Effects of Health Education on Substance Use in Adolescence: Implications for Policy*

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Abstract: The pattern of tobacco addiction, alcohol addiction, and drug addiction typically begin in teenage years. Young people begin smoking tobacco, drinking alcohol, and using substances for various psycho-social reasons. The first priority of policy-makers should be to prevent first use, and educate adolescents about addiction and health consequences of substance use. Social influences-based community prevention programs can significantly delay the onset of the tobacco and other substance use, and slow the rate of increase in substance use prevalence among whole populations of early adolescents. In this paper the effects of social influences-based community prevention programs is investigated from the longitudinal perspective. The analyses demonstrated the community prevention program positively affected adolescent substance use behavior. It was shown that the community based prevention trial resulted in a smaller rate of increase in substance use behavior in adolescence across all waves.

Keywords: Program evaluation, longitudinal assessment, Health education, school performance, Mean and covariance structure modeling

Studies have conclusively shown that smoking tobacco, drinking alcohol, and using drugs are profoundly addictive. The pattern of tobacco addiction, alcohol addiction, and drug addiction typically begin in teenage years. Young people begin smoking tobacco, drinking alcohol, and using substances for various psycho-social reasons: peer pressure, easy access, parental role models, defiance, and image of maturity. While we develop better treatment for addiction in adulthood, it is important to keep in mind that prevention is the sole most effective treatment for the development of addictive disorders. The first priority of policy-makers should be to prevent first use, and educate

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adolescents about addiction and health consequences of substance use.

Several reviews of substance abuse prevention literature conclude that social influences-based community prevention programs can significantly delay the onset of the tobacco, alcohol, and other drug use and slow the rate of increase in substance use prevalence among whole populations of early adolescents. A Social influence-based community prevention program is able to reach and positively affect baseline tobacco. alcohol and other substance users. And in a time of diminishing financial resources, many argue for spending limited funds on targeted interventions focusing on high risk youth. But while we know several of the risk factors that describe an individual at high risk for druguse,itisadifficultundertakingtoidentify and target these individuals. In addition, separating individuals identified as high risk from the rest of the class for targeted programming may be both stigmatizing to the individual and potentially disruptive to the classroom environment. There is some concern that even targeted interventions often do not reach most of the high risk youth for which they are designed. For instance, providing after-school programs to high risk youth may fail if youth for whom they are designed do not attend the voluntary extra activities. Another concern is that these "high risk" interventions often target older youth, who are clearly identifiable by early substance use and other high risk behaviors. The advantage of a primary prevention program is that it may reach and affect a "silent", not-yet-identified high risk population of early drug users in a non-stigmatizing, non-labeling, fashion at an age when youth are more easily persuaded, treating the young users in effect like non-users contemplating use.

Adolescent smoking behavior is no longer a matter of a few individuals in our society, but has become a national concern, which has to be understood in the context of social climate. In fact, an amazing number of adolescents are involved in smoking behavior. The age of beginning smoking behavior is an important contextual variable that influences the success of intervention programs.

The risk factors can be divided into two categories. First are societal and cultural factors, which provide the legal and normative expectations for behavior. The second group includes factors that lie within individuals and their interpersonal environments. Current knowledge about the risk factors for substance abuse does not provide a panacea for prevention, but it does point to potential routes for preventive intervention. Predecessors of smoking and alcohol problems have been described as risk factors for substance abuse. Risk factors occur before substance abuse and are associated statistically with an increased probability of drug abuse. A risk-focused approach seeks to prevent substance abuse by eliminating or mitigating its precursors.

This research suggests that a promising method for prevention research lies in testing interventions on early risk factors for substance abuse from the developmental point of view.

Policies and health education programs need to become much more sensitive to understanding the developmental profile of adolescent substance use behavior.

Acknowledging growth profile requires an awareness of the initial status and growth rate of adolescent substance use behavior.

A substantial body of research on substance use has accumulated in the past several decades and has provided the empirical basis for identifying substance use and resiliency factors. Accumulated research findings have simultaneously provided the foundation for conceptual models for substance use. It is well known that, as an age group, youth are particularly susceptible to developing substance use problems. However, every adolescent is not at the same risk; some are more clearly vulnerable than others. Therefore, identifying the risk and protective factors and the mechanism through which such factors work out. Much of the research on substance use has focused on youth in order to develop and test prevention approaches likely to be effective with this vulnerable age group. Many studies have contributed greatly to understanding the correlates and predictors of substance use among adolescent. Social-environmental factors associated with adolescent substance use include family or peer approval ofdrug use, family orpeer models of substance use, peer pressure to use substance, and ready access to substance (see Murray& Hannen, 1990). Hawkins and his colleagues a social development model (Hawkins, Lishner, Catalano, & Howard, 1986) blends the work of earlier theorists. Hawkins et al. include elements of social control theory (Hirschi, 1969) and social learning theory (Bandura, 1977), and consider substance use experimentation from a developmental perspective in their model.

In this study we intend to apply the latent growth curve analysis to the investigation of adolescent smoking behavior from a developmental perspective. Using the fundamental form of growth curve analysis, this study will focus on the two parameters that reflect growth profile: the initial point of growth and the rate, or trajectory, of growth. A longitudinal data set obtained from a school-based smoking prevention program developed for adolescents is used. Two common assumptions on growth trajectories of smoking behavior among adolescents are considered in this paper: the linear growth trajectories and curvilinear, or quadratic, growth trajectories. The linear growth assumption models a monotonic increase on smoking behavior while the curvilinear assumption hypothesizes that smoking behavior among adolescents increases at a faster pace and then levels off. Using school as the unit of analysis, the outcome variable is school prevalence of cigarette use in the last month. Schools were observed repeatedly at five occasions. Two variables available at the school level, intervention conditions (program or control) and school types (public or private), are used to investigate their impact on the differences in growth trajectory.

Measuring growth has been a very fascinating challenge for social scientists (Bock & Tissen, 1980; McArdle & Aber, 1990; Meredith & Tisak, 1990; Rogosa, Brandt & Zimowski, 1982; Rogosa & Willet, 1985; Willet, 1988). To better understand individual change, or growth profile, it is necessary to include time in a model. An approach that includes time in the model can be regarded as a type of growth profile analysis. Growth curve models have various traditions in broad areas, such as biostatistics (Laird

& Ware, 1982; Liang & Zeger, 1986; Rao, 1958; Zeger & Liang, 1986), educational statistics (Bryk & Raudenbush, 1992; Burstein, 1980; Goldstein, 1987; Rogosa & Willet, 1985), and psychometrics (McArdle & Epstein, 1987; Meredith & Tisak, 1990; Tucker, 1958).

A growth curve model usually considers repeated measures of an outcome behavior as a function of time and other measures. Two of the most frequently considered components in the investigation of growth profiles are initial status of the growth curve and the rate, or trajectory, of growth. Understanding systematic changes among these two growth components due to individual differences is critical. One approach to better understand how and why each adolescent develops different smoking behavior is to examine the influence of individual background variables on the growth trajectory of smoking behavior. It is important to find out what factors may affect some adolescents to have higher level of use than others at younger ages and what conditions may change the level of use as they get older. Furthermore, different groups of adolescents may show different growth profiles if a group level variable is expected to relate to the outcome variable. Longitudinal panel data are often analyzed to investigate long-term trends of growth.

The latent growth curve model (LGM) was developed as a method to represent development (Meredith & Tisak, 1990). The LGM treats repeated measures of individual behavior as a function of development. For example, the developmental change of smoking behavior among adolescents can be modeled as a function of age in the LGM. The longitudinal measures of smoking behavior can be modeled as a function of two factors: an underlying smoking behavior (that is, initial smoking status) and the developmental trajectory of smoking behavior. Furthermore, the two factors can in turn be considered as functions of other smoking-related behaviors. Information on both mean vector and covariance matrix of the variables is required by the LGM to examine growth profile.

Meredith and Tisak (1990) developed a simple two-curve latent curve model. Two exogenous latent factors, ξ_1 and ξ_2, are used in the model. The LGM approach with a linear growth assumption can be expressed as:

$$y_{ij} = \lambda_{0i}\eta_{0j} + \lambda_{1i}\eta_{1j} + \varepsilon_{ij}, \quad (1)$$

$$\eta_{0j} = \nu_0 + \gamma_{01}\xi_{1j} + \gamma_{02}\xi_{2j} + \zeta_{0j}, \quad (2)$$

$$\eta_{1j} = \nu_1 + \gamma_{11}\xi_{1j} + \gamma_{12}\xi_{2j} + \zeta_{1j}, \quad (3)$$

Equations 1, 2, and 3 are mean and covariance structure equations. The first equation represents a measurement model and the latter two represent regressions among latent variables. The y_{ij} refers to measure of individual *j* at time *i* and is predicted by η_{0j} and η_{1j}. Further, η_{0j} and η_{1j} are the underlying factors representing the initial status and linear growth trajectory, respectively. The η_{0j} and η_{1j} factors with ν_0 and ν_1 as their

corresponding intercepts are predicted by ξ_{1j} and ξ_{2j}, with residuals ζ_{1j} and ζ_{2j}, respectively. Typical structural equation model assumptions are made, e.g., γs are regression weights, and ξs are normally distributed with mean μ and ψ variance. Considered as a random-effects model, random-effects are represented by the variances of ζ_{1j}, ζ_{2j}, and ε_{ij} which are residual variances of standard structural equation model. The measurement error variances (ε_{ij}) are assumed to be equal, or homogeneous, over time.

The LGM approach allows specification of growth, which is more complicated than just a linear increase. With a curvilinear growth assumption, a quadratic term of time needs to be added to Equation 1:

$$y_{ij} = \lambda_{0i}\eta_{0j} + \lambda_{1i}\eta_{1j} + \lambda_{2i}\eta_{2j} + \varepsilon_{ij}. \qquad (4)$$

The η_{2j} is added as another latent variable to represent the curvilinear growth trajectory. The quadratic assumption is made by fixing λ_{2i} at a known constant, say i^2 where i is the time of measurement. The new factor, η_{2j}, is regressed on the explanatory variables, ξ_{1j} and ξ_{2j}:

$$\eta_{2j} = \nu_{2} + \gamma_{21}\xi_{1j} + \gamma_{22}\xi_{2j} + \zeta_{2j}, \qquad (5)$$

where a new residual ζ_{2j}, also considered random-effect, is introduced as is typical in structural equation model.

Ⅰ. Method

Longitudinal data obtained from a smoking prevention program were used in this study. The project was a multi-component social influences-based community intervention program to prevent substance use among adolescents. The social influence-based community prevention program included general assertive skill training and skill training for refusing offers of cigarettes, alcohol, and drugs. The key element of the social influence-based community trial was to establish negative adult value and peer value about smoking, drinking alcohol, and using other substances. A total of 50 middle schools (23 control and 27 program schools) in mid-western area of the US were randomly assigned to a health education program as usual control group or a smoking prevention intervention program as the program group. A total of 2,779 students who started at the seventh grade were surveyed at the baseline wave. Four follow-ups were conducted with the first being six months after baseline, and then one year apart for the other three follow-ups. Students at each of the five interviews were asked whether they

had used any cigarettes in the last 30 days. School, which was the unit of experimental assignment, was also used as the unit of analysis. Prevalence of monthly cigarette use that is the percentage of students reporting any monthly cigarette use in each school was used as the outcome measure. Two school-level covariates were chosen to investigate their influences on the development of prevalence of cigarette use at the school level across time. These two conditioning variables were group membership (GROUP=0 for control group, and GROUP=1 for program group), and school type (TYPE=0 for private school, and TYPE=1 for public school).

Figure 1. presents the conceptual model using the LCA notations with the linear growth assumption. The repeated measures (i.e., Y_0 to Y_4) of school prevalence of monthly cigarette use were assumed to be affected by the two growth parameters defined as factors: the initial status (INTERCEPT, or η_0) and the growth trajectory (SLOPE, or η_1). The factor loadings associated with initial status, or λ_0's, were all fixed at 1, while those associated with slope, or λ_1's, were fixed at the value to reflect the time point at which the measure was obtained. It is important to appropriately reflect the distance of the time of follow-ups from the baseline. In this study the measurement points were not equally spaced. To more accurately represent this spacing of measurement, the λ_1's was defined at 0 for baseline or 1, 3, 5, and 7 for the four follow-ups, respectively, since the first follow-up was only six months after baseline and the other three follow-ups were then one year apart. Each unit of increment in time, therefore, represents six months apart. Figure 1 also includes the constant of 1. Because a regression on a constant is an intercept, any covariates (such as GROUP and TYPE) or factors (such as INTERCEPT and SLOPE) with a path from the diamond indicate that an intercept term has been specified as a free parameter. Both INTERCEPT and SLOPE factors were further assumed to be influenced by the two school-level covariates: ξ_1 and ξ_2 which are GROUP and TYPE, respectively, after being adjusted by their corresponding means. Finally, the variances of measurement errors, are assumed to be homogeneous across time, i.e., $\sigma^2(\varepsilon_0) = \cdots = \sigma^2(\varepsilon_4)$. With the quadratic growth curve assumption, another SLOPE factor should be added to represent the quadratic term. The factor loadings for SLOPE2 (see λ_{2i} in Equation 4) will be fixed at 0, 1, 9, 25, and 49, respectively.

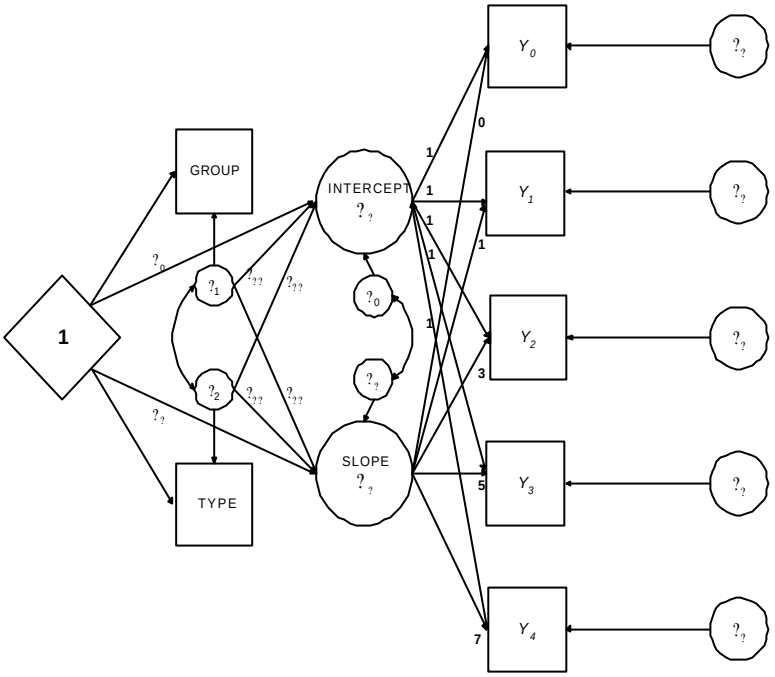

Figure1. the latent Curve Model

It further should be noted that the growth trajectory in the LGM approach proposed by Meredith and Tisak (1990) is not limited to linear or polynomial growth assumptions. Their approach is very general and allows some of the factor loadings associated with SLOPE to be free parameters to reflect relative growth trajectories across time. For the purpose of model identification and interpretation, the factor loading at the baseline is usually set at 0, i.e., no growth is assumed, and the factor loading at first follow-up is set at 1 as a reference. The estimates of loadings associated with the subsequent follow-ups, therefore, indicate the relative growth of each follow-up compared to that at the first follow-up.

Ⅱ. Results

Means and standard deviations of prevalence of monthly cigarette use across all five waves of observation are summarized in Table 1. The prevalences are also reported by the different categories of each of the two covariates: GROUP and TYPE.

Table 1.
Mean Prevalence of Cigarette Monthly Use by Group and School Type[a]

Cigarette Monthly Use	Wave 0	Wave 1	Wave 2	Wave 3	Wave 4
Total (N=50)	10.98 (8.08)	14.96 (11.33)	19.02 (10.62)	23.56 (8.24)	26,69 (12.48)
GROUP					
Control (N=23)	11.15 (8.78)	17.61 (13.11)	20.66 (10.25)	24.36 (7.72)	30.22 (14.07)
Program (N=27)	10.85 (7.60)	12.70 (9.23)	17.63 (10.93)	22.89 (8.74)	23.68 (10.27)
TYPE					
Private (N=28)	8.16 (8.19)	10.68 (11.09)	16.09 (11.44)	23.39 (9.73)	27.68 (15.49)
Public (N=22)	14.59 (6.46)	20.41 (9.28)	22.75 (8.31)	23.79 (6.05)	25.43 (7.21)
TYPE by GROUP					
Control-Private (N=12)	7.84 (9.87)	13.23 (14.95)	19.09 (11.81)	25.13 (10.20)	32.37 (18.78)
Control-Public (N=11)	14.76 (5.92)	22.39 (9.17)	22.36 (8.46)	23.52 (3.92)	27.87 (6.00)
Program-Private (N=16)	8.40 (7.02)	8.76 (6.95)	13.84 (10.98)	22.08 (9.48)	24.16 (11.92)
Program-Public (N=11)	14.42 (7.24)	18.43 (9.39)	23.14 (8.55)	24.05 (7.83)	22.98 (7.75)

a. Standard deviations are reported in parentheses.

Results obtained from the LGM model with the linear growth curve assumption is reported in the Table 2.

Table 2.
Parameter estimates from LGM with linear growth curve

Parameter	Estimate	Standard Error
γ_0	15.01	(1.38)**
γ_{01}	-1.13	(0.40)
γ_{03}	9.11	(0.41)**
γ_{10}	5.19	(0.25)**
γ_{11}	-0.25	(0.43)
γ_{13}	-1.05	(0.43)**
$\psi_{\eta}(\zeta_0)$	20.32	(1.42)**
$\psi_{\eta}(\zeta_1)$	1.02	(0.48)+
$\psi_{\eta}(\zeta_0,\zeta_1)$	-5.08	(0.51)
$\psi_{\varepsilon}(\varepsilon)$	40.14	(4.12)**
	χ^2_{30} = 20.44	
	p < 0.01	

+. Significantat.10level;*.Significantat .05 level; **. Significant at .01level.

Because of the definition of GROUP and TYPE variables in the school level model, the reference schools in this study are private schools in the control group. Under the linear growth assumption, the LGM results indicated that the average school prevalence of monthly cigarette use among the private schools in the control group at the baseline is 12.02%, and increases by 19% at each 6 month. Controlling for school type (TYPE), program schools are 1.13% lower in prevalence of monthly cigarette use than the control group at the baseline. And the growth rate of monthly cigarette use at each 6-month period in the program schools is 0.57% lower than that of the control schools. With GROUP membership controlled, public schools are 9.11% higher in prevalence of monthly cigarette use than private schools. Compared to the private schools, the growth rate significantly dropped by 1.60% for the public schools at each 6-month period. The goodness-of-fit χ^2 test statistic obtained from the LGM indicated that the models with linear growth do not appropriately fit the data. In other words, the hypothesis that growth rates of monthly cigarette use monotonically increase across time is not acceptable.

Results obtained from the LGM approach incorporating the quadratic growth curve assumption are summarized in Table 3. Although the χ^2 test statistic of the LGM reported at the bottom of the table indicated that the quadratic growth curve model still does not fit the data, it is substantially better than the linear LGM. The positive

estimates of regression coefficients associated with η_1 and the negative estimates of regression coefficients associated with η_2 indicated that the growth rate in general increases at a faster pace at the beginning, then at a slower pace, and levels off subsequently. This pattern seems to offer a better understanding of the growth profile of monthly cigarette use among adolescents.

Table 3.

Parameter estimates from LGM with quadratic growth curve

Parameter	Estimate	Standard Error
π_0	11.36	(1.54)**
π_{01}	-1.43	(3.36)
π_{02}	2.85	(3.34)**
π_{10}	3.02	(0.28)**
π_{11}	0.30	(1.18)
π_{12}	0.06	(1.18)
π_{20}	-0.13	(0.10)
π_{21}	-0.11	(0.19)
π_{22}	-0.34	(0.19)
$\psi_{11}(\zeta_1)$	36.34	(13.16)**
$\psi_{21}(\zeta_2)$	3.12	(3.84)
$\psi_{31}(\zeta_3)$	0.19	(0.10)
$\psi_{41}(\zeta_4,\zeta_1)$	6.31	(2.10)
$\psi_{51}(\zeta_5,\zeta_1)$	-0.36	(0.19)
$\psi_{61}(\zeta_6,\zeta_1)$	-0.43	(4.25)**
	$\chi^2_{14} = 36.35$	
	$p = 0.03$	

+. Significant at .10 level; *. Significant at .05 level; **. Significant at .01 level.

There is a sharp increase in prevalence at the first follow-up for each category of schools. The private schools in both control and program groups started with lower prevalence rates of monthly cigarette use than the public schools. However, the growth trajectories of monthly cigarette use for the private schools monotonically increases over time; while that for the public schools, on the other hand, seems to have reached a plateau and flattens out after the first follow-up (Time 1). The prevalence rates for the public schools, therefore, become lower than those for the private schools. Public schools show higher percentages of use than the private schools at baseline. They also demonstrate a larger increase in monthly cigarette use than the private schools at the first follow-up. However, the growth rate for public schools seems to be smaller than that of the private schools after the first follow-up in the seventh grade. Although not significant, the program schools not only show a smaller rate of increase in cigarettes use than the control schools, and the gap increases across time.

Comparisons between the program and control groups in the proportions of students who decreased their level of drug were shown. Baseline substance users in the program group consistently demonstrated decreased levels of use relative to the control group across all follow-up years. The prevention program showed a secondary prevention effect on decreasing cigarette use at six months after the intervention. In general, the social influences-based community intervention program consistently demonstrated a

tendency of decreasing use for tobacco among the baseline users across all four follow-ups.

Ⅲ. Discussion

Early efforts at health education are essential for preventing adolescent substance use. Educational policy and intervention programs, as well as the research agenda of government need to be attuned to tracking the developmental profile of adolescent smoking behavior. A lot of research on adolescent substance use has used cross-sectional designs. This may lead to some problems in that the research results can not generalize across time points and they can not address the issue of the growth trajectory. The longitudinal design is important for prevention research. Acknowledging growth profile requires an awareness of the initial status and growth rate of adolescent smoking behavior.

A risk-focused approach in substance abuse prevention research and policy is promising, and the approach in reducing risk factors for problems is as divergent as disease control and school failure control. The failure of early prevention interventions, such as drug information programs that did not address known risk factors for substance abuse, resulted from the failure to addresses the various risk factors. Many of the risk factors for adolescent substance use also predict other adolescent problem behaviors. There is evidence that adolescent substance abuse is correlated with delinquency, teenage pregnancy, school misbehavior, and dropouts. Comprehensive risk-focused efforts probably can prevent other adolescent problem behaviors besides alcohol and drug abuse. If prevention of substance use in adolescence is the goal, then the development of risk factors salient for substance use should be investigated from the perspective of longitudinal growth.

Growth curve models have received increasing attention in social science research. The models are very appealing since they specifically model individual growth as a function of time and also can compare different growth rates across different groups. The latent growth curve model (LGM) deals with the two major characteristics of a growth profile, initial status and trajectory of growth curve, as latent factors, and models the repeated measures as a function of time and the latent factors. General advantages of the application of LGM approach to growth curve model can be found in Willet and Sayer (1994). Meredith and Tisak (1990) offered the concept of relative growth trajectories over time. Although researchers in the area of health education have tried to adopt covariance structure analysis, growth curve methodology implementing mean and covariance structure models have not been widely used in the study of adolescent smoking behavior. But the approach will enable a broad range of researchers in the area of health education to earn the possibility for various analyses of growth profiles and developmental processes.

REFERENCES

Bandura, A. (1977). Social learning theory. Englewood Cliffs, NJ: Prentice Hall.

Bock, R.D.,&Thissen,D.(1980).Statisticalproblems of fitting individual growth curve. In F. E. Johnston, A. F. Roche & C. Susanne (Eds.), *Human physical growth and maturation: Methodologies and factors* (pp. 265-290). New York: Plenum Press.

Bryk, A. S., & Raudenbush, S. W. (1992). *Hierarchical linear model: Applications and data analysis methods.* Newbury Park, CA: Sage.

Bryk, A. S., Raudenbush, S. W., & Congdon, R. (1994). *HLM: Hierarchical linear modeling with the HLM/2L and HLM/3L programs.* Chicago: Scientific Software International.

Burstein, L. (1980). The analysis of multilevel data in educational research and evaluation. In D. Berliner (Ed.), *Review of research in education, Vol. 8.* Washington D.C.: American Educational Research Association.

Goldstein, H. (1987). *Multilevel models in educational and social research.* London: Griffin.

Goldstein, H. (1995). *Multilevel statistical models (2nd Ed.).* London, Edward Arnold, New York Halstead Press.

Hawkins, J. D., Lishner, D. M., Catalano, R. F., & Howard, M. O. (1986). Childhood predictors of adolescent substance abuse: Toward an empirically grounded theory. *Journal of Children in Contemporary Society, 18,* 11-48.

Hirschi, T. W. (1969). Infraction as action: A study of the antecedents of illegal acts. *Dissertation Abstracts International, 29(9-A),* 1969, 3233.

Laird, N. M., & Ware, H. (1982). Random-effects models for longitudinal data. *Biometrics, 38,* 963-974.

Liang, K.-Y., & Zeger, S. L. (1986). Longitudinal data analysis using generalized linear models. *Biometrika. 73,* 13-22.

Longford, N. T. (1990). VARCL. Software for variance component analysis of data with nested random effects (maximum likelihood). Princeton, NJ: Educational Testing Service.

Mason, W. M., Wong, G. M., & Entwistle, B. (1983). Contextual analysis through the multilevel linear models. In S. Leinhardt (Ed.), *Sociological methodology* (pp. 72-103). San Francisco: Jossey-Bass.

McArdle, J. J., & Aber, M.S. (1990). Patterns of change within latent variable structural equation models. In A. von Eye (ed.) *Statistical methods in longitudinal research. Vol 1.* Boston: Academic Press.

McArdle, J. J., & Epstein, D. (1987). Latent growth curves within developmental structural equation models. *Child Development, 58,* 110-133.

McDonald, R. P. (1978). A simple comprehensive model for the analysis of covariance structure. *British Journal of Mathematical and Statistical Psychology, 31,* 59-72.

Meredith, W., & Tisak, J. (1990). Latent curve analysis. *Psychometrika, 55,* 107-122.

Rao, C. R. (1958). Some statistical methods for the comparison of growth curve.

Biometrics, 14, 1-17.

Murray, D. M., & Hannan, P. J. (1990). Planning for the appropriate analysis in school-based drug-use prevention studies. *Journal of Consulting and Clinical Psychology, 58,* 458-468.

Rogosa, D. R., Brandt, D., & Zimowski, M. (1982). A growth curve approach to the measurement of change. *Psychological Bulletin, 90,* 726-748.

Rogosa, D. R., & Willet, J. B. (1985). Understanding correlates of change by modeling individual differences in growth. *Psychometrika, 50*, 203-228.

Willet, J. B. (1988). Questions and answers in the measurement of change. In Rothkopf, E. (Ed), *Review of research in education,* (pp. 345-422). Washington, DC: American Educational Research Association.

Willet, J. B., & Sayer, A. G. (1994). Using covariance structure analysis to detect correlates and predictors of individual change over time. *Psychological Bulletin, 16,* 363-381.

Zeger, S. L., & Liang, K. Y. (1986). Longitudinal data analysis for discrete and continuous outcomes. *Biometrics, 42*, 121-130.