, between proportion population Black and smoking intensity, also consistent with lower smoking intensity among minorities at the individual level.

Table 1. Individual and community risk factors and smoking outcomes (N=3646).

Variable	n	Proportion of Sample	Proportion Who Have Tried Smoking	Smoking Intensity Scale Mean
Individual descriptors				
Categorical				
Age				
13	114	0.03	0.18	1.81
14	722	0.20	0.24	1.73
15	827	0.23	0.29	2.04
16	804	0.22	0.37	2.21
17	769	0.21	0.43	2.57
18	410	0.11	0.56	3.10
Gender				
Male	1,810	0.50	0.38	2.39
Female	1,836	0.50	0.34	2.32
Race/ethnicity				
White	2,091	0.57	0.36	2.74
Black	818	0.22	0.32	1.61
Hispanic	481	0.13	0.41	1.89
Mixed race/other	256	0.07	0.38	2.37
Sibling smokes				
No	2,924	0.80	0.31	2.29
Yes	720	0.20	0.56	2.51
Friend smoking				
None	1,615	0.44	0.17	1.27
Some	1,711	0.47	0.45	2.15
Most	316	0.09	0.78	4.23
Ever smoked				
No	2,349	0.64		
Yes	1,297	0.36		
	Median	Quartiles 1 and 3	(correlation)	(correlation)
Continuous				
Smoking Intensity (among smokers)	1	1,3		
Socioeconomic status	0.08	-0.65,0.65	-0.12	0.01
Movie smoking exposure	558	285,883	0.21	0.05
Team sports participation	1	0,2	-0.08	-0.16
Sensation seeking	12	10,14	0.31	0.27

Community descriptors				
Tobacco outlet density (per 1000 people)	0.34	0.03,1.12	0.03	-0.07
Distance (mi) to nearest outlet	0.59	0.29,1.19	0.001	0.03
Proportion population Black[a]	0.03	0.01,0.21	-0.03	-0.19
Proportion population Hispanic[a]	0.03	0.01,0.09	0.02	-0.10
Poverty[a,b]	0.06	0.03,0.11	0.02	-0.12

[a]For each adolescent's census tract.

[b]Proportion of families with income below the poverty level.

The community characteristics were also correlated with each other. Higher tobacco outlet density was associated with larger proportions of families with incomes below the poverty level, proportion of the population that was Black and Hispanic (Table 2). Tobacco outlet density decreased as distance to nearest outlet increased (correlation = -0.32), but the relationship was not linear. There was a wide range for distance to closest outlet among adolescents living in low tobacco outlet density areas, and a wide range of densities among adolescents living close to an outlet, justifying the consideration of both factors as being independently associated with smoking behavior.

Table 2. Correlation among the environmental descriptors.

	Correlation				
Environmental descriptor	1	2	3	4	5
1 Tobacco outlet density (per 1000 people)	1.00				
2 Distance (mi) to nearest outlet	-0.32	1.00			
3 Proportion population Black[a]	0.27	-0.17	1.00		
4 Proportion population Hispanic[a]	0.26	-0.13	-0.10	1.00	
5 Poverty[a,b]	0.39	-0.12	0.52	0.38	1.00

[a]For each adolescent's census tract.

[b]Proportion of families with income below the poverty level.

Relation with ever tried smoking: Overall, 35.6 percent of respondents reported ever having tried a cigarette. Being male, being Hispanic, having sibling(s) who smoke, being of lower socioeconomic status, having friends who smoke, being older, having more exposure to movie smoking, not playing team sports, being higher in sensation seeking, and living in a neighborhood with higher tobacco outlet density were all significantly associated with ever trying smoking in the unadjusted models (Table 3). Two types of multivariate models were built to test these associations with ever trying smoking. In the first, only community-level factors

were included; it showed a significant inverse association with proportion of the population that was Black and a significant association with census tract poverty. In the second multivariate model, individual characteristics were added, which substantially improved model fit. Whereas most individual characteristics (sibling smoking, socioeconomic status, friend smoking, age, movie smoking exposure, team sports participation, and sensation seeking) were significantly associated with ever trying smoking in the second model, none of the community characteristics were significantly associated with ever trying smoking. Notably, the coefficient for tobacco outlet density changed little across models and, although small, remained close to statistical significance, in contrast to the other community predictors.

Table 3. Crude and multivariate association with ever tried smoking.

		Community only[a] n = 3,621		All variables[b] n = 3,543	
Variable	Crude Odds Ratio	Adj Odds Ratio	95% CI	Adj Odds Ratio	95% CI
Individual characteristics					
Categorical					
Gender					
Male	Ref				
Female	0.84*			1.03	0.88,1.21
Race/ethnicity					
White	Ref				
Black	0.85			0.85	0.62,1.18
Hispanic	1.24*			1.18	0.88,1.59
Mixed race/other	1.13			1.08	0.77,1.50
Sibling smokes					
No	Ref				
Yes	2.85*			2.13*	1.75,2.59
Friend smoking					
None	Ref				
Some	3.93*			2.60*	2.19,3.10
Most	17.14*			7.01*	5.05,9.74
Continuous					
Age (for each additional year)	1.39*			1.23*	1.16,1.31
Socioeconomic status	0.76*			0.82*	0.74,0.91
Movie smoking exposure	5.14*			2.66*	1.95,3.63
Team sports participation	0.59*			0.69*	0.54,0.89
Sensation seeking	20.71*			7.72*	5.26,11.34
Community characteristics					
Tobacco outlet density (per 1000 people)	1.30*	1.28	0.97,1.70	1.27	0.92,1.76
Tobacco outlet proximity (distance in miles to nearest outlet)	0.86	0.94	0.69,1.27	0.96	0.67,1.36
Proportion population Black[c]	0.80	0.59*	0.42,0.83	0.93	0.53,1.61
Proportion population Hispanic[c]	1.47	0.87	0.49,1.55	0.88	0.41,1.87
Poverty[c,d]	2.06	3.66*	1.07,12.42	0.74	0.17,3.22

*p<0.05

[a]Pseudo R^2 = 0.003

[b]Pseudo R^2 = 0.20

[c]For each adolescent's census tract

[d]Proportion of families with income below the poverty level

Relation with smoking intensity: Most of the respondents who had tried smoking (73%) reported no smoking in the past 30 days. Multivariate model results for smoking intensity among the experimental smokers are reported in Table 4. Minority status, friend smoking, age, team sports participation, sensation seeking, tobacco outlet density, proportion population Black and Hispanic, and poverty, were all associated with smoking intensity at the bivariate level. In the community-only multivariate model, proportion population Black and Hispanic retained a significant inverse relation with smoking intensity. In the full model, friend smoking, age, and sensation seeking were all associated with higher intensity and being Black or Hispanic and participating in team sports associated with lower intensity. None of the community characteristics retained a statistically significant association with smoking intensity.

The tobacco outlet density—smoking association was not significantly different for those 18 years and older in either the tried smoking or the smoking intensity model. Additionally, excluding subjects for whom Zip Code centroid was used as a proxy for home address had little impact on the results.

Table 4. Crude and multivariate association with smoking intensity among experimental smokers.

		Community only[a] n = 1,289		All variables[b] n = 1,263	
Variable	Crude Odds Ratio	Adj Odds Ratio	95% CI	Adj Odds Ratio	95% CI
Individual characteristics					
Categorical					
Gender					
Male	Ref				
Female	0.93			1.05	0.84,1.33
Race/ethnicity					
White	Ref				
Black	0.25*			0.48*	0.30,0.79
Hispanic	0.40*			0.46*	0.31,0.69
Mixed race/other	0.60*			0.53*	0.34,0.85
Sibling smokes					
No	Ref				
Yes	1.21			0.98	0.76,1.26
Friend smoking					
None	Ref				
Some	4.73*			3.37*	2.37,4.81
Most	33.62*			20.27*	13.22,31.08
Continuous					
Age (for each additional year)	1.37*			1.32*	1.21,1.44
Socioeconomic status	1.10			1.09	0.94,1.26
Movie smoking exposure	1.29			1.04	0.68,1.59
Team sports participation	0.36*			0.38*	0.26,0.55
Sensation seeking	12.95*			6.57*	3.71,11.64
Community characteristics					
Tobacco outlet density (per 1000 people)	0.62*	0.98	0.64,1.50	1.11	0.70,1.79
Tobacco outlet proximity (distance in miles to nearest outlet)	1.32	0.76	0.48,1.20	0.74	0.45,1.20
Proportion population Black[c]	0.15*	0.12*	0.07,0.22	0.42	0.18,1.00
Proportion population Hispanic[c]	0.20*	0.13*	0.06,0.32	0.43	0.14,1.33
Poverty[c,d]	0.02*	1.54	0.24,9.96	1.14	0.13,10.03

*p<0.05

[a]Pseudo R^2 = 0.02

[b]Pseudo R^2 = 0.15

[c]For each adolescent's census tract.

[d]Proportion of families with income below the poverty level

DISCUSSION

This study highlights the much stronger association between individual health risk factors and youth smoking behavior compared to community risk factors. Two studies that have examined the relationship between tobacco outlet density or proximity and youth smoking have suggested that tobacco outlet density (but not proximity) is associated with youth smoking.(21, 22) Consistent with those studies, in the unadjusted model we saw a statistically significant association between tobacco outlet density and youth smoking, but not after accounting for additional community and individual risk factors for youth smoking. More importantly, the magnitudes of the community associations with youth smoking were small compared to individual risk factors. Thus, regardless of whether the association of tobacco outlet density reached accepted standards for statistical significance, the small potential effect across a broad range of tobacco outlet densities suggests that policies designed to lower density would have only a small impact on adolescent smoking. In contrast, the associations between team sports participation and both smoking outcomes were large enough to suggest that interventions and policies aiming to support those activities could help prevent adolescent smoking.

This study used Bronfenbrenner's Ecological Systems Theory to frame the possible joint effects of individual-level, microsystem, mesosystem, and exosystem variables on youth smoking. When variables were scaled so as to compare effect sizes, our findings indicated a relative importance of individual-level variables compared to the community variables we studied. We

suggest empirical multi-level studies pay attention to estimating effects that allow for such comparisons, in addition to focusing on statistical significance. Although we found no strong associations with smoking for the community variables studied, this study does not rule out the possibility that other neighborhood characteristics, such as measures of social capital or neighborhood smoking, may have an important impact on youth smoking. In fact, one study using the Brofenbrenner model found that neighborhood rates of youth smoking affected adolescent smoking trajectories, over and above individual risk factors.(41)

The association between some risk factors and smoking was present for trying smoking but not smoking intensity among experimental smokers, underlying the importance of modeling different smoking transitions separately. Trying smoking is strongly influenced by social risk factors (sibling smoking, friend smoking, movie smoking, and team sports participation). Among experimental smokers, smoking intensity continues to be associated with smoking by some social influence factors—peers, team sports, and exposure to tobacco marketing,(35, 42) but is also is predominantly driven by addiction processes.(43, 44) In this study, sensation seeking was a risk factor for both trying smoking and higher smoking intensity, consistent with other research.(45) Sensation seeking level probably captures, in part, biological characteristics that promote experience seeking(46) and tolerance of deviance,(47) but it may also be associated with higher sensitivity to the addictive influence of nicotine.(48) Given its large association with both smoking outcomes in this study, research on using sensation seeking to target high risk adolescents,(49) modifying risk factors that affect sensation seeking deserve greater emphasis. For example, one study suggested that higher exposure to adult-rated movies resulted in higher growth in sensation seeking during adolescence.(50)

Consistent with other studies that have distinguished between trying smoking and smoking intensity,(51) some characteristics were associated with one outcome but not the other. Exposure to smoking in movies was associated with trying smoking but not smoking intensity, consistent with some other reports.(35, 42) Minority youth tried smoking at rates similar to White youth, but minority ever smokers had much lower smoking intensity than Whites. This finding is not surprising, given that minority adolescents have lower rates of smoking compared with Whites,(52, 53) with larger temporal declines in smoking among Black adolescents(54) and lower rates of progression to regular use.(55) Studies of trying smoking have been inconsistent, with some confirming lower rates among minorities,(56)whereas others,(57) including this one, did not. Why minority youth that try smoking have lower smoking intensity than Whites deserves further research, given that the finding holds across studies;(52, 55) minority adolescents could be less susceptible to nicotine addiction in its earliest stages or social or family circumstances could reduce the likelihood of progression of experimental smoking during adolescence.

This study was limited in that it relied on cross-sectional data and therefore cannot address temporality. However, it would be unusual to see a weak correlation in a cross-sectional study become a key predictor in a longitudinal one. The national scope of the study could be viewed as a strength but precluded us from directly assessing where tobacco outlets were in each community. Instead, we relied on available commercial data, subject to higher levels of error. Although this limitation could have widened confidence intervals due to random error, we have no reason to believe that the error is larger in some neighborhoods than others, which would lead

to biased estimates. We suggest that, even if the results were statistically significant, the size of the associations were still small for tobacco outlet density and the other community characteristics we measured.

Compared to individual risk factors, tobacco outlet density might be less relevant for minors who are legally constrained in their purchase of tobacco. One previous study of adolescent smoking found no association for tobacco outlet density but a positive association between access—the proportion of stores that illegally sell to minors—and youth smoking.(25) This suggests that tobacco outlet density could be more important in determining smoking patterns among adults, who are less constrained in their purchase of tobacco at retail outlets. Although we found no evidence for that in the small number of adults present in this sample, further study in adult samples may be indicated. Our study did not explicitly measure exposure to tobacco storefront advertising in the context of community-level influences and therefore cannot address this issue explicitly—we cannot rule out a storefront advertising influence without more elaborate measurements of access to this particular aspect of tobacco retailing. Tobacco outlet density should be a proxy for exposure to storefront advertising but would not capture individual differences in how adolescents respond to or remember it, which could explain differences between our findings and those of others who assessed recollection of storefront advertising.(58) Finally, we studied tobacco density and proximity at the home, not the school. McCarthy et al. looked at the relationship between tobacco retail density near schools and youth tobacco use and found that the effects were limited to trying smoking (not established smoking), and only among high school students in urban areas.(59) However, their work did not include the depth of individual-level variables presented in this analysis. Future studies should consider the role of

school density and proximity to tobacco outlets around schools in context of individual risk factors.

This study adds to the growing body of evidence that public health campaigns to prevent and reduce youth smoking should emphasize individual risk factors for smoking, including supporting participation in team sports, minimizing exposure to movie smoking, addressing the social influence of friend smoking, and addressing experience seeking among high sensation-seekers.

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A comparison of individual versus community influences on youth smoking behaviors: A cross-sectional observational study

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ABSTRACT

Objectives To compare individual with community risk factors for adolescent smoking.

Design A cross-sectional observational study with multivariate analysis.

Setting National telephone survey.

Participants 3646 US adolescents aged 13-18 years in 2007 recruited through a random digit-dial survey.

Outcome measures Ever tried smoking and, among experimental smokers, smoking intensity (based on smoking in past 30 days).

Results One-third of participants (35.6%, N=1297) had tried smoking. After controlling for individual risk factors, neither tobacco outlet density nor proximity were associated with tried smoking or smoking intensity. Associations with trying smoking included age (Adjusted Odds Ratio [AOR] = 1.23, 95% CI 1.16, 1.31), lower socioeconomic status (AOR = 0.82, 95% CI 0.74, 0.91), sibling smoking (AOR=2.13, 95% CI 1.75, 2.59), friend smoking (AOR = 2.60, 95% CI 2.19, 3.10 for some and AOR = 7.01, 95% CI 5.05,9.74 for most), movie smoking exposure (AOR = 2.66, 95% CI 1.95, 3.63), team sports participation (AOR = 0.69, 95% CI 0.54, 0.89) and sensation seeking (AOR = 7.72, 95% CI 5.26, 11.34). Among experimental smokers, age (AOR = 1.323, 95% CI 1.210, 1.448), minority status (AOR = 0.482, 95% CI 0.3022, 0.7981 for Black; AOR = 0.4650, 95% CI 0.310, 0.6983 for Hispanic; AOR = 0.53, 95% CI 0.43, 0.85 for Mixed race/other), friend smoking (AOR = 36.378, 95% CI 3.292.37,12.394.81 for some; AOR = 32.9820.27, 95% CI 16.4313.22,66.1931.08 for most), team sports participation (AOR = 0.4638, 95% CI 0.3026, 0.7255), and sensation seeking (AOR = 6.8957, 95% CI 3.4271, 13.8811.64) were associated with smoking intensity.

Conclusions The study suggests that interventions and policies to prevent and reduce youth smoking should focus on individual risk factors for smoking, including supporting participation in team sports, minimizing exposure to movie smoking, addressing the social influence of friend smoking, and addressing experience seeking among high sensation-seekers.

INTRODUCTION

Preventing adolescent smoking is a key public health imperative. Individual risk factors for youth smoking have been studied for decades. They include personality factors such as sensation seeking,(1, 2) and other social influences like parent(3-6) and friend(7, 8) smoking. They also include exposure to tobacco marketing(9) and smoking in entertainment media(10), which were both considered causal risk factors in a recent (2012) Surgeon General's report on smoking in adolescents and young adults.(11) Research has shown that extracurricular activities, such as team sports participation, are associated with preventing youth smoking.(12-16) Knowledge about these risk factors has informed interventions aiming to minimize adolescents' responsiveness to social risk factors(17) and policies to minimize adolescent's exposure to tobacco marketing and movies.(18)

In addition to individual risk factors, community influences such as frequent exposure to tobacco outlets(19) and tobacco outlet density,(20, 21) have been associated with youth smoking. Compared to the compelling research on individual risk factors, evidence for community influence is mixed. Studies to date have been regional, have not extensively controlled for individual characteristics, and have applied varying approaches to density measurement.(21-24) To our knowledge, studies have not yet tested whether the association between tobacco outlet density and proximity is confounded by race or social influences like sibling and friend smoking. One study that controlled for individual sociodemographics failed to find an association between tobacco outlet density and youth smoking.(25)

Another area to consider in the context of tobacco outlet density and proximity is their association with neighborhood characteristics, such as poverty, that may also pose a community risk factor for smoking. Many studies show an association between tobacco outlet density and neighborhoods characterized by high percentages of minorities(21, 23, 26-29) and low income,(21, 23, 27-29) although this finding has not been consistent across regions.(26) Thus, the finding that tobacco outlet density is related to youth smoking could also be confounded by community factors. Nevertheless, the literature was robust enough for Cohen et al. to propose policies to limit tobacco outlet density to reduce youth smoking,(30) raising the question of whether individual or community-level factors have greater potential to prevent youth smoking.

This study examines the role of access to tobacco outlets on youth smoking in a national sample of U.S. adolescents. By access, we mean approaching, entering, exiting, and having exposure to information imparted to potential customers about tobacco products, including visibility of in-store and storefront advertising. Our focus is twofold—to assess the multivariate association with youth smoking after controlling for other individual and community risk factors, and to compare the sizes of these associations. It is the first to consider the role of community-level factors on adolescent smoking in the U.S. nationwide, and the first to jointly examine individual social and media influence risk factors with community-level factors. The intent of this work is to inform interventional research and policies related to tobacco control efforts directed at youth.

METHODS

Theoretical Framework

This study is guided by Bronfenbrenner's Ecological Systems Theory,(31-33) which posits that development, health and well-being are situated within and shaped by the interactions that occur between the individual and the four systems: microsystem (immediate environment), mesosystem (connections between immediate environments, e.g., tobacco outlet density and proximity), exosystem (indirect external environmental settings), and macrosystem (larger cultural context).(31-33) For this study, we include individual-level variables that are well-established risk factors for smoking: gender, race/ethnicity, socioeconomic status, and the personality characteristic of sensation seeking. We also include the microsystem variables of friend smoking, sibling smoking, exposure to smoking in movies, and team sports participation. Our mesosystem variables include tobacco outlet density and distance to closest tobacco outlet. Our exosystem variables include proportion population Black, proportion population Hispanic, and proportion of families with income below the poverty level.

Sample Recruitment

A detailed description of the recruitment methods for study participants has been published previously.(34) Briefly, between June and October 2003, 6522 U.S. adolescents aged 10-14 years were recruited through a random digit-dial telephone survey, which captured a representative sample of U.S. adolescents. Five follow-up surveys were conducted at 8-month intervals. This study involves the fifth follow-up survey conducted in the fall of 2007. Interviewers successfully contacted 3055 (47%) of the original 6522 adolescents for this round. Loss to follow up was higher among Blacks, older adolescents, those of lower socioeconomic status, baseline smokers and higher sensation seekers. To address the minority attrition, a sample of 598 Black adolescents (in the same age range) were recruited through lists of residential

numbers for U.S. census tracts for which African-Americans represented 20% or more of the population, resulting in available sample of 3653 for this study. Parental consent and adolescent assent were required for participation. The study was approved by the Committee for the Protection of Human Subjects at Dartmouth Medical School. The 3653 subjects lived in 3456 unique census tracts, of which the majority (95.5%) contained only 1 subject; 144 tracts (4.2%) contained two subjects, and 11 tracts (0.3%) contained three subjects. Most adolescent residential locations were geocoded to their home street address (N=3167). When home street address was not available, they were geocoded to their ZIP code centroid (N=479), resulting in a final sample size of N=3646 for this study. We used a complete case analysis approach because only 110 subjects (3%) were missing data from one or more variables. The dependent and independent variables include dichotomous, polychotomous and continuous variables. Three variables (smoking intensity, socioeconomic status, and sensation seeking) are scales derived from two or more items, constructed using the "alpha, gen(varlist)" command in Stata 12. The sections below describe how we ascertained the information, constructed the variables, handled outliers, and rescaled the variables in order to compare the associations in our analytical models.

Outcome Variables

Ever tried smoking: Respondents were asked, "How many cigarettes have you smoked in your life" and those who responded "none" were categorized as never smokers. Those who responded in a category that indicated lifetime smoking were then asked about past 30 day smoking intensity.

Smoking intensity: Smoking intensity was based on a composite measure using ~~three~~ two items (alpha = 0.8~~7~~2): "During the past 30 days, on how many days did you smoke cigarettes?" (none, 1-10 days, 11-29 days, or every day); "~~During the past 30 days, on the weekdays that you smoked, how many cigarettes did you usually smoke per day?" (1 to 5, 6 to 10, 11 to 20, more than 20); "During the past 30 days, on the weekends that you smoked, how many cigarettes did you usually smoke per day?" (1 to 5, 6 to 10, 11 to 20, more than 20)~~How many cigarettes have you smoked in your life?" (none, a few puffs, one to 19 cigarettes, 20-100 cigarettes, more than 100 cigarettes). This measure had whole number values ranging from 1 to 7. We have used this measure in previously published work.(35)

Individual risk factors

Sociodemographics: Individual measures of age, race and ethnicity were included. Socioeconomic status (SES) was assessed using a standardized composite measure based on parent reports of their own education and household income (alpha = 0.69). The variable was centered around zero and a 1-point increase corresponded to a 1 standard deviation increase in SES.

Sibling smoking: Sibling smoking was assessed with the question, "Do any of your older brothers or sisters smoke cigarettes? (Yes, No)"

Friend smoking: Friend smoking was assessed with the question, "How many of your friends smoke cigarettes? Your choices are none, some, or most."

Exposure to movie smoking: Adolescents' exposure to movie smoking was estimated using the Beach method(36) for top U.S. box-office hits from 2000-2006 (n = 384). Movies were content-coded for smoking using previously validated methods.(36) Each adolescent survey was programmed to randomly select 50 movie titles from the larger pool of 384 movies; respondents were asked whether they had ever seen each movie title. To create a measure of exposure to movie smoking, the number of smoking occurrences in films each adolescent had seen from his/her unique list of 50 movies were summed. A proportion was generated by dividing this number by the number of smoking occurrences that the adolescent would have seen had all 50 movies in the unique list been viewed and this proportion was multiplied by the number of smoking occurrences in the entire parent sample of 384 movies.

Team sports participation: Team sports participation was assessed with a single item, "Now I'd like you to think about all the sports teams you played on during the past 12 months, including all school, community or recreational teams. How many sports teams did you play on in the past 12 months?" Team sports participation was skewed right, with responses ranging up to 12, with 4 at the 95th percentile.

Sensation seeking: Sensation seeking propensity was assessed using a short 5-item measure: "I would like to explore strange places," "I like to do frightening things," "I like new and exciting experiences, even if I have to break the rules," "I like to listen to loud music," "I like to do dangerous things." Each of these items had the following response categories for each statement:

Strongly Agree, Disagree, Agree, Strongly Agree. These items had a Cronbach's alpha (α) of 0.70. The sensation seeking scale ranged from 0 to 15 with 12 at the 95th percentile.

Community influences

Tobacco outlets: To obtain a national dataset for tobacco outlets, we reviewed North American Industry Classification System (NAICS) codes from 2007 and selected establishments that were likely to sell tobacco products. The Office of Management and Budget (OMB) developed NAICS for use by Federal statistical agencies in classifying all business establishments based on their primary activity. We selected the 306,695 establishments coded as tobacco stores, grocery stores, gas stations, and convenience stores and obtained geocoded data from the NAICS Association. Although some businesses classified as department stores, liquor stores, and pharmacies may sell tobacco as well (e.g. Wal-Mart, Costco, CVS), they were not classified as tobacco outlets because they also include many stores that do not sell tobacco (e.g. Sears, Dollar Stores, hospital pharmacies), and the NAICS categories do not allow differentiation between sub-classes of stores that do or do not sell tobacco.

Tobacco outlet density using adaptive bandwidth kernel density estimation: A nationwide density surface of the tobacco outlets using adaptive bandwidth kernel density estimation (KDE)(37, 38) and the LandScan™ Global Population Database(39) was produced. Adaptive bandwidth KDE accounts for the underlying population density by limiting the bandwidth of each tobacco outlet to the surrounding population of 1000 people. Setting a limit constrains the influence of a single outlet to a small spatial extent where the population density is high (urban

areas) while in rural areas the reach of the tobacco outlet is geographically larger. For sparsely populated regions, the bandwidth of each tobacco outlet was limited to a 25 km radius to prevent the density calculation from expanding to a spatially unreliable distance. The resultant density surface covers the continental U.S. with pixels that are ~0.5 miles on each side and have a density value in units of tobacco outlets per 1000 people. Each adolescent was assigned the density value based on the pixel at their geocoded location.

Distance to closest tobacco outlet: ArcGIS Network Analyst (ESRI, Redlands, CA) was used to compute the distance along the road network from the adolescent's geocoded location to the closest tobacco outlet. Street data was obtained from the 2008 edition of StreetMap North America,(40) which was created in 2005 and based on the ground conditions in 2003. Other methods of measuring proximity were also considered, including Euclidian distance and driving time. A sensitivity analysis demonstrated no difference between methods in the final model (data not shown).

Census tract measures of race/ethnicity and poverty: Community characteristics that might be confounders for tobacco outlet density and proximity were included. Using the U.S. Census 2000 data, the proportion population Black, the proportion population Hispanic, and the proportion of families with income below the poverty level for each adolescent's census tract were calculated.

Statistical analysis

Pearson correlation coefficients were used to describe the association among community influences. Multiple logistic regression was used to assess the association between individual and

environmental risk factors and ever tried smoking, and multiple ordered logistic regression was used to assess the odds of being higher on the frequency of smoking scale among smokers. Because the majority of the sample resided in unique census tracts, it was not necessary to fit hierarchical models. Instead, the environmental variables were entered as individual-level risk indicators of the adolescent's environment. Some variables (movie smoking exposure, sensation seeking, team sports participation, tobacco outlet density, distance to the closest outlet, proportion population Black, proportion population Hispanic, and proportion families with incomes below the poverty level) were skewed right. In order to limit the influence of high outliers, values higher than the 95th percentile were trimmed to the 95th percentile. Additionally, to allow a comparison of effect size among the variables, friend smoking, movie smoking exposure, tobacco outlet density, proportion of families with incomes below the poverty level, sensation seeking, and team sports participation were rescaled so that the lowest value was 0 and the highest value was 1. This scaling procedure allowed a comparison between the dose-response between individual/community measures and adolescent smoking. Ninety-five percent confidence intervals were assessed based on two-tailed hypothesis assumptions.

RESULTS

Individual and community characteristics: Table 1 describes the characteristics of the adolescents and their correlation with the two smoking outcomes. Thirty-six percent had tried smoking, and this percentage increased across age categories from 18 to 56 percent in 13 and 18 year olds respectively. Among smokers, mean smoking intensity also increased with age. There were no large differences in tried smoking prevalence across gender or race, but smoking

intensity was much lower among Black and Hispanic smokers compared with Whites and those of mixed race. The correlation between community variables and smoking was an order of magnitude lower than correlations with individual characteristics. Whereas tobacco outlet density was positively correlated with trying smoking, it was negatively correlated with smoking intensity. The largest correlation for community predictors was -0.~~13~~19, between proportion population Black and smoking intensity, also consistent with lower smoking intensity among minorities at the individual level.

Table 1. Individual and community risk factors and smoking outcomes (N=3646).

Variable	n	Proportion of Sample	Proportion Who Have Tried Smoking	Smoking Intensity Scale Mean
Individual descriptors				
Categorical				
Age				
13	114	0.03	0.18	~~0.30~~1.81
14	722	0.20	0.24	~~0.23~~1.73
15	827	0.23	0.29	~~0.34~~2.04
16	804	0.22	0.37	~~0.39~~2.21
17	769	0.21	0.43	~~0.51~~2.57
18	410	0.11	0.56	~~0.81~~3.10
Gender				
Male	1,810	0.50	0.38	~~0.49~~2.39
Female	1,836	0.50	0.34	~~0.43~~2.32
Race/ethnicity				
White	2,091	0.57	0.36	~~0.59~~2.74
Black	818	0.22	0.32	~~0.20~~1.61
Hispanic	481	0.13	0.41	~~0.29~~1.89
Mixed race/other	256	0.07	0.38	~~0.57~~2.37
Sibling smokes				
No	2,924	0.80	0.31	~~0.43~~2.29
Yes	720	0.20	0.56	~~0.55~~2.51
Friend smoking				
None	1,615	0.44	0.17	~~0.05~~1.27
Some	1,711	0.47	0.45	~~0.35~~2.15
Most	316	0.09	0.78	~~1.29~~4.23
Ever smoked				
No	2,349	0.64		
Yes	1,297	0.36		
	Median	Quartiles 1 and 3	(correlation)	(correlation)
Continuous				
Smoking Intensity (among smokers)	~~0~~1	~~0~~1,~~1~~3		
Socioeconomic status	0.08	-0.65,0.65	-0.12	~~-~~0.01~~3~~
Movie smoking exposure	558	285,883	0.21	0.05~~4~~
Team sports participation	1	0,2	-0.08	-0.1~~6~~4
Sensation seeking	12	10,14	0.31	0.2~~7~~5

Community descriptors				
Tobacco outlet density (per 1000 people)	0.34	0.03,1.12	0.03	-0.075
Distance (mi) to nearest outlet	0.59	0.29,1.19	0.001	0.03
Proportion population Black[a]	0.03	0.01,0.21	-0.03	-0.193
Proportion population Hispanic[a]	0.03	0.01,0.09	0.02	-0.1008
Poverty[a,b]	0.06	0.03,0.11	0.02	-0.1207

[a]For each adolescent's census tract.

[b]Proportion of families with income below the poverty level.

The community characteristics were also correlated with each other. Higher tobacco outlet density was associated with larger proportions of families with incomes below the poverty level, proportion of the population that was Black and Hispanic (Table 2). Tobacco outlet density decreased as distance to nearest outlet increased (correlation = -0.32), but the relationship was not linear. There was a wide range for distance to closest outlet among adolescents living in low tobacco outlet density areas, and a wide range of densities among adolescents living close to an outlet, justifying the consideration of both factors as being independently associated with smoking behavior.

Table 2. Correlation among the environmental descriptors.

	Correlation				
Environmental descriptor	1	2	3	4	5
1 Tobacco outlet density (per 1000 people)	1.00				
2 Distance (mi) to nearest outlet	-0.32	1.00			
3 Proportion population Black[a]	0.27	-0.17	1.00		
4 Proportion population Hispanic[a]	0.26	-0.13	-0.10	1.00	
5 Poverty[a,b]	0.39	-0.12	0.52	0.38	1.00

[a]For each adolescent's census tract.

[b]Proportion of families with income below the poverty level.

Relation with ever tried smoking: Overall, 35.6 percent of respondents reported ever having tried a cigarette. Being male, being Hispanic, having sibling(s) who smoke, being of lower socioeconomic status, having friends who smoke, being older, having more exposure to movie smoking, not playing team sports, being higher in sensation seeking, and living in a neighborhood with higher tobacco outlet density were all significantly associated with ever trying smoking in the unadjusted models (Table 3). Two types of multivariate models were built to test these associations with ever trying smoking. In the first, only community-level factors

were included; it showed a significant inverse association with proportion of the population that was Black and a significant association with census tract poverty. In the second multivariate model, individual characteristics were added, which substantially improved model fit. Whereas most individual characteristics (sibling smoking, socioeconomic status, friend smoking, age, movie smoking exposure, team sports participation, and sensation seeking) were significantly associated with ever trying smoking in the second model, none of the community characteristics were significantly associated with ever trying smoking. Notably, the coefficient for tobacco outlet density changed little across models and, although small, remained close to statistical significance, in contrast to the other community predictors.

Table 3. Crude and multivariate association with ever tried smoking.

Variable	Crude Odds Ratio	Community only[a] n = 3,621 Adj Odds Ratio	95% CI	All variables[b] n = 3,543 Adj Odds Ratio	95% CI
Individual characteristics					
Categorical					
Gender					
Male	Ref				
Female	0.84*			1.03	0.88,1.21
Race/ethnicity					
White	Ref				
Black	0.85			0.85	0.62,1.18
Hispanic	1.24*			1.18	0.88,1.59
Mixed race/other	1.13			1.08	0.77,1.50
Sibling smokes					
No	Ref				
Yes	2.85*			2.13*	1.75,2.59
Friend smoking					
None	Ref				
Some	3.93*			2.60*	2.19,3.10
Most	17.14*			7.01*	5.05,9.74
Continuous					
Age (for each additional year)	1.39*			1.23*	1.16,1.31
Socioeconomic status	0.76*			0.82*	0.74,0.91
Movie smoking exposure	5.14*			2.66*	1.95,3.63
Team sports participation	0.59*			0.69*	0.54,0.89
Sensation seeking	20.71*			7.72*	5.26,11.34
Community characteristics					
Tobacco outlet density (per 1000 people)	1.30*	1.28	0.97,1.70	1.27	0.92,1.76
Tobacco outlet proximity (distance in miles to nearest outlet)	0.86	0.94	0.69,1.27	0.96	0.67,1.36
Proportion population Black[c]	0.80	0.59*	0.42,0.83	0.93	0.53,1.61
Proportion population Hispanic[c]	1.47	0.87	0.49,1.55	0.88	0.41,1.87
Poverty[c,d]	2.06	3.66*	1.07,12.42	0.74	0.17,3.22

*p<0.05

[a]Pseudo R^2 = 0.003

[b]Pseudo R^2 = 0.20

[c]For each adolescent's census tract

[d]Proportion of families with income below the poverty level

Relation with smoking intensity: Most of the respondents who had tried smoking (73%) reported no smoking in the past 30 days. Multivariate model results for smoking intensity among the experimental smokers are reported in Table 4. Minority status, ~~sibling smoking~~ friend smoking, age, team sports participation, sensation seeking, tobacco outlet density, proportion population Black and Hispanic, and poverty, were all associated with smoking intensity at the bivariate level. In the community-only multivariate model, proportion population Black and Hispanic retained a significant inverse relation with smoking intensity. In the full model, friend smoking, age, and sensation seeking were all associated with higher intensity and being Black or Hispanic and participating in team sports associated with lower intensity. None of the community characteristics retained a statistically significant association with smoking intensity.

The tobacco outlet density—smoking association was not significantly different for those 18 years and older in either the tried smoking or the smoking intensity model. Additionally, excluding subjects for whom Zip Code centroid was used as a proxy for home address had little impact on the results.

Table 4. Crude and multivariate association with smoking intensity among experimental smokers.

Variable	Crude Odds Ratio	Community only[a] n = 1,289 Adj Odds Ratio	95% CI	All variables[b] n = 1,263 Adj Odds Ratio	95% CI
Individual characteristics					
Categorical					
Gender					
Male	Ref				
Female	0.8993			1.059	0.8475,1.330
Race/ethnicity					
White	Ref				
Black	0.259*			0.482*	0.3022,0.7981
Hispanic	0.407*			0.4650*	0.310,0.6983
Mixed race/other	0.60*85			0.53*85	0.3450,1.8542
Sibling smokes					
No	Ref				
Yes	1.2133*			1.9808	0.7681,1.2465
Friend smoking					
None	Ref				
Some	49.7311*			36.378*	23.3729,412.8139
Most	3357.6289*			2032.2798*	136.2243,3166.0819
Continuous					
Age (for each additional year)	1.37*			1.323*	1.210,1.448
Socioeconomic status	10.1098			10.0998	0.9482,1.2617
Movie smoking exposure	1.2914			10.0481	0.6849,1.5934
Team sports participation	0.365*			0.3846*	0.2630,0.5572
Sensation seeking	124.955*			6.5789*	3.7142,113.6488
Community characteristics					
Tobacco outlet density (per 1000 people)	0.62*9	01.9803	0.642,1.5071	1.115	0.7066,12.7903
Tobacco outlet proximity (distance in miles to nearest outlet)	1.3227	0.7683	0.489,1.2040	0.7482	0.456,1.2046

Proportion population Black[c]	0.1523*	0.128*	0.079,0.2237	0.4297	0.1833,12.0084
Proportion population Hispanic[c]	0.204*	0.136*	0.065,0.3245	0.4335	0.1409,1.3342
Poverty[c,d]	0.026*	12.5431	0.245,921.9615	10.1478	0.1305,101.0343

*p<0.05

[a]Pseudo R^2 = 0.021

[b]Pseudo R^2 = 0.154

[c]For each adolescent's census tract.

[d]Proportion of families with income below the poverty level

DISCUSSION

This study highlights the much stronger association between individual health risk factors and youth smoking behavior compared to community risk factors. Two studies that have examined the relationship between tobacco outlet density or proximity and youth smoking have suggested that tobacco outlet density (but not proximity) is associated with youth smoking.(21, 22) Consistent with those studies, in the unadjusted model we saw a statistically significant association between tobacco outlet density and youth smoking, but not after accounting for additional community and individual risk factors for youth smoking. More importantly, the magnitudes of the community associations with youth smoking were small compared to individual risk factors. Thus, regardless of whether the association of tobacco outlet density reached accepted standards for statistical significance, the small potential effect across a broad range of tobacco outlet densities suggests that policies designed to lower density would have only a small impact on adolescent smoking. In contrast, the associations between team sports participation and both smoking outcomes were large enough to suggest that interventions and policies aiming to support those activities could help prevent adolescent smoking.

This study used Bronfenbrenner's Ecological Systems Theory to frame the possible joint effects of individual-level, microsystem, mesosystem, and exosystem variables on youth smoking. When variables were scaled so as to compare effect sizes, our findings indicated a relative importance of individual-level variables compared to the community variables we studied. We suggest empirical multi-level studies pay attention to estimating effects that allow for such comparisons, in addition to focusing on statistical significance. Although we found no strong associations with smoking for the community variables studied, this study does not rule out the possibility that other neighborhood characteristics, such as measures of social capital or neighborhood smoking, may have an important impact on youth smoking. In fact, one study using the Brofenbrenner model found that neighborhood rates of youth smoking affected adolescent smoking trajectories, over and above individual risk factors.(41)

The association between some risk factors and smoking was present for trying smoking but not smoking intensity among experimental smokers, underlying the importance of modeling different smoking transitions separately. Trying smoking is strongly influenced by social risk factors (sibling smoking, friend smoking, movie smoking, and team sports participation). Among experimental smokers, smoking intensity continues to be associated with smoking by some social influence factors—peers, team sports, and exposure to tobacco marketing,(35, 42) but is also is predominantly driven by addiction processes.(43, 44) In this study, sensation seeking was a risk factor for both trying smoking and higher smoking intensity, consistent with other research.(45) Sensation seeking level probably captures, in part, biological characteristics that promote experience seeking(46) and tolerance of deviance,(47) but it may also be associated

with higher sensitivity to the addictive influence of nicotine.(48) Given its large association with both smoking outcomes in this study, research on using sensation seeking to target high risk adolescents,(49) modifying risk factors that affect sensation seeking deserve greater emphasis. For example, one study suggested that higher exposure to adult-rated movies resulted in higher growth in sensation seeking during adolescence.(50)

Consistent with other studies that have distinguished between trying smoking and smoking intensity,(51) some characteristics were associated with one outcome but not the other. Exposure to smoking in movies was associated with trying smoking but not smoking intensity, consistent with some other reports.(35, 42) Minority youth tried smoking at rates similar to White youth, but minority ever smokers had much lower smoking intensity than Whites. This finding is not surprising, given that minority adolescents have lower rates of smoking compared with Whites,(52, 53) with larger temporal declines in smoking among Black adolescents(54) and lower rates of progression to regular use.(55) Studies of trying smoking have been inconsistent, with some confirming lower rates among minorities,(56)whereas others,(57) including this one, did not. Why minority youth that try smoking have lower smoking intensity than Whites deserves further research, given that the finding holds across studies;(52, 55) minority adolescents could be less susceptible to nicotine addiction in its earliest stages or social or family circumstances could reduce the likelihood of progression of experimental smoking during adolescence.

This study was limited in that it relied on cross-sectional data and therefore cannot address temporality. However, it would be ~~an~~ unusual to see a weak correlation in a cross-sectional study

become a key predictor in a longitudinal one. The national scope of the study could be viewed as a strength but precluded us from directly assessing where tobacco outlets were in each community. Instead, we relied on available commercial data, subject to higher levels of error. Although this limitation could have widened confidence intervals due to random error, we have no reason to believe that the error is larger in some neighborhoods than others, which would lead to biased estimates. We suggest that, even if the results were statistically significant, the size of the associations were still small for tobacco outlet density and the other community characteristics we measured.

Compared to individual risk factors, tobacco outlet density might be less relevant for minors who are legally constrained in their purchase of tobacco. One previous study of adolescent smoking found no association for tobacco outlet density but a positive association between access—the proportion of stores that illegally sell to minors—and youth smoking.(25) This suggests that tobacco outlet density could be more important in determining smoking patterns among adults, who are less constrained in their purchase of tobacco at retail outlets. Although we found no evidence for that in the small number of adults present in this sample, further study in adult samples may be indicated. Our study did not explicitly measure exposure to tobacco storefront advertising in the context of community-level influences and therefore cannot address this issue explicitly—we cannot rule out a storefront advertising influence without more elaborate measurements of access to this particular aspect of tobacco retailing. Tobacco outlet density should be a proxy for exposure to storefront advertising but would not capture individual differences in how adolescents respond to or remember it, which could explain differences between our findings and those of others who assessed recollection of storefront advertising.(58)

Finally, we studied tobacco density and proximity at the home, not the school. McCarthy et al. looked at the relationship between tobacco retail density near schools and youth tobacco use and found that the effects were limited to trying smoking (not established smoking), and only among high school students in urban areas.(59) However, their work did not include the depth of individual-level variables presented in this analysis. Future studies should consider the role of school density and proximity to tobacco outlets around schools in context of individual risk factors.

This study adds to the growing body of evidence that public health campaigns to prevent and reduce youth smoking should emphasize individual risk factors for smoking, including supporting participation in team sports, minimizing exposure to movie smoking, addressing the social influence of friend smoking, and addressing experience seeking among high sensation-seekers.

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.