Individual and Neighborhood Socioeconomic Status Effects on Adolescent Smoking: A Multilevel Cohort-Sequential Latent Growth Analysis

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Objectives. We examined the prospective effects of parental education (as a proxy for individual socioeconomic status [SES]) and neighborhood SES on adolescent smoking trajectories and whether the prospective effects of individual SES varied across neighborhood SES.

Methods. The study included 3635 randomly recruited adolescents from 5 age cohorts (12–16 years) assessed semiannually for 3 years in the Minnesota Adolescent Community Cohort study. We employed a cohort–sequential latent growth model to examine smoking from age 12 to 18 years with predictors.

Results. Lower individual SES predicted increased levels of smoking over time. Whereas neighborhood SES had no direct effect, the interaction between individual and neighborhood SES was significant. Among higher and lower neighborhood SES, lower individual SES predicted increased levels of smoking; however, the magnitude of association between lower individual SES and higher smoking levels was significantly greater for higher neighborhood SES.

Conclusions. We found evidence for differential effects of individual SES on adolescent smoking for higher and lower neighborhood SES. The group differences underscore social conditions as fundamental causes of disease and development of interventions and policies to address inequality in the resources. (*Am J Public Health.* 2013;103:543–548. doi:10.2105/AJPH.2012.300830)

There is increasing evidence that the neighborhoods in which people live influence health through such mechanisms as the availability and accessibility of health services and other infrastructure, the prevalence of attitudes toward health and health-related behaviors, stress levels, and social capital.[1]

In addition, research suggests that there are persistent and definite patterns of youth smoking across communities defined by geographical areas and groups defined by gender, race, education level, occupation income, and marital status.[2] These findings substantiate the prospect of environmental influences at the neighborhood level on youth smoking, including both as a direct effect as well as the moderating or conditioning effects of such contexts. To better understand individual behaviors and outcomes, it may be beneficial to analyze not only the characteristics of individuals but also those of the social groups to which they belong.[3] Health behaviors, including youth smoking, are typically studied at the individual level, ignoring the social context that shapes and constrains these behaviors.[4] Even after controlling for numerous individual-level characteristics across multiple studies, significant unexplained variability in smoking remains.[5]

Wilcox has defined neighborhood as a geographic space (although geographic boundaries can be imprecise and variable) in which individuals, their proximal contexts (e.g., families and peer groups), and their physical structures (e.g., stores, churches, farms, schools, hospitals, playgrounds, businesses, billboards, roads) are embedded, resulting in a larger, more distal context that has aggregate social and cultural characteristics of its own.[5] Darling and Steinberg describe the possible mechanism of how context influences outcomes; individuals in a neighborhood share resources and a common sense of identity.[6]

There is an increasing amount of empirical evidence that neighborhood variables may shape the distribution of health-related behaviors of its residents directly, independent of individual variables. A recent literature review on the effect of neighborhood social factors on smoking among adults reported an inverse relationship between neighborhood-level socioeconomic status (SES) and smoking in 4 of 5 studies.[7]

Research on the contextual effects of neighborhood SES on adolescent smoking has produced mixed results.[8–12] However, the majority of studies report an increase in smoking among youths residing in affluent neighborhoods. Ennett et al., for example, report higher rates of lifetime cigarette use in schools located in neighborhoods that have greater social advantages.[13] The study used neighborhood attachment, neighborhood safety, population mobility, population density, and neighborhood drug activity as measures of neighborhood social advantages. Consistent with this finding, MacBride et al. report lower rates of smoking among adolescents residing in poor neighborhoods.[11] Another single study conformed to patterns found in adulthood indicating increased smoking among adolescents residing in disadvantaged neighborhoods.[12] Higher scores on such census variables as poverty rate, percentage of residents receiving public assistance, percentage of woman-headed families, unemployment rate, and percentage with less than a high school diploma were used to define neighborhoods as disadvantaged. These studies emphasize the need to investigate the role of contextual effects further and include individual-level indicators of SES.

A review of the literature examining the association between adolescent smoking and individual SES reveals that adolescents do not consistently show the reciprocal SES and smoking relationship seen with adults. Instead,

studies have found the associations to adhere to a "traditional" (i.e., consistent with adult literature), null, or even reversed pattern.[14]

One major drawback of the prior studies is the lack of examination of cross-level interaction between neighborhood SES and individual SES. A handful of studies have examined how community effects interacted with individual SES, and only 1 study examined the effect of a cross-level interaction between individual and neighborhood SES on smoking.[15] Using longitudinal data from the Taiwan Social Change Survey conducted in 1990, 1995, and 2000, the authors examined the association between both neighborhood-level and individual-level SES on smoking behavior among 5883 individuals older than 20 years living in 434 neighborhoods. They found evidence for an interaction between neighborhood education and individual SES, with higher neighborhood education having a positive effect on smoking for lower SES women but a negative effect on smoking for higher SES women.[15]

We addressed numerous gaps in the existing literature, including a lack of consistent data on the effect of individual SES on adolescent smoking, the effect of neighborhood SES on adolescent smoking, and the possible moderating effect of neighborhood SES on the relation between individual SES and adolescent smoking progression over time.

METHODS

The Minnesota Adolescent Community Cohort study is a prospective cohort study designed to assess the effects of state and local tobacco control policies and programs on youth tobacco use in Minnesota. The study design is detailed elsewhere.[16] Briefly, participants were recruited through cluster random sampling from geopolitical units (GPUs) in Minnesota, Michigan, Kansas, and North and South Dakota. A combination of probability and quota sampling ensured an even distribution of individuals aged 12 through 16 years in 2000. For this analysis, all 5 age cohorts (aged 12–16 years) were followed for 3 years and were linked to form a common developmental trajectory spanning those aged 12 to 18 years, thus limiting the study to adolescents. The final analysis sample includes 3635 participants from Minnesota.

The sample included 50.8% girls and 49.2% boys, and adolescents were 85.2% White, 5.0% African American, 2.5% American Indian, 2.3% Hispanic or Latino, 2.4% Asian, and 2.6% other racial groups.

Measures

Our main outcome measure was smoking progression. We determined smoking level using a combination of 5 items defined as smoking stage on the basis of theoretical perspectives about the onset and progression of cigarette smoking among young people in the United States.[17–19] We assessed smoking practices at each round of data collection, using the following 5 items: "Have you ever smoked a whole cigarette?" "Have you ever tried or experimented with cigarette smoking, even one or two puffs?" "Have you smoked more than one whole cigarette?" "Thinking about the last seven days, on how many of those days did you smoke a cigarette, even one or two puffs?" and "Now thinking about the last 30 days, on how many of those days did you smoke a cigarette, even one or two puffs?"

The smoking stage variable had 6 categories representing increasing levels of smoking (1 = never smoker, 2 = trier, 3 = less than a monthly smoker, 4 = experimental smoker, 5 = regular smoker, 6 = established smoker). We defined a "never smoker" as someone who never smoked (not even a puff) in her or his lifetime. We defined a "trier" as someone who smoked 1 cigarette or less in her or his lifetime. We defined a "less than monthly smoker" as someone who smoked more than 1 cigarette in her or his lifetime but did not smoke in the past 30 days. We defined an "experimenter" as someone who smoked at least once in the past 30 days but not at all in the past week. We defined a "regular smoker" as someone who smoked at least once in the past week but on fewer than 20 days in the past month. Finally, we defined an "established smoker" as someone who smoked daily or most days. All smoking stage categories are mutually exclusive.

Individual socioeconomic status. We used the highest level of education attained by either parent as an indicator of individual SES, dichotomized into low SES (high school or less) and high SES (some college or above).[20,21] We treated parental education attainment as a dichotomous indicator, because the attainment of college education significantly reduces the risk for smoking initiation.[22] We collected information on parental education from adolescents by phone interview.

Neighborhood and geopolitical unit socioeconomic status. No single measure of neighborhood SES was available. Therefore, we combined multiple indicators from the US Census 2000 database to create a measure. We treated these census variables as time invariant and assigned them to study participants on the basis of the GPU where a participant resided at baseline.

Building on the approach by Trim et al.,[23] we conducted principal components analysis[24] on 6 census variables shown to reflect neighborhood SES: percentage with less than a high school diploma, percentage living below the poverty line (income to a poverty ratio of less than 1.5), percentage unemployed (among those aged 16 years and older), percentage of families headed by a woman, median housing value, and median household income. Where needed, we rescaled variables so that high scores on the 6 SES variables reflected higher levels of SES. All 6 census variables loaded highly on the first component, which accounted for 73.54% of the cumulative variance. We used optimal regression weights to create a continuous neighborhood SES variable, which had a mean of zero and an SD of 1 and ranged from −3.39 to 1.86. We used a median split to dichotomize the continuous neighborhood SES variable into 2 levels: lower (below the median) and higher (above the median). We conducted principal components analyses using Proc Factor in SAS for Windows (version 9.1; SAS Institute Inc., Cary, NC).

Other demographic characteristics. We collected demographic information, including gender and race/ethnicity, from participants at baseline. The sample was predominantly White (85.2%). All other races/ethnicities constituted less than 5% each, and we therefore collapsed them into a single category. We coded GPU type (urban vs rural) on the basis of GPU membership. We defined all GPUs in the metro area as urban (Minneapolis and Saint Paul) and the rest as rural.

We collected data on all variables at baseline except smoking level, which we collected at each survey. All covariates in the model, therefore, were time invariant.

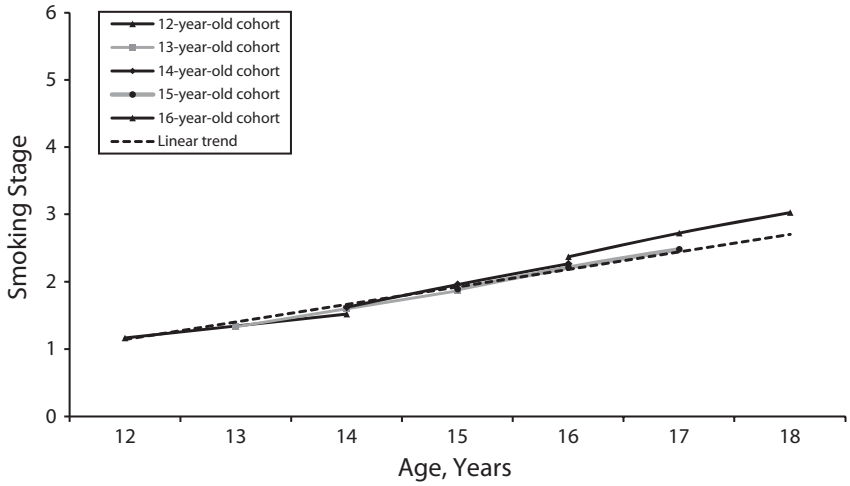


FIGURE 1—Smoking stage (age 12–16 years) joined to form a trajectory of smoking at age 12–18 years: Minnesota Adolescent Community Cohort, 2000–2002.

Analysis

The cohort–sequential or accelerated longitudinal design[25] links adjacent segments of limited longitudinal data from different cohorts to determine the common underlying developmental trend.[25–27] Using this technique, a long-term longitudinal study can be approximated by simultaneously conducting and connecting several short-term longitudinal studies of different age cohorts.[27,28]

We specified a cohort–sequential latent growth model and tested it for existence of a common trajectory for smoking from those aged 12 to 18 years to ensure that the age outcome trajectories did not vary by cohort.[29] In other words, we tested for assumptions of invariance of growth parameters across cohorts (i.e., the viability of specifying a common developmental trend across the 8 years represented by the design).[26] A cohort–sequential latent growth analysis is appropriate for limited repeated measurements of independent age cohorts, resulting in temporally overlapping measurements of the various cohorts. A naive analysis suggested that the adjacent cohort means were fairly similar and that their confidence intervals (CIs) overlapped (i.e., there were no cohort differences).[29] Also, as can be seen in Figure 1, the observed and the estimated means are quite similar, justifying the use of a cohort–sequential model to approximate a true longitudinal curve in these data and supporting the assumption that the cohorts came from the same population.[30] Findings suggested that a linear growth function would accurately describe the overall curve. Additionally, because of the hierarchical nature of the data (adolescents nested in GPUs), we used multilevel modeling to account for clustering,[31] and we obtained the SEs of all estimates through the sandwich estimator option.

We estimated models in a multiple group, multiple cohort context. We constrained all parameters related to the growth factors to be equal across all groups. We held other parameters equal when more than 1 cohort represented an age. A previous study from the Minnesota Adolescent Community Cohort[32] indicated that smoking rates varied by gender, race/ethnicity, and GPU type (i.e., urban vs rural); therefore, we adjusted all models for these covariates. We conducted all analyses in MPlus version 5.2 (Muthén & Muthén, Los Angeles, CA).[30]

RESULTS

The linear accelerated latent growth model fit better than did the no change model (indicated by lower Akaike information criterion and Bayesian information criterion values) and,

TABLE 1—Associations Between Individual SES, Neighborhood SES, and Individual Smoking Behavior: Minnesota Adolescent Community Cohort, 2000–2002

Variable	Model 1, Mean (SE)	Model 2, Mean (SE)	Model 3, Mean (SE)
Individual SES			
Baseline	−0.184** (0.05)	NA	−0.123 (0.07)
Linear rate of change	−0.089** (0.02)	NA	−0.045 (0.03)
Neighborhood SES			
Baseline	NA	−0.071 (0.04)	0.051 (0.09)
Linear rate of change	NA	−0.019 (0.03)	0.062 (0.04)
Individual SES*			
Neighborhood SES			
Baseline	NA	NA	−0.135 (0.10)
Linear rate of change	NA	NA	−0.097* (0.05)
Ethnicity			
Baseline	−0.209 (0.07)	−0.208 (0.08)	−0.197 (0.08)
Linear rate of change	−0.008 (0.023)	−0.009 (0.03)	−0.004 (0.03)
Geopolitical unit type			
Baseline	−0.052 (0.03)	−0.02 (0.04)	−0.014 (0.04)
Linear rate of change	−0.015 (0.02)	−0.009 (0.03)	−0.004 (0.03)
Gender			
Baseline	0.019 (0.03)	0.022** (0.03)	0.020*** (0.03)
Linear rate of change	0.004 (0.01)	0.004 (0.02)	0.006 (0.01)

Note. NA = not available; SES = socioeconomic status. We generated estimates from multiple group, multiple cohort growth models adjusted for gender, ethnicity, and geopolitical unit type at baseline.
*$P < .05$; **$P < .01$; ***$P < .001$.

on the basis of the standalone fit indices, fit the data reasonably well (comparative fit index [CFI] = 0.89; root mean square error of approximation [RMSEA] = 0.09).[33,34] Results from the linear model showed a significant intercept ($M_i = 1.145$; $P < .001$) and a significant slope ($M_s = 0.26$; $P < .001$), suggesting an age effect on smoking behavior. Specifically, the average smoking stage at aged 12 years was just above stage 1 and increased 0.26 stages for every 1-year increase in age from 12 to 18 years. The variances for the intercept ($D_i = 0.316$; $P < .001$) and the slope ($D_s = 0.097$; $P < .001$) indicated considerable variation across individuals in initial smoking behavior and in the developmental trajectory. Both the observed smoking behavior over time by cohort and the overall (across cohort) estimated smoking behavior (via the cohort–sequential model) are shown in Figure 1.

Estimates from the growth curve analyses are presented in Table 1. Model 1 regresses smoking stage on individual SES after adjusting for demographic variables. Baseline levels of smoking were significantly different between high and low SES group individuals ($P < .001$), with low SES youths having a higher average smoking stage at age 12 years than did high SES youths (1.48 vs 1.29, respectively). In addition, there were significant between-group differences in the trajectories of smoking over time. Average smoking stage increased 0.344 per year of age among low SES youths and increased 0.255 per year of age among high SES youths (a difference of 0.089; $P < .001$).

Model 2 demonstrated the effect of neighborhood SES on adolescent smoking (Table 1) after adjusting for demographic variables. There were no significant differences at baseline or in the trajectories (rates of growth) of smoking levels over time between individuals in high versus low SES neighborhoods.

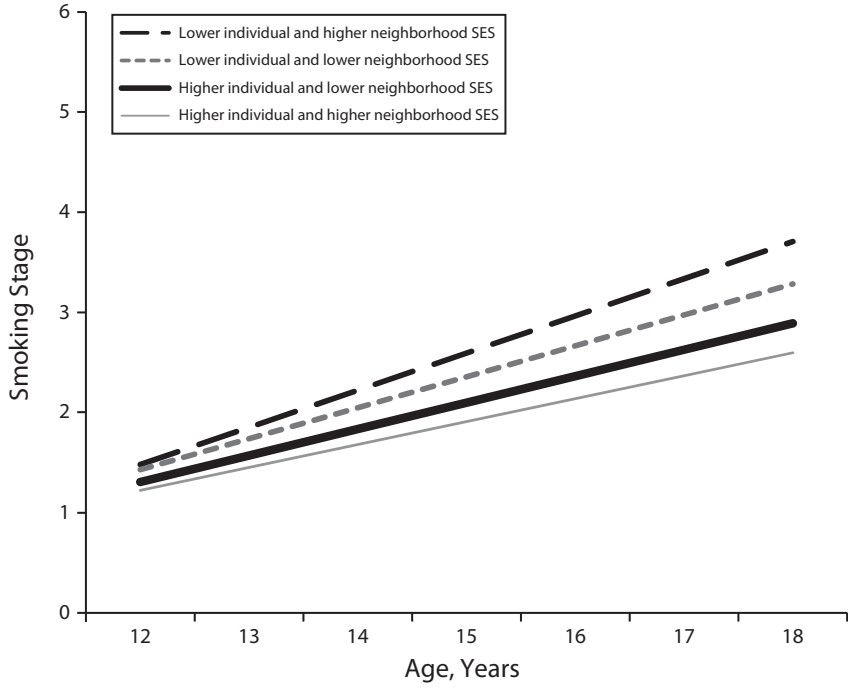
Finally, we examined neighborhood SES as a potential effect modifier of the relationship between individual SES and smoking trajectory after adjusting for demographic variables (model 3). Although baseline levels of smoking were not significantly different between the 4 groups, there were significant between-group differences in the trajectories of smoking over time. Among higher SES neighborhood participants, smoking stage increased more over time among the lower individual SES group (0.371 per year) than among the higher individual SES group (0.229 per year). In addition, among the lower neighborhood SES participants, smoking stage increased more over time among the lower individual SES group (0.309 per year) than among the higher individual SES group (0.264 per year). This interaction is depicted in Figure 2.

DISCUSSION

We examined the prospective relations of individual and neighborhood SES on adolescent smoking progression. We also investigated the moderating effect of neighborhood SES on the relationship between individual SES and adolescent smoking. The results are consistent with those of prior studies that have assessed the effect of parental SES (measured by parental education) on adolescent smoking behavior and found smoking to be most common among adolescents from less educated families.[20,21] Parental SES may exert its effect through behavior modeling and life opportunities for adolescents.[20,35] Lower SES may also reflect adolescents' or family's attitude toward health in general, and therefore adverse health consequences of smoking may not be salient to them. Adolescents from a lower SES background might also experience more stressors and have fewer opportunities, making them more likely to seek instant gratification through smoking.[21] Although we were not able to evaluate the pathways through which individual SES exerts its effect on adolescent smoking in more detail, future studies exploring these potential mechanisms are certainly warranted.

The results did not support the notion that socioeconomic characteristics of communities are directly associated with youth smoking. However, individual socioeconomic position affected smoking behavior differentially, depending on neighborhood socioeconomic context (i.e., individual SES had stronger effects on adolescents residing in more affluent neighborhoods).

Overall, lower SES adolescents had higher levels of smoking over time in both lower and



Note. SES = socioeconomic status.

FIGURE 2—Moderating effect of neighborhood SES on the relationship between individual SES and adolescent smoking over time: Minnesota Adolescent Community Cohort, 2000–2002.

higher SES neighborhoods. However, lower individual SES was a stronger risk factor for smoking progression over time for adolescents residing in more affluent neighborhoods than for adolescents living in less affluent or poor neighborhoods.

Specifically, adolescents with lower individual SES living in more affluent communities had the highest levels of smoking progression compared with other groups. This result supports the hypothesis of "relative deprivation,"[15,36,37] which suggests that residing in communities with higher socioeconomic levels might be detrimental to the health of individuals from less educated or less affluent families. They might experience health effects of structural or psychosocial relative deprivation. Deprivation could cause higher levels of stress and anxiety, leading to smoking as a coping mechanism. This hypothesis, too, should be explored in future studies of adolescent smoking.

A major contribution of this study is the examination of neighborhood influences on adolescent smoking trajectories and its moderating effect on the relationship between individual SES and adolescent smoking. The multiple growth trajectories defined by SES that we have described underscore the significance of both individual and neighborhood socioeconomic influences on smoking behavior.

This study has limitations to be considered when interpreting the results. First is the measurement of individual-level SES. We used highest educational attainment by either parent as a proxy measure for an adolescent's SES. Unlike this study, most published studies have used 2 or more parental characteristics to assess an adolescent's SES. However, education is measured with little error and is more stable over one's lifetime than are alternative measures of SES, such as occupation or income.[38] Second, the current GPU-level measures of socioeconomic status were limited to indicators of structural features (i.e., census-based SES variables), and there were no available data on other characteristics of the socioeconomic context of GPUs such as social and service environments. Future research should examine the effects of different dimensions of neighborhood SES on adolescent smoking. Third, because family mobility is very limited, we did not take into account variation in neighborhood SES over time. Finally, there are some limits to the generalizability of these findings. Our participants were adolescents from the state of Minnesota and may not be representative of the general US population. Therefore, to test the generalizability of the current findings, the study should be replicated in different geographical regions.

This study has several methodological advantages over previous studies, including our use of an accelerated, longitudinal design. Unlike previous group-level studies that had very small sample sizes and therefore limited power to detect group-level effects, the Minnesota Adolescent Community Cohort has a large sample size in terms of both overall number and the number of individuals per group (there are approximately 60 individuals in 60 GPUs in Minnesota, accounting for the total sample size of 3635). Most importantly, this study was the first to our knowledge in the United States to examine the effects of neighborhood SES on changes in amount, frequency, and stabilization of smoking behavior among adolescents longitudinally.

Our findings suggest that continued efforts to prevent or intervene with adolescent smoking may be particularly helpful for adolescents from less educated families residing in affluent neighborhoods. More important, broad-based societal interventions should address inequality in social and economic resources to alleviate fundamental social causes of disease and to improve health.[39] ■

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Contributors

C. Mathur and D. J. Erickson contributed to study conceptualization and design, interpretation of data, and article writing. J. L. Forster contributed to data acquisition and provided final approval of the article. J. R. Finnegan Jr contributed to drafting the article. M. H. Stigler critically revised the article for important intellectual content and provided final approval of the article.

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Human Participant Protection

The University of Minnesota institutional review board approved this study.

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