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Introduction to the special issue on “Statistical approaches and methodological issues in longitudinal analysis of substance use and related behaviors”

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During the past decade, there has been a growing interest within the field of substance abuse research and treatment in the potential relevance of a perspective of continuing care or chronic disease management (McLellan, Lewis, O’Brien, and Kleber, 2000; Institute of Medicine, 2006) and in examining patterns and processes of recovery (Laudet, 2007, Hser et al., 2007, Hser & Anglin, 2010, Moos, 2007). This expanding interest has, in turn, substantially increased attention to longitudinal analyses as a way to identify and examine patterns of substance abuse and related events and behaviors over time, as well as predictors, correlates, and outcomes of these patterns.

During this same period, there has been a continuing expansion of statistical models and methods for analyzing longitudinal data, allowing more detailed representation of complex processes of substance use/abuse and recovery processes over time. Several general classes of analytic approaches and models have proven useful in assessing substance abuse as it persists or changes over time, for different individuals, and in different contexts. Differences among these general classes of statistical models allow us to address different critical questions about substance use and related trajectories (e.g., Beckett et al., 2004; Grimm, 2007). For example, growth curve models can answer questions about patterns of substance use over time and relationships of user and contextual characteristics to those patterns (Bollen & Curran, 2004; Brecht et al., 2008; Hser et al., 2008), whereas growth mixture models and group-based trajectory models can be used to identify subgroups with distinctive trajectories (e.g., Hser et al., 2007; Jones & Nagin, 2007; Kreuter & Muthen, 2008; Murphy et al., in press; Muthen, 2008; Nagin, 1999).

To facilitate the appropriate application of an expanding array of available methods and highlight some of the key problems in longitudinal analysis, the Center for Advancing Longitudinal Drug Abuse Research (CALDAR) at the University of California, Los Angeles, has prepared this special issue. While there are many textbooks available on commonly used approaches for longitudinal analysis, choices of their application are complex particularly when real world data are analyzed, e.g. when data may not meet model/estimation assumptions or when details of model specification are tentative (e.g. Bauer, 2007; Eggleston, Laub, and Sampson, 2004; Kreuter and Muthen, 2008). Yet analysis results can provide useful information when researchers understand data and model constraints and their implications for the application of longitudinal estimation methods and when there is a match of methods to the research questions. The set of papers in this special issue provides examples to assist researchers with choice and use of selected statistical approaches and specializations for addressing common research questions about longitudinal patterns and processes of substance use/abuse. These papers combine both statistical and empirical discussion, making the results accessible to a broad range of researchers and analysts. The papers generally fall into two broad categories: 1) primarily illustrative of the application of a specific statistical model to answering a specific research question, explaining the analysis and interpretation process, as well as how the model is appropriate for the question at hand; or 2) comparative (across specific models or statistical approaches)

for a specific empirical context and/or research question, showing how results may differ under the different conditions and across the different approaches.

Papers illustrating the application of specific models or methods include the following. The paper by Prendergast, Huang, Evans, and Hser has estimated a growth mixture model for Poisson response data to identify trajectory groups with distinctive arrest patterns for substance abuse treatment clients, and then has examined gender and other differences among pattern groups. Liu, Hedeker, Segawa, and Flay have also used a growth mixture modeling approach, with ordinal drug use outcomes, to identify pattern groups and examine intervention effects. Xie, McHugo, He, and Drake have used a dual outcome latent trajectory model, in order to examine jointly the patterns over time of the interrelated behaviors of social contact with non-abusing friends and stage of substance abuse treatment and recovery. In order to examine trajectories of substance use and criminal behavior, Sullivan and Piquero have utilized an autoregressive latent trajectory (ALT) model that permits the capture of both persistent individual differences in behavioral trends and stage to stage relationships. Lanza, Patrick, and Maggs have applied a latent transition analysis (LTA) to identify substance use profiles (of use across several specific substances) and changes in those profiles across time, in order to identify college students at high risk for substance-related problems. Liang, Huang, Brecht, and Hser have used a Bayesian approach with a mixed effects model that incorporates both survival and patterns of substance use over time to examine differences in mortality among users of different types of drugs from data combined across three studies.

Papers falling generally into the comparison category focus on issues and situations often encountered when analyzing data to answer longitudinal research questions and the impact on results of the choice of model or method to handle those issues. The paper by Harris, Finney, and Moos has considered the impact of different approaches to addressing the issue of baseline heterogeneity in abstinence when comparing groups on treatment outcomes using logistic regression. Chou, Chi, Weisner, Pentz, and Hser have examined whether the conventional approach in controlled trials of including the baseline observation in examining longitudinal group differences is appropriate when assessing intervention effects using a growth model. The paper by Huang, Brecht, Hara, and Hser has illustrated the impact of including covariates in identifying longitudinal pattern groupings to predict later outcomes; empirical results differed depending on the relationship of the trajectories to the covariates and distal outcomes and on the distribution of the covariates in the sample. Saunders has examined the issue of including certain random effects to the latent growth factors in a group-based trajectory model and has discussed both research questions that can be addressed by different model specifications and technical details of modeling. The paper by Li, Evans, and Hser has addressed the issue of controlling for self-selection bias over time by applying a marginal structural model in comparison to traditional regression analysis in order to assess cumulative treatment effects.

This group of papers illustrate and/or compare selected methods and models within the context of specific research questions pertaining to: patterns or groupings of patterns of substance use/abuse and/or related behaviors such as delinquency, crime, and arrests; changes in substance use profiles over time; predictors of patterns of substance use/abuse and characteristics of individuals exhibiting these patterns; how such patterns predict later outcomes such as mortality; the effects of interventions on patterns of substance use/abuse and related behaviors; and the cumulative effect of treatment over time. For addressing these common research questions, the papers use a range of statistical approaches including (latent) growth/trajectory models, autoregressive latent trajectory model, growth mixture models and group-based trajectory models, dual trajectory models, marginal structural models, Bayesian analysis, and logistic regression. This special issue is not designed to

advocate specific approaches, but rather to illustrate the applicability of a range of approaches for longitudinal analyses matched to specific research questions within specific empirical contexts, as well as to illustrate how results can differ when different approaches are used to address some of issues encountered in longitudinal analysis.

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References

- Bauer D. Observations on the use of growth mixture models in psychological research. *Multivariate Behavioral research*. 2007; 42:757–786.
- Beckett L, Tancredi D, Wilson R. Multivariate longitudinal models for complex change processes. *Statistics in Medicine*. 2004; 23:231–239. [PubMed: 14716725]
- Bollen K, Curran P. Autoregressive latent trajectory (ALT) models: A synthesis of two traditions. *Sociological Methods & Research*. 2004; 32:336–383.
- Brecht M-L, Huang D, Evans E, Hser Y-I. Polydrug use and implications for longitudinal research: ten-year trajectories for heroin, cocaine, and methamphetamine users. *Drug and Alcohol Dependence*. 2008; 96(3):193–201. [PubMed: 18329825]
- Eggleston E, Laub J, Sampson R. Methodological sensitivities to latent class analysis of long-term criminal trajectories. *Journal of Quantitative Criminology*. 2004; 20:1–26.
- Grimm K. Multivariate longitudinal methods for studying developmental relationships between depression and academic achievement. *International Journal of Behavioral Development*. 2007; 31:328–339.
- Hser, Y-H.; Anglin, MD. Addiction treatment and recovery careers. In: Kelly, J.; White, W., editors. *Addiction Recovery Management: Theory, Science, and Practice*. Humana; Totowa, NJ: 2010.
- Hser Y-H, Huang D, Chou C, Anglin MD. Trajectories of heroin addiction: growth mixture modeling results based on a 33-year follow-up study. *Evaluation Review*. 2007; 31:548–563. [PubMed: 17986707]
- Hser Y-I, Huang D, Brecht M-L, Li L, Evans E. Contrasting trajectories of heroin, cocaine, and methamphetamine use. *Journal of Addictive Diseases*. 2008; 27(3):13–21. [PubMed: 18956525]
- Institute of Medicine (IOM). Improving the quality of health care for mental and substance-use conditions. National Academy Press; Washington, DC: 2006.
- Jones B, Nagin D. Advances in group-based trajectory modeling and a SAS procedure for estimating them. *Sociological Methods and Research*. 2007; 35:542–571.
- Kreuter, F.; Muthen, B. Longitudinal modeling of population heterogeneity: Methodological challenges to the analysis of empirically derived criminal trajectory profiles. In: Hancock, GR.; Samuelsen, KM., editors. *Advances in latent variable mixture models*. Information Age Publishing, Inc.; Charlotte, NC: 2008. p. 53-75.
- Laudet A. What does recovery mean to you? Lessons from the recovery experience for research and practice. *Journal of Substance Abuse Treatment*. 2007; 33:243–256. [PubMed: 17889296]
- McLellan T, Lewis D, O'Brien C, Kleber H. Drug dependence, a chronic medical illness: Implications for treatment, insurance, and outcomes evaluation. *Journal of the American Medical Association*. 2000; 284:1689–1695. [PubMed: 11015800]
- Moos R. Theory-based processes that promote the remission of substance use disorders. *Clinical Psychological Review*. 2007; 27:537–551.
- Murphy D, Brecht M-L, Herbeck D, Huang D. Trajectories of HIV risk behavior from age 15-25 in the National Longitudinal Survey of Youth sample. *Journal of Youth and Adolescence*. 2009; 38(9): 1226–1239. [PubMed: 19669902]

- Muthén, B. Latent variable hybrids: Overview of old and new models. In: Hancock, GR.; Samuelsen, KM., editors. *Advances in latent variable mixture models*. Information Age Publishing, Inc.; Charlotte, NC: 2008. p. 1-24.
- Nagin D. Analyzing Developmental Trajectories: A Semi-parametric, Group-based Approach. *Psychological Methods*. 1999; 4:139–177.