The Application of Poisson Random-Effects Regression Models to the Analyses of Adolescents’ Current Level of Smoking

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Background. In school-based smoking prevention research, it is still debatable whether parents or peers are most influential in maintaining smoking among adolescents. As a result, this study examines the effects of parental and peer approval of smoking on adolescents’ current levels of smoking.

Methods. Poisson random-effects regression models were used to assess the effects of parental and peer approval of smoking on adolescents’ (n = 913) current level of smoking.

Results. Results of these analyses indicate that a stronger relationship between parental approval of smoking and current level of smoking was found for female adolescents than for male adolescents. Conversely, a stronger relationship between peer approval of smoking and current level of smoking was found for male adolescents than for female adolescents. With respect to race, the influence of parental approval of smoking on adolescents’ current level of smoking was generally more pronounced for minority adolescents, relative to white adolescents. However, the influence of peer approval of smoking on current level of smoking was strongest for white adolescents and was less strong for black, Hispanic, and Asian adolescents.

Conclusion. The findings of this study demonstrated that the effects of parental and peer approval of smoking on adolescents’ current levels of smoking were varied by gender and race. These differential effects may have some implication for the development of future school-based smoking prevention and cessation programs.

Key Words: Poisson random-effects model; count data; smoking prevention; adolescents’ current level of smoking.

INTRODUCTION

Cigarette smoking is a major cause of premature death and disability throughout the world. It has earned the reputation of public health enemy number one. Over the past decade, considerable progress has been made in reducing the prevalence of cigarette smoking among adults, but the prevalence of smoking among adolescents remains high, with the age of onset actually declining over time [1]. As a result, primary concerns of health professionals include not only the prevention of the onset of cigarette use among adolescents, but the reduction of their current levels of smoking as well. However, to facilitate the development of effective smoking cessation programs among adolescents, it would be helpful to identify risk factors that lead to advanced smoking behaviors among adolescents who have already initiated cigarette smoking.

Most research to date has focused on the identification of risk factors for smoking onset or initiation among adolescents. That is, there is a paucity of recent research which has examined the correlates of higher levels of cigarette use among adolescents [2]. This kind of unequal focus can lead to problematic conclusions, such as that the factors which lead adolescents to begin smoking are the same as those which help them to maintain existing levels of smoking. For instance, there are a wide variety of studies which have demonstrated that adolescents whose friends and parents approve (or do not disapprove) of smoking cigarettes are more likely to begin smoking themselves [for a review see 3]. We cannot assume, however, that such friend and family variables remain equally important to the maintenance of current levels of smoking among smokers. There are some studies which have found that parental and peer influences may be important to both onset
and maintained smoking among adolescents [4,5]. This would suggest that school-based programs which target parent and peer influences might effectively reduce the likelihood of smoking onset among adolescents who do not smoke, as well as current levels of smoking among adolescents who are already smokers. However, other research has suggested that peer and parent influences on higher level smoking are greatly diminished [2] or that only peer influences remain as stronger predictors of higher level smoking [6]. Thus, while existing evidence clearly speaks to the notion of targeting parental and peer influences when trying to prevent smoking onset, the implications for adolescent smoking cessation programs are less clear. Additional research is needed to shed further light on the types of approaches that might effectively be used in this regard.

Explanations for changing trends in rates of smoking among boys and girls has also ignited an interest in exploring the effects of gender differences in peer and parent predictors of smoking. Female smoking in first half of 20th century was considerably lower than males [7]. By the post-1960s, however, this gap began to decrease. Despite a move toward the increased expression of masculine and androgynous traits, gender socialization and identity acquisition shows that females remain more people-oriented and that males still display more independence [8]. Given this, we might expect girls' smoking to be influenced more by others' (parents and peers) behaviors and opinions on smoking. On the other hand, boys may be less likely to be influenced by the same.

However, there is little existing information regarding gender differences in the influences of parents and friends on higher levels of smoking. While some work has suggested that peer and parental approval of smoking may be more strongly related to the maintenance/escalation of smoking behaviors among girls [8], there is little other evidence available by which to compare these findings. Flay and colleagues compared structural models predicting smoking initiation and escalation among adolescents, but only tested for gender and ethnic differences in the influences on smoking initiation [2]. Similarly while other research [8,10,11] supports the notion that girls may be more influenced by social pressures to smoke than boys, these studies have either focused on smoking initiation or have not distinguished between adolescent levels of smoking in their analyses.

There is a corresponding paucity of available evidence concerning racial/ethnic differences in parent and peer influences on higher levels of adolescent smoking. Differences in family life between racial/ethnic groups may very well lead to cultural differences in susceptibility to peer and parental approval of smoking. Scholars who study cultural diversity and/or racial identity [12,13] remind us that black and Hispanic cultures may often be more family-oriented than white cultures. Therefore, minority socialization patterns that privilege immediate and extended family over peers and others external to family might translate into a stronger influence of parent approval variables on black and Hispanic smoking and a stronger influence of peer approval variables on white smoking.

With regard to current cigarette use among adolescents, the limited amount of extant research on this phenomenon has produced mixed results. For instance, Newcomb and Bentler [14] found that the effects of peer substance use on current levels of adolescent substance use were weakest for black adolescents. However, Hu and colleagues [10] found that both peer and parent predictors of higher level smoking were weaker for blacks than for other racial/ethnic groups. This remains a focus of the current research, as successful adolescent smoking cessation programs will have to be based on techniques which help adolescents from different population subgroups cope with the day-to-day influences on their current level of cigarette smoking [15].

There are also methodological shortcomings in existing research which provide an impetus for these analyses. A large majority of the empirical analyses of adolescent smoking have relied on linear regression models which do not take proper account of the fact that the distribution of responses in a current smoking dependent variable (i.e., the number of cigarettes smoked in the past week) may be positively skewed with a long right tail. Such a distribution of responses much more closely resembles a Poisson distribution. Empirical analyses of adolescent smoking also typically assume an independence between subjects. However, in school-based samples, the smoking behavior of subjects may very well be correlated within classrooms, thereby violating the independence assumption [16–19]. Poisson random-effects regression analyses may be better able to account for the skewed distribution of the dependent variable, as well as the lack of independence between the smoking behaviors of subjects from the same classroom.

In order to inform these matters, the current research examines the determinants of current smoking (number of cigarettes smoked in the past week) among adolescents who have smoked in the past year. Our focus on an advanced stage of smoking will allow us to speak to whether the effects of peer and parental approval differ across stages of cigarette use and if there are both main effects and/or interactions by race and gender. In addition, we also contrast the utility of classic Poisson regression and Poisson random-effects regression techniques to address distributional and independence assumptions which have not been addressed by prior research in this area. Such an effort may uncover important insights for intervention strategies. For instance, if the findings of this research remain consistent
with the notion that the correlates of cigarette smoking change with the adolescents’ current stage of smoking, separate interventions for trials and heavy smokers might be warranted. Results might also suggest a need for differential intervention strategies by race/ethnicity and gender. The majority of all cigarette smokers began smoking while in high school [20]. Thus, research which further informs us as to the determinants of smoking maintenance/escalation among current smokers in high school may be programmatically useful to smoking cessation interventions and may have far-reaching implications for the future health and well-being of this nation’s children.

METHOD

To measure current smoking behavior, we used self-reported responses to the question “How many cigarettes did you smoke in the last 7 days?” The responses were the number of cigarettes smoked by the students. The distribution of responses in our smoking outcome was positively skewed with a long right tail. They generally followed the Poisson distribution. To analyze such count data, researchers often use suboptimal strategies. Sometimes the counts are rescaled to a set of categories (e.g., 0–5, 6–10, and more than 10). These categories and the variables that may predict them are then analyzed as a cross-classified table. Sometimes the counts may also be collapsed all the way to a dichotomy (such as “smoked/did not smoke”), and the scores can be analyzed using logistic regression or a similar technique suitable for binary dependent variables. However, reducing counts to categories wastes information and may dilute statistical power. Moreover, the results may be affected by the choice of cut point in defining the categories. If this is the case, reduction to categories may defeat the purposes of the analysis. A second problematic strategy is to analyze weekly smoking frequencies using ordinary linear regression. The linear regression model relates the expected value of the dependent variable (i.e., number of cigarettes) to the predictors linearly and is likely to produce negative predicted values.

Alternative regression techniques based on nonlinear models can respect the fact that the dependent measures are nonnegative. Moreover, nonlinear models use probability distributions for the dispersion of the dependent variable scores around the expected value. The simplest such nonlinear regression model for count data is the Poisson regression model. Poisson models are commonly used in biomedial and social science research. Recent applications of this model involve modeling doctor consultations [21], daily beverage consumption [22], daily homicide counts [23], and lung cancer mortality among industrial workers [24].

When using classic Poisson regression analyses, the assumption of independence between subjects is made. However, it is reasonable to expect that in any school-based smoking prevention study, current levels of smoking will be correlated to some degree between subjects in the same classroom. Evidence of this correlation lies in the higher variability in the rates of current smoking between classrooms than might be attributed to chance. Poisson random-effects regression models can additionally consider this interdependence of subjects within classrooms [10]. Thus, in the current study, we compare the relative merits of classic Poisson regression and Poisson random-effects regression to appropriately model the correlates of adolescents’ current levels of smoking. Several authors, including Lawless [16], Gaver and O’Muircheartaigh [17], Collings and Margetin [18], Thall [19], and Dean and Lawless [25] have developed Poisson random-effects regression models which include distributed random effects. The distributed for random effects is a convenient choice in the Poisson regression model because it is mathematically easy to manipulate and has a closed-form solution. Details of the derivation of the likelihood function and parameter estimation are discussed elsewhere [26]. For the analysis described below, a computer program written in GAUSS [27] was used to provide model estimates and standard errors. The accuracy of this program was verified in a large simulation study [28].

DATA SET

The study sample included 6,695 seventh-grade students in 287 classrooms within 35 Los Angeles and 12 San Diego schools. These subjects were drawn from six different school districts and were interviewed in April 1986 to measure smoking prevalence [29]. The number of cigarettes smoked in the past 7 days was considered as the dependent measure. Independent measures were gender, race, peer approval of smoking, and parental approval of smoking. Gender was coded as 0 = female and 1 = male. Three dummy-coded variables, black, Hispanic, and other, were created from the race variable with white being the reference group. Peer approval of smoking was assessed by asking the students how many of their 10 closest friends would approve if they smoked cigarettes (from 0 = none to 5 = 8–10 friends). Parental approval of smoking was measured by asking the students how their parents would feel about their smoking (0 = disapprove or 1 = approve or do not care about the smoking status of their children).

Poisson models cannot accurately assign a zero probability to the dependent measure if separate processes are simultaneously at work influencing the dependent measure. For example, in measuring number of cigarettes smoked in the past 7 days, the response “zero” might arise from two circumstances: (a) the adolescents who already began smoking might not have smoked in
the past 7 days and thus their response would be “zero”; or (b) the adolescents who are nonsmokers will respond “zero,” regardless of the predictors considered in the model. If both circumstances are present in the same model, then it is called a zero-inflated Poisson (ZIP) model [22,26,30]. The response “zero” from the second circumstance is different from the response “zero” from the first circumstance. Of the total 6,695 subjects, 5,553 subjects were either nonsmokers or had not smoked in the past 12 months. Therefore, they were dropped from the present analysis. The remaining 1,142 subjects were considered as current smokers. Among the current smokers, 913 subjects had complete data with respect to the variables of interest in this study. Therefore, they were dropped from the present analysis. The remaining 1,142 subjects were considered as current smokers. Among the current smokers, 913 subjects had complete data with respect to ethnic group, gender, peer approval, and parental approval. The sample consisted of 9.64% black, 41.73% white, 33.19% Hispanic, and 15.44% Asian adolescents.

RESULTS

Before fitting the Poisson regression models, some descriptive statistics are presented. Table 1 shows the distribution of the total sample (N = 913) with respect to ethnic group, gender, peer approval, and parental approval. The sample consisted of 9.64% black, 41.73% white, 33.19% Hispanic, and 15.44% Asian adolescents. In terms of gender, 47.86% of the sample were females. With regard to peer approval of smoking, 23.66% of subjects reported having no friends, 23.66% of subjects had 1-2 friends, 19.28% of subjects had 3-4 friends, 12.81% of subjects had 5-6 friends, and 20.59% of subjects had 7-10 friends who approved of their smoking. Conversely, 83.90% of adolescents had parents who did not approve of their smoking and 16.10% of adolescents had parents who did not care about or approved of their smoking.

Table 1 also shows the distributions of the current level of smoking by each of the covariates: race, gender, peer approval, and parental approval of smoking. The number of cigarettes smoked in the past 7 days are grouped into six categories (0, 1-2, 3-4, 5-10, 11-20, and 21+) in constructing Table 1 only. It can be seen that the frequency distribution for the level of smoking in the past 7 days is positively skewed with a long right tail. Over 68% had not smoked in the past seven days,

<table>
<thead>
<tr>
<th>Variables (100)</th>
<th>Number of cigarettes smoked in past 7 days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>Race</td>
<td></td>
</tr>
<tr>
<td>Black (9.64)</td>
<td>77.27</td>
</tr>
<tr>
<td>White (41.73)</td>
<td>67.45</td>
</tr>
<tr>
<td>Hispanic (33.19)</td>
<td>69.31</td>
</tr>
<tr>
<td>Asian (15.44)</td>
<td>64.54</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Female (47.86)</td>
<td>67.73</td>
</tr>
<tr>
<td>Male (52.14)</td>
<td>69.33</td>
</tr>
<tr>
<td>Number of friends approve 10 friends</td>
<td></td>
</tr>
<tr>
<td>0 (23.66)</td>
<td>77.31</td>
</tr>
<tr>
<td>1-2 (23.66)</td>
<td>73.15</td>
</tr>
<tr>
<td>3-4 (19.28)</td>
<td>71.02</td>
</tr>
<tr>
<td>5-6 (12.81)</td>
<td>61.54</td>
</tr>
<tr>
<td>7-10 (20.59)</td>
<td>51.32</td>
</tr>
<tr>
<td>Parental approval*</td>
<td></td>
</tr>
<tr>
<td>Disapprove (83.90)</td>
<td>69.06</td>
</tr>
<tr>
<td>Approve (16.10)</td>
<td>65.99</td>
</tr>
</tbody>
</table>

* Disapprove, disapprove of adolescents’ smoking; approve, approve of or do not care about adolescents’ smoking.
17.85% had smoked 1–2 cigarettes in the past 7 days, and a small percentage of adolescents had smoked at higher levels (e.g., 4.71% smoked 3–4 cigarettes, 3.16% smoked 5–10 cigarettes, and so on). The percentages of current smokers among the black, white, Hispanic, and Asian adolescents were 22.73, 32.55, 30.69, and 35.46%, respectively. These percentages reveal that the prevalence of current smokers among the black adolescents was lower than the prevalence for the other ethnic groups. Among the current smokers, 14.77% of the blacks, 18.64% of the whites, 19.47% of the Hispanics, and 14.18% of the Asians had smoked 1–2 cigarettes in the past 7 days. At a higher level of smoking (i.e., three or more cigarettes), the percentages for the Asian adolescents were higher than the corresponding percentages for the white, black, and Hispanic adolescents. Among the female and male adolescents, 32.27% of the females and 30.67% of the males had smoked at least one cigarette in the past 7 days. Of the adolescents with no friends who approved of their smoking, 77.31% had not smoked in the past 7 days. With one to two friends who approved of smoking, 73.15% of adolescents had not smoked in the past 7 days. With an increase in the number of friends who approved of smoking, the percentages of current smoking in the past 7 days increased. Among the adolescents with disapproval of smoking from their parents, 69.06% of them had not smoked in the past 7 days and 7.84% had smoked 5 or more cigarettes in the past 7 days. Conversely, 65.99% of the adolescents whose parents approved of their smoking had not smoked in the past 7 days and 14.28% had smoked 5 or more cigarettes in the past 7 days. In general, disapproval by parents of smoking was associated with lower levels of current smoking among the adolescents.

Table 2 lists results from the classic Poisson and the Poisson random-effects models assuming γ distributions for the random effects. The log-likelihood values are $-3355.696$ for the classic Poisson model and $-2132.879$ for the Poisson random-effects model. By the likelihood ratio test, the Poisson random-effects model fit the data better than the classic Poisson model ($\chi^2 = 2445.634$, df = 1).

Table 2 lists the estimates, standard errors, and $t$-values for the classical Poisson regression and the Poisson random-effects regression models. Notice that including the random effect in the model changed the estimates of regression coefficients and their standard errors relative to those obtained in the classic Poisson regression model (in columns 2 and 3). However, the signs of the coefficients did not change across models. Since the Poisson random-effects regression model provided a better fit to the data, the estimates associated with this model will now be discussed. Before discussing the interpretation of the main effects, interpretation of the interactions will be discussed.

The interaction effect of gender and race was statistically significant. The significance of the interaction between gender and race can be interpreted in two equivalent ways: (a) race differences vary by gender, or (b) gender differences vary by race. For example, based on the model for females the coefficients for white, black, Hispanic, and Asian were $-1.313$, $0.623$, $0.530$, and $0.696$, respectively. For males, the corresponding coefficients were $-0.972$, $-0.419$, $0.995$, and $-0.356$, respectively. Thus, controlling for gender, the coefficients for white, black, Hispanic, and Asian were different. Analogously, controlling for race, the coefficients for male and female were also different.

The interaction effect of gender and peer approval (Gender $\times$ Fri_app) was estimated as 0.141 and was statistically significant. This indicates that the number of friends who approved of smoking had differential effects by gender on the number of cigarettes smoked in the past 7 days. With higher numbers of friends who approved of their smoking, male adolescents smoked more cigarettes in the past 7 days than female adolescents. In other words, the positive relationship between friends’ approval of smoking and number of cigarettes smoked (in the past 7 days) was more pronounced for males than females. Conversely, the interaction effect of gender and parental approval (Gender $\times$ Par_app) was negative (estimated as $-0.530$) and statistically significant. This indicates that there was a less pronounced relationship between parental approval of smoking and number of cigarettes smoked for males than females. In other words, the female adolescents were less likely to smoke if their parents disapproved of smoking compared to male adolescents.

The interaction effect of race and peer approval of smoking was also significant. The coefficients for Black $\times$ Fri_app, Hispanic $\times$ Fri_app, and Asian $\times$ Fri_app were estimated as $-0.509$, $-0.334$, and $-0.014$, respectively. The statistical significance of the coefficients for Black $\times$ Fri_app and Hispanic $\times$ Fri_app indicates that the effects of peer approval of smoking varied by race. The coefficient for Asian $\times$ Fri_app was not statistically significant. This suggests that the effect of peer approval of smoking for Asian adolescents was not different from the effect of peer approval of smoking for white adolescents. The effects of peer approval of smoking on current level of smoking for the white, black, Hispanic, and Asian adolescents were 0.522, (0.522 – 0.509) = 0.013, (0.522 – 0.334) = 0.188, and (0.522 – 0.014) = 0.508, respectively. These coefficients indicate that with an increase in number of friends who approved of smoking, white and Asian adolescents smoked relatively higher numbers of cigarettes than black and Hispanic adolescents.

Finally, there was also a significant interaction between race/ethnicity and parental approval of smoking.
**TABLE 2**
Significant Predictors of Current Levels of Smoking among Ever Smokers (N = 913)

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>SE</th>
<th>t value</th>
<th></th>
<th>Estimate</th>
<th>SE</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-1.066</td>
<td>0.143</td>
<td>-7.437</td>
<td></td>
<td>-1.313</td>
<td>0.141</td>
<td>-9.293</td>
</tr>
<tr>
<td>Black</td>
<td>1.102</td>
<td>0.259</td>
<td>4.239</td>
<td></td>
<td>0.623</td>
<td>0.334</td>
<td>1.865</td>
</tr>
<tr>
<td>Hispanic</td>
<td>0.306</td>
<td>0.166</td>
<td>1.842</td>
<td></td>
<td>0.530</td>
<td>0.097</td>
<td>5.427</td>
</tr>
<tr>
<td>Asian</td>
<td>0.830</td>
<td>0.179</td>
<td>4.633</td>
<td></td>
<td>0.696</td>
<td>0.103</td>
<td>6.752</td>
</tr>
<tr>
<td>Gender (0 = Female)</td>
<td>0.123</td>
<td>0.152</td>
<td>0.808</td>
<td></td>
<td>0.341</td>
<td>0.079</td>
<td>4.279</td>
</tr>
<tr>
<td>Friends' approval</td>
<td>0.453</td>
<td>0.039</td>
<td>11.445</td>
<td></td>
<td>0.522</td>
<td>0.022</td>
<td>23.774</td>
</tr>
<tr>
<td>Parental approval</td>
<td>0.671</td>
<td>0.098</td>
<td>6.811</td>
<td></td>
<td>0.980</td>
<td>0.042</td>
<td>23.270</td>
</tr>
<tr>
<td>Gender × black</td>
<td>-1.758</td>
<td>0.245</td>
<td>-7.151</td>
<td></td>
<td>-1.383</td>
<td>0.216</td>
<td>-6.386</td>
</tr>
<tr>
<td>Gender × Asian</td>
<td>0.044</td>
<td>0.129</td>
<td>-4.764</td>
<td></td>
<td>0.124</td>
<td>0.051</td>
<td>2.407</td>
</tr>
<tr>
<td>Gender × friends' approval</td>
<td>0.141</td>
<td>0.038</td>
<td>4.585</td>
<td></td>
<td>0.141</td>
<td>0.020</td>
<td>6.920</td>
</tr>
<tr>
<td>Gender × parental approval</td>
<td>-0.002</td>
<td>0.103</td>
<td>-0.204</td>
<td></td>
<td>-0.530</td>
<td>0.046</td>
<td>-11.431</td>
</tr>
<tr>
<td>Black × friends' approval</td>
<td>-0.571</td>
<td>0.081</td>
<td>-7.061</td>
<td></td>
<td>-0.509</td>
<td>0.077</td>
<td>-6.607</td>
</tr>
<tr>
<td>Hispanic × friends' approval</td>
<td>-0.151</td>
<td>0.044</td>
<td>-3.394</td>
<td></td>
<td>-0.334</td>
<td>0.019</td>
<td>-16.902</td>
</tr>
<tr>
<td>Asian × friends' approval</td>
<td>-0.059</td>
<td>0.048</td>
<td>-2.128</td>
<td></td>
<td>-0.014</td>
<td>0.021</td>
<td>-0.675</td>
</tr>
<tr>
<td>Black × parental approval</td>
<td>0.705</td>
<td>0.244</td>
<td>2.888</td>
<td></td>
<td>0.486</td>
<td>0.296</td>
<td>1.639</td>
</tr>
<tr>
<td>Hispanic × parental approval</td>
<td>0.137</td>
<td>0.123</td>
<td>1.112</td>
<td></td>
<td>0.192</td>
<td>0.065</td>
<td>2.940</td>
</tr>
<tr>
<td>Asian × parental approval</td>
<td>0.099</td>
<td>0.124</td>
<td>0.801</td>
<td></td>
<td>0.684</td>
<td>0.055</td>
<td>12.314</td>
</tr>
</tbody>
</table>

φ (Variance = 1/φ)  
Log L: -3355.696  
-2132.879

The estimated coefficients for Black × Par_app, Hispanic × Par_app, and Asian × Par_app were 0.486, 0.192, and 0.684, respectively. The significance of the coefficients for Hispanic × Par_app and Asian × Par_app indicates that the effects of parental approval of smoking on current smoking were significantly greater for the Hispanic and Asian adolescents than for the white adolescents. This difference was nearly significant (t = 1.64) for Black adolescents as well. For whites, blacks, Hispanics, and Asians, we calculated these effects to be 0.980, (0.980 + 0.486) = 1.466, (0.980 + 0.192) = 1.172, and (0.980 + 0.684) = 1.664, respectively. The coefficients indicate that the effects of parental approval of smoking were lowest for whites, highest for Asians, and were in between for blacks and Hispanics.

Based on the model estimates, separate regression lines can be derived for each race and gender subgroup to further illustrate the effects of peer approval and parental approval of smoking on the number of cigarettes smoked in the past 7 days. Using the equations shown in the Appendix, Table 3 lists the estimated mean number of cigarettes smoked in the past 7 days at the observed mean levels of peer approval and parental approval of smoking. The black male adolescents smoked the lowest number of cigarettes in the past 7 days (estimated mean 0.296), while the white male and female adolescents smoked the highest number of cigarettes in the past 7 days (estimated mean 1.282 and 1.218, respectively). Averaging over gender, black adolescents smoked the least, white adolescents smoked the most, and Hispanic and Asian adolescents were in between.

**DISCUSSION AND CONCLUSION**

When examining the determinants of the number of cigarettes smoked in the past 7 days, Poisson regression models may more accurately capture the distributional properties of the dependent variable than linear regression techniques. In addition, when students are nested within classrooms in school-based smoking prevention studies, Poisson random-effects regression models are additionally needed to account for the clustering of children with similar cigarette smoking tendencies within classrooms. In this article, the correlates of the number of cigarettes smoked in the past 7 days were compared using the classic Poisson regression model and a Poisson random-effects regression model. The Poisson random-effects regression model provided a better overall fit to the data than the classic model. This suggests that the significant clustering of behaviors within classrooms makes Poisson random-effects models, compared to classic Poisson models, more appropriate analytic technique for school-based data on current cigarette smoking.

These findings also represent a departure from many other studies of adolescent cigarette smoking in that they reflect the correlates of current level of smoking among a sample of smokers. The process of becoming
TABLE 3
Estimated Mean Number of Cigarettes Smoked in the Past 7 Days Using the Fitted Poisson Random-Effects Regression Model

<table>
<thead>
<tr>
<th>Race</th>
<th>Gender</th>
<th>Intercept</th>
<th>$\hat{\beta}_{\text{Fri},\text{app}}$</th>
<th>$\hat{\beta}_{\text{Par},\text{app}}$</th>
<th>Fri_app</th>
<th>Par_app</th>
<th>$\lambda$</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Female</td>
<td>-1.569</td>
<td>0.598</td>
<td>1.007</td>
<td>2.280</td>
<td>0.400</td>
<td>1.218</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>-1.242</td>
<td>0.704</td>
<td>0.525</td>
<td>1.766</td>
<td>0.471</td>
<td>1.282</td>
</tr>
<tr>
<td>Black</td>
<td>Female</td>
<td>-0.774</td>
<td>0.011</td>
<td>1.392</td>
<td>1.727</td>
<td>0.409</td>
<td>0.830</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>-1.958</td>
<td>0.117</td>
<td>0.910</td>
<td>1.590</td>
<td>0.613</td>
<td>0.296</td>
</tr>
<tr>
<td>Hispanic</td>
<td>Female</td>
<td>-1.053</td>
<td>0.213</td>
<td>1.203</td>
<td>1.811</td>
<td>0.279</td>
<td>0.717</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>-0.584</td>
<td>0.319</td>
<td>0.721</td>
<td>1.631</td>
<td>0.437</td>
<td>1.180</td>
</tr>
<tr>
<td>Asian</td>
<td>Female</td>
<td>-0.665</td>
<td>0.576</td>
<td>1.665</td>
<td>0.773</td>
<td>0.185</td>
<td>1.092</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>-1.713</td>
<td>0.682</td>
<td>1.182</td>
<td>1.651</td>
<td>0.348</td>
<td>0.838</td>
</tr>
</tbody>
</table>

Note. Fri_app, friends’ approval; Par_app, parental approval. $\lambda$, mean number of cigarettes smoked in the past 7 days.

A cigarette smoker may be comprised of four distinct stages [31]—(1) preparation, (2) trying, (3) experimentation, and (4) regular use. There are numerous empirical analyses of the transition from having never smoked to smoking at some level among adolescents [3]. These studies would mostly reflect the correlates of transitions from the preparatory to the trying stage of smoking. Far less is known about the determinants of higher level smoking among adolescents [9], and as a result, this research examined the correlates of regular smoking (stage 4) among high school students. We now consider some of our findings in turn.

Our descriptive analyses indicated that within this sample of adolescents who had smoked within the past year, boys were less likely than girls to have reported smoking cigarettes in the past week. Work by Mitchel and Amos [32] supports this gender pattern. Similarly, African-Americans were less likely than other racial/ethnic groups to be current smokers. However, multivariate results suggested that gender and race also interacted as black male adolescents reported smoking the fewest number of cigarettes while white males reported smoking the most cigarettes in the past week. While many of these findings corroborate those of larger epidemiological analyses of current cigarette smoking in the United States [33,34] they may reflect gender and ethnic differences in the true rate of smoking or merely in the reporting of current cigarette smoking by adolescents. It is important for future analyses to determine the extent to which these and other findings may be the result of systematic differences between children in the labeling and/or reporting of smoking events or in actual smoking behavior.

Findings obtained from the random-effects model reveal some clear, consistent, and interpretable differences in correlates of higher level smoking among adolescents. Peer and parental approval of smoking displayed strong, significant main effects on the number of cigarettes smoked in the past 7 days. There is a considerable amount of empirical literature which suggests that parental and peer approval of smoking may be related to smoking onset among adolescents [2,3,9,10]. However, evidence regarding parent and peer influences on higher level smoking is less consistent [2,4–6]. The findings of this study are most consistent with prior work which has suggested that parent and peer influences remain important across various levels of cigarette use [4,5]. However, the cross-sectional nature of these findings is a limitation, and these results require longitudinal replication before stronger preventive implications can be drawn. In addition, the data did not include separate measures of approval for each parent. Thus, differences in adolescent responses to maternal or paternal approval of smoking could not be addressed and also remain an important direction for subsequent inquiry. Nevertheless, these findings remain consistent with the notion that programs which similarly target the social influences of parents and peers on cigarette smoking may have a dual effectiveness in that they may reduce the likelihood of onset among adolescents who do not smoke, while at the same time reducing current levels of smoking among adolescents who are already smokers.

Our multiplicative results also suggested that the influences of parents and peers may operate differentially for boys and girls, as well as for children of different race or ethnic groups. A stronger relationship between parental approval of smoking and current level of smoking was found for female adolescents than for male adolescents. However, the relationship between peer approval of smoking and current smoking was most pronounced for male adolescents. These findings run somewhat contrary to those which have found both peer and parent influences to be stronger for girls [6,10,11]. However, as most of these studies reflect the transitions between earlier stages of cigarette use, it remains a possibility that once smoking initiation has taken place, parental approval remains more important to smoking maintenance among girls while approval from peers becomes more crucial to the maintenance of boys’ smoking habits.
With respect to race, these findings generally indicated that peer approval was less important to current smoking among black and Hispanic youth than among white youth. On the other hand, parental approval of smoking was somewhat more influential to the current smoking tendencies of minority youth than white youth. This supports the notion that minority socialization patterns that place an increased importance in the immediate and extended family over peers [12,13] might translate into an increased susceptibility of black and Hispanic adolescents to parental approval of smoking and their decreased susceptibility to similar peer influences. Another possible explanation for these findings comes from recent evidence which has suggested that susceptibility to prodrug social influences may not necessarily be positively related to the number of drug-using models to which an adolescent is exposed [10]. This could also explain vulnerabilities to parent and peer influences which vary systematically with race/ethnicity. For example, to the extent that minority children are, on average, increasingly forced to adapt to neighborhoods in which they are exposed to models of drug-using behavior on a day-to-day basis, their development of an increased resiliency to the influences of peer drug approval (such as approval of regular cigarette use) might be expected. On the other hand, when coping with these types of influences out of the home, stabilizing forces within the family, such as disapproval of drug use by parents, may become particularly important. While either of these explanations would account for the decreased black and Hispanic susceptibility to peer drug approval, and their increased susceptibility to parental drug approval observed in these data, these findings also require longitudinal replication in another data set. Furthermore, the mechanisms by which ethnically based vulnerability and resiliency may take place remain unclear and are an important area for future investigation.

In summary, this research suggests that Poisson random-effects regression may be an appropriate methodology for analyzing the number of cigarettes smoked in school-based prevention studies. In addition, this research also demonstrated that the tendency of students with similar smoking behaviors to be grouped within classrooms in schools may bias the estimates of analyses which do not use random-effects or other techniques which can account for this type of clustering in data. Finally, as the majority of existing research on adolescent smoking has focused on the determinants of smoking onset or initiation, the current analyses were specifically structured to assess associations between parent and peer influences and the maintenance of smoking behaviors among adolescents who have already started smoking. While further replication in other data are needed, these findings indicated that smoking cessation programs among adolescents may need to target both parent and peer influences in the adolescent’s lives. However, these influences may vary considerably by the gender and race/ethnicity of the child. The majority of all current cigarette smokers began smoking while in high school [20]. Thus, additional research which can further inform us of the etiological mechanisms which underlie these relationships may be especially useful to smoking cessation intervention development and may have important implications for the future health and well-being of this nation’s school children.

**APPENDIX**

For the white female adolescents (i.e., Gender = 0 and Black = 0 and Hispanic = 0 and Asian = 0),
\[
\lambda = \exp(-1.313 + .522*\text{Fri\_app} + .980*\text{Par\_app})
\]
For the white male adolescents (i.e., Gender = 1 and Black = 0 and Hispanic = 0 and Asian = 0),
\[
\lambda = \exp(-1.313 + .341 + .522*\text{Fri\_app} \\
+ .980*\text{Par\_app} + .141*\text{Fri\_app} \\
- .530*\text{Par\_app}) \\
= \exp(-.972 + .663*\text{Fri\_app} + .450*\text{Par\_app}).
\]
For the black female adolescents (i.e., Gender = 0 and Black = 1),
\[
\lambda = \exp(-1.313 + .623 + .522*\text{Fri\_app} \\
+ .980*\text{Par\_app} - .509*\text{Fri\_app} \\
+ .486*\text{Par\_app}) \\
= \exp(-.690 + .013*\text{Fri\_app} + 1.466*\text{Par\_app}).
\]
For the black male adolescents (i.e., Gender = 1 and Black = 1),
\[
\lambda = \exp(-1.313 + .623 + .341 + .522*\text{Fri\_app} \\
+ .980*\text{Par\_app} - 1.383 + .141*\text{Fri\_app} \\
- .530*\text{Par\_app} - .509*\text{Fri\_app} \\
+ .486*\text{Par\_app}) \\
= \exp(-1.732 + .154*\text{Fri\_app} + .936*\text{Par\_app}).
\]
For the Hispanic female adolescents (i.e., Gender = 0 and Hispanic = 1),
\[ \hat{\lambda} = \exp(-1.313 + 0.530 + 0.522 \cdot \text{Fri}_\text{app} \\
+ 0.980 \cdot \text{Par}_\text{app} - 0.334 \cdot \text{Fri}_\text{app} \\
+ 192 \cdot \text{Par}_\text{app}) \\
= \exp(-0.783 + 0.188 \cdot \text{Fri}_\text{app} + 1.172 \cdot \text{Par}_\text{app}). \]

For the Hispanic male adolescents (i.e., Gender = 1 and Hispanic = 1),

\[ \hat{\lambda} = \exp(-1.313 + 0.530 + 0.341 + 0.522 \cdot \text{Fri}_\text{app} \\
+ 0.980 \cdot \text{Par}_\text{app} + 0.124 + 0.141 \cdot \text{Fri}_\text{app} \\
- 0.530 \cdot \text{Par}_\text{app} - 0.334 \cdot \text{Fri}_\text{app} \\
+ 0.192 \cdot \text{Par}_\text{app}) \\
= \exp(-0.318 + 0.329 \cdot \text{Fri}_\text{app} + 0.642 \cdot \text{Par}_\text{app}). \]

For the Asian female adolescents (i.e., Gender = 0 and Asian = 1),

\[ \hat{\lambda} = \exp(-1.313 + 0.696 + 0.522 \cdot \text{Fri}_\text{app} \\
+ 0.980 \cdot \text{Par}_\text{app} - 0.014 \cdot \text{Fri}_\text{app} \\
+ 0.684 \cdot \text{Par}_\text{app}) \\
= \exp(-0.617 + 0.508 \cdot \text{Fri}_\text{app} + 1.664 \cdot \text{Par}_\text{app}). \]

For the Asian male adolescents (i.e., Gender = 1 and Asian = 1),

\[ \hat{\lambda} = \exp(-1.313 + 0.696 + 0.341 + 0.522 \cdot \text{Fri}_\text{app} \\
+ 0.980 \cdot \text{Par}_\text{app} - 1.393 + 0.141 \cdot \text{Fri}_\text{app} \\
- 0.530 \cdot \text{Par}_\text{app} - 0.014 \cdot \text{Fri}_\text{app} \\
+ 0.684 \cdot \text{Par}_\text{app}) \\
= \exp(-1.669 + 0.649 \cdot \text{Fri}_\text{app} + 1.134 \cdot \text{Par}_\text{app}). \]

**REFERENCES**


26. Greene W. Accounting for excess zeros and sample selection in
