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NATIONAL EVALUATION DATA SERVICES

THE NATIONAL TREATMENT IMPROVEMENT EVALUATION STUDY: MULTILEVEL REANALYSIS OF TREATMENT OUTCOMES

January 2000

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CSAT
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TABLE OF CONTENTS

	<u>Page</u>
FOREWORD	i
ACKNOWLEDGMENTS	ii
EXECUTIVE SUMMARY	iii
I. INTRODUCTION	1
1. THE USE OF MULTILEVEL, RANDOM-EFFECTS MODELS TO ANALYZE CROSS-SITE DATA	1
2. EXAMPLES FROM THE LITERATURE	2
3. THE ORIGINAL NTIES CLIENT OUTCOME ANALYSIS	3
3.1 Client-Level Analysis	4
3.2 SDU-Level Analysis	5
4. REANALYZING THE NTIES OUTCOME DATA IN A MULTILEVEL, RANDOM EFFECTS FRAMEWORK	6
5. STUDY QUESTIONS	7
II. METHODS	9
1. OUTCOME VARIABLES	9
2. PREDICTOR VARIABLES	9
3. MODELING PROCESS	10
III. RESULTS	12
1. MODEL FIT STATISTICS	12
2. MAIN EFFECTS MODELS	14
3. MAIN EFFECTS PLUS INTERACTIONS MODELS	16
3.1 Methadone Facilities	16
3.2 Non-Methadone Outpatient Facilities	17
3.3 Long-Term Residential Facilities	19
3.4 Short-Term Residential Facilities	21

TABLE OF CONTENTS (CONTINUED)

	<u>Page</u>
IV. SUMMARY AND DISCUSSION	22
1. LIMITATIONS	22
2. ANSWERS TO STUDY QUESTIONS	23
2.1 What SDU-Level Factors Appear to Improve Client Outcomes, and How Do These Relationships Vary by Modality?	23
2.2 What Interactions Occur Between Client-Level and SDU-Level Factors?	24
2.3 To What Degree Does the Inclusion of SDU-Level Factors and SDU-Client Interactions Improve Overall Model Fit?	25
3. IMPLICATIONS FOR FURTHER ANALYSIS, POLICY, AND PRACTICE	26
3.1 Analysis	26
3.2 Policy and Practice	27
REFERENCES	28
APPENDIX DESCRIPTION OF THE NTIES AND CSAT DEMONSTRATIONS (1990-1992)	A-1

FOREWORD

The Center for Substance Abuse Treatment (CSAT) works to improve the lives of those affected by alcohol and other substance abuse, and, through treatment, to reduce the ill effects of substance abuse on individuals, families, communities, and society at large. Thus, one important mission of CSAT is to expand the knowledge about and the availability of effective substance abuse treatment and recovery services. To aid in accomplishing that mission, CSAT has invested and continues to invest significant resources in the development and acquisition of high-quality data about substance abuse treatment services, clients, and outcomes.

In support of these efforts, the Program Evaluation Branch (PEB) of CSAT established the National Evaluation Data Services (NEDS) contract to provide a wide array of data management and scientific support services across various programmatic and evaluation activities and to mine existing data whose potential has not been fully explored. Essentially, NEDS is a pioneering effort for CSAT in that CSAT previously had no mechanism established to pull together databases for broad analytic purposes or to house databases produced under a wide array of activities. One of the specific objectives of the NEDS project was to provide CSAT with a flexible analytic capability to use existing data to address policy-relevant questions about substance abuse treatment. This report has been produced in pursuit of that objective.

Over the past decade, multilevel, random-effects modeling has emerged as the most appropriate statistical method for analyzing cross-site and multi-site outcome evaluation data. However, evaluators of substance abuse treatment programs have only recently begun to exploit this approach. The present study describes a multilevel reanalysis of treatment outcomes from the National Treatment Improvement Evaluation Study (NTIES) (see Appendix for a full description of NTIES). The study examined what service delivery unit (SDU)-level factors appear to improve outcomes, how these relationships vary by modality, and how effects differ across clients.

The results presented here show a range of significant SDU-level main effects and interactions between SDU variables and client-level variables. The results also highlight how these effects and interactions vary across modalities. The study therefore demonstrated some of the potential benefits in considering program effects in multilevel analyses of cross-site substance abuse treatment evaluations, and in particular for NTIES data analyses.

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

1. INTRODUCTION

Treatment outcome data from cross-site evaluations are inherently multilevel and hierarchical in that multiple service delivery units (SDUs) exist, each with multiple clients. Statistically, clients are considered “nested” within SDUs. Often, the SDUs selected are formally sampled from a larger universe of SDUs to ensure statistical representativeness. Other times, they are not formally sampled but still function as a sample *conceptually*, that is, the scientific question is rarely limited to the effectiveness of specific SDUs at specific locations, but rather to a class of SDUs *like* them to permit generalization. Consequently, whether formally representative or just conceptually representative, cross-site or between-SDU effects are properly modeled statistically as random rather than fixed. Therefore, a multilevel, random-effects modeling approach is appropriate for analyzing these types of data. In addition, multilevel models more adequately address the direct effects of SDU characteristics on individual behaviors, and interactions between individual and SDU characteristics, than typically expressed in the framework of multiple regression and logistic regression. That is, terms can be specified as individual-level variables, SDU-level variables, or as interactions both within and across levels.

This paper describes a multilevel reanalysis of treatment outcomes from the National Treatment Improvement Evaluation Study (NTIES). It is primarily a methods demonstration whose main intent is to illustrate the application of multilevel modeling to the analysis of multisite treatment outcome data. However, it also addressed substantive questions using these methods. Analysis questions were:

- # What SDU-level factors appear to improve client outcomes, and how do these relationships vary by modality?
- # What interactions occur between client-level and SDU-level factors?
- # To what degree does the inclusion of SDU-level factors improve overall model fit?
- # What are the implications for further analysis, policy, and practice?

2. METHODS

Outcome variables and client-level predictors (level 1 variables) were the same as those used in the original analysis (National Opinion Research Corporation, 1997), with some slight modifications (described in report). The choice of SDU-level variables was guided by two primary criteria: the amount of nonmissing data in the variable, and the variability of the

variable across SDUs. The first criterion excluded variables whose values were missing for high numbers of observations. The second criterion excluded variables that had little or no explanatory power due to their flat distribution.

We illustrate the model with an example using one single client-level variable, X , and no interactions. The notation gets more complex once we move to the more general cases considered in our analyses. With a formulation analogous to that presented in Singer (1999), for example, the model expresses the outcome Y_{ij} for client_{*i*} in SDU_{*j*} as a function of a vector Z of SDU-level variables:

$$Y_{i,j} = a_j + b_j X_{i,j} + e_{i,j}$$

$$a_j = c + \sum_k \{d_{j,k} Z_{j,k}\} + E_j$$

$$b_j = C + \sum_k \{g_{j,k} Z_{j,k}\} + F_j$$

where a_j is a random intercept for SDU_{*j*}, b_j is a random slope coefficient that relates the covariate X to the outcome Y . The latter two equations connect the random coefficients, a and b , to the SDU-level variables, Z . The error structure specifies that $e_{i,j}$ is normally distributed with mean 0 and standard deviation s and E_j, F_j have a joint bivariate normal distribution with mean 0.

This approach allows the introduction first of client-level variables for each modality, then SDU-level. With the addition of SDU-level variables for each modality, we can assess the improvement in the model fits. For this purpose, we used goodness of fit measures that take into account the number of parameters used in the models. That is, these measures—e.g., Akaike Information Criterion (AIC)—adjust the log-likelihood to favor more parsimonious models. Thus, our comparisons did not unduly or unfairly favor the more complete, two-level models including SDU-level variables and cross-level interactions. Because each of six outcomes was examined in each of five modalities, there were $6 \times 5 = 30$ models in all. However, the introduction of SDU-level variables into the models for the correctional modality decimated the number of SDUs and cases due to missing data in the SDU-level variables. Consequently, further analyses on the correctional modality could not be performed.

3. SUMMARY OF RESULTS AND DISCUSSION

Significant main effects of SDU-level variables were observed in three of the four modalities in which models could be run: methadone, non-methadone outpatient, and long-term residential. All six outcome domains were affected: drug, alcohol, criminal, employment, medical, and psychiatric. In terms of factors associated with positive client change

(i.e., increased reductions in severity scores), all but one were in the non-methadone outpatient modality. Specifically, SDU-level variables associated with *increased* client improvement after controlling for client-level factors were:

- # SDU had a designated case manager (non-methadone outpatient × alcohol, drug, and criminal outcome domains)
- # SDU tailors program to populations (non-methadone outpatient × criminal and medical domains)
- # SDU had staff training specialists (long-term residential × drug domain), and average frequency of individual counseling (non-methadone outpatient × medical domain).

At the same time, SDU-level variables associated with *reduced* client improvement were:

- # SDU tailors program to populations (methadone × drug domain; long-term residential × employment domain)
- # SDU had staff training specialists (non-methadone outpatient × alcohol and criminal domains)
- # Average frequency of individual counseling (long-term residential × drug domain)
- # Average length of individual sessions (non-methadone outpatient × medical and employment domains).

No other SDU-level variable had any significant main effects; however, this was in part because missing values removed any variation in SDU-level variables so they were not really tested, particularly in the methadone and short-term residential modalities.

Taken at face value, the data suggest that SDU-level main effects—as measured by these variables—were consistent across the six outcomes within a given modality, in that no variable had both positive and negative main effects within the same modality. However, they were inconsistent across modality, and effects representing reduced client improvement were about as likely to occur as effects representing increases. The one exception is having a designated case manager, which showed increases in improvement only, albeit in only one modality (non-methadone outpatient). Also noteworthy in the outpatient modality is the oppositional relationship of the frequency and duration of counseling sessions. This would seem to suggest that frequent, short sessions might be more beneficial than longer, less frequent sessions to clients in outpatient treatment.

Interactions occurred more frequently than main effects, suggesting that SDU-level characteristics do have a substantial impact on outcomes, but that impact is contingent on client-level characteristics. The pattern of significant interactions varies substantially by modality. As with main effects, some interactions in the methadone and short-term residential modalities could not be tested due to lack of variance in SDU factors.

In the four modalities in which models could be tested, the introduction of SDU-level variables generally made little improvement in model fit, as assessed by the AIC statistic. In contrast, the addition of client by SDU interactions consistently improved model fit across all dependent variables and modalities. Improvements ranged from a low of 1 percent (i.e., short-term residential, medical severity) to a high of 6 percent (i.e., long-term residential, alcohol severity). In general, the largest improvements in fit were in the long-term residential modality, with the second largest in the methadone modality.

The following limitations should be considered in interpreting these results:

- # The large amount of missing data has repercussions for SDU-level analyses, which must discard an entire SDU where values are missing for one or more of the SDU-level analysis variables (listwise deletion). Consequently, some of the modality-specific mixed models had limited degrees of freedom as we increased the number of (potential) explanatory variables. We compensated for this by making reasonable tradeoffs in limiting the number of independent variables considered at the SDU level as well as the client level. Still (as noted above), the number of nonmissing cases remaining in the correctional modality was too small to support the modeling process. As a consequence, we cannot speak to the effects of SDU-level factors on clients in correctional treatment facilities. We also cannot speak to the effects of SDU-level factors with no variability in the methadone and short-term residential modalities.
- # While the hierarchical models were specified correctly in Proc Mixed to the extent possible, one simplifying assumption was necessary for the procedure to successfully run. Specifically, it was necessary to assume that regression slopes of client-level predictors were similar across SDUs. The degree to which this assumption was violated, and its effect on the results if it was, are unknown.
- # Some of the counterintuitive findings on SDU-level effects may in fact represent unmeasured selection bias. An example is the negative association between tailoring treatment to populations and outcomes in the methadone and long-term residential modalities. It seems unlikely that population tailoring would actually cause clients to do worse on outcomes; rather, the finding might be reflecting that SDUs with the most difficult clients tend to do more tailoring. By including the client-level variables first, outcome variance common to client-level factors and SDU-level factors was “credited” to client level factors. This offered some measure of protection

against the misinterpretation of selection bias as SDU-level factors effects, but only to the extent that the selection bias is captured by the client-level factors that were measured and included in the models.

- # This analysis was based upon analysis of six outcomes in four treatment modalities, in which each of 42 interactions was tested for significance along with main events. It should be expected that a portion of the significant results presented here could be due to chance alone.

4. IMPLICATIONS FOR TREATMENT RESEARCH, POLICY, AND PRACTICE

The results of our mixed model analyses show a range of significant SDU-level main effects and interactions between SDU variables and client-level variables. The results also highlight how these effects and interactions vary across modalities. These findings are possible with the multilevel modeling methodology that extends the multiple regression models previously conducted. The study therefore demonstrated some of the potential benefits in considering program effects in multilevel analyses of cross-site substance abuse treatment evaluations, and in particular for NTIES data analyses. The following are areas for further research that could productively be investigated with the NTIES data:

- # We view this report as a first attempt at applying multilevel random-effects models to the NTIES data, and it may well be that further refinements could yield more readily interpretable results. Given the limitations caused by missing data, however, it might be worth investigating the degree to which missing values on some SDU-level characteristics could be logically or statistically imputed from the response pattern on other, non-missing variables, or even recontacting the original SDU administrators who filled out the NBAR.
- # In principle, a three-level random effects analysis could be conducted that integrated the different modalities into a single model for each dependent variable. That is, clients and SDUs would still represent levels 1 and 2, respectively, and modality would represent level 3. This would permit a direct test of the effect of modality on outcomes, controlling for differences in both client case mix and SDU-level characteristics, as well as accounting for the intraclass correlations of clients within SDUs and SDUs within modality. It could also address interactions of modality with both SDU-level and client-level factors.
- # Though this study was primarily a methods demonstration, it nonetheless has substantive implications for policy and practice. In particular, the identification of SDU characteristics with positive effects and SDU by client interactions across different modalities and outcomes suggests ways in which the treatment community might refine programs along these dimensions. For example:

- The finding that positive main effects of SDU characteristics were primarily found in the non-methadone outpatient modality suggests that the likelihood of improving client outcomes through manipulating SDU-level factors (e.g., having a designated case manager and tailoring the program to the population) may be greatest in that modality.
- The finding that frequent, short sessions may be more beneficial than longer, less frequent sessions in outpatient treatment has implications for structuring outpatient programming.
- The finding that interactions occurred more frequently than main effects suggests that SDU-level effects are highly contingent on client-level characteristics and modality—confirming that in substance abuse treatment, the question of “what works” is more productively specified as “what works for whom, and in what setting?”

Other implications can be drawn from the findings highlighted above. However, as noted earlier, some of the significant results presented here could be due to chance because of the large number of main effects and interactions examined. The optimal next step for policy and practice would be new prospective studies that rigorously examined some of the relationships suggested here.

I. INTRODUCTION

I. INTRODUCTION

1. THE USE OF MULTILEVEL, RANDOM-EFFECTS MODELS TO ANALYZE CROSS-SITE DATA

Treatment outcome data from cross-site evaluations are inherently multilevel and hierarchical in that multiple service delivery units (SDUs) exist, each with multiple clients. Statistically, clients are considered “nested” within SDUs.¹ Often, the SDUs selected are formally sampled from a larger universe of SDUs to ensure statistical representativeness. Other times they are not formally sampled but still function as a sample *conceptually*—that is, the scientific question is rarely limited to the effectiveness of specific SDUs at specific locations, but rather to a class of SDUs *like* them to permit generalization. Consequently, whether formally representative or just conceptually representative, cross-site or between-SDU effects are properly modeled statistically as random rather than fixed. Therefore, a multilevel, random-effects modeling approach is appropriate for analyzing these types of data.

For readers who may be familiar with multilevel modeling from other contexts, we note that several different fields have contributed to the development of this approach, from mathematical statistics to demography and epidemiology to survey research, clinical trials, and program evaluation. While the terminology varies according to the field, multilevel models, hierarchical linear models, random regression models, and random coefficient models and mixed model analysis of variance all refer to the same basic kind of model. Sometimes called “contextual” models, they are a class of models designed to account for the nested structure of the data (e.g., individuals are embedded in treatment groups within different settings). In these models, sampling units such as SDUs are appropriately modeled as random rather than fixed effects, and measurements within these SDUs may be correlated. Failure to account for this correlation—called the intraclass correlation or design effect—and the additional variance attributable to random effects can result in underestimated standard errors and spurious statistical significance. Consequently, traditional statistical models that ignore the multilevel structure of the data are likely to produce erroneous results.

In addition, multilevel models more adequately address the direct effects of SDU characteristics on individual behaviors and interactions between individual and SDU characteristics, than typically expressed in the framework of multiple regression and logistic regression. That is, terms can be specified as level 1 variables, level 2 variables, or as interactions both within and across levels. In our context, level 1 will correspond to clients or individuals, and level 2 will correspond to SDUs.

¹ The Center for Substance Abuse Treatment (CSAT) defines an SDU as a single treatment facility providing a single treatment modality.

If SDU characteristics associated with positive outcomes can be identified, these in turn can lead to programmatic recommendations for improving the effectiveness of treatment. It can also be expected that including level 2 variables would reduce the variance left as “error” in the original multiple regression models and increase overall model fit. This is because much of the unexplained error variance from the regression models is variance caused by systematic differences across sites (e.g., SDUs) on level 2 variables.

Until a few years ago, a multilevel, random-effects analysis required development of special software. Recently, however, programs such as PROC MIXED from SAS, HLM (a stand-alone program) and others have become available that make the use of random effects models more accessible to analysts. Moreover, they are flexible enough to accommodate many different statistical assumptions and provide diagnostic guidance to facilitate choices between model specifications.

For all these reasons, multilevel models with random effects are an excellent choice for cross-site evaluation data.

2. EXAMPLES FROM THE LITERATURE

The application of multilevel analysis and hierarchical linear modeling to multisite evaluations has induced successful and revealing analyses even where there is considerable diversity among the implemented interventions. An excellent example of the use of the technique is Seltzer’s (1994) systematic exploration of multilevel modeling techniques in his analysis of the Transition Mathematics program. Rather than selecting the “most appropriate” unit of analysis (student or classroom), the characteristics of sites were coded and included in an integrated analysis of individual-level outcome data, first fitting a linear model to individual outcomes, then fitting another model to the variation among site characteristics, and then fitting a hierarchical or “mixed” model. In contrast to a single-level (traditional) analysis of covariance (ANCOVA) that indicated only a very small overall effect, the mixed models showed that the size of the effect of the program was strongly related to the thoroughness of a site’s implementation of the intervention. This relationship was obtained even though the implementation measure and site characteristics were not elaborately developed scales or quantitative measures, or even lengthy structured questionnaires.

Multilevel models also have been employed in substance abuse research, though more in prevention than in treatment to date (McNeal, & Hansen, 1995; Saxe et al., 1997; Yin, Kaftarian, Yu, & Jansen, 1997). In treatment evaluation, Hser (1995) first outlined plans for the use of the framework to analyze the effect of substance abuse treatment counselors’ practices on treatment

effectiveness, by considering client outcomes in relation to varying characteristics of clients, counselors, and programs. In so doing, she proposed a three-level hierarchical linear model that assessed counselor effects on client outcomes while allowing considerations of potential interactions among the three levels of influence. Barnett and Swindle (1997) used random-effects regression to determine the effect of program and client characteristics on treatment cost and readmission rates for 38,863 clients treated in 98 Veterans Affairs inpatient substance abuse programs (clients nested within programs). They found that readmission rates were lower when the program had longer intended length of stay, was smaller, had more compulsory admissions as an alternative to jail, or assessed family or friends as part of treatment at least 50 percent of the time. In contrast, clients with a history of prior treatment had higher readmission rates but were less costly to treat during subsequent admissions.

Chou, Hser, and Anglin (1998) applied a hierarchical linear modeling approach to explore the interaction effects of treatment program and client characteristics on client retention in treatment. Program characteristics included services provision, funding sources, and staff-client gender congruence. Client characteristics included gender, age at admission, and level of drug use prior to admission. The same model was applied separately to three modalities: residential, methadone maintenance, and outpatient drug-free programs. Data were obtained from 59 treatment programs and 3,764 of their clients who had discharge records. According to the authors, the most significant interaction effect detected was the program's funding source and the client's gender in the outpatient drug-free modality. For example, female clients remained in the programs that accepted only public funding for less time than in the programs that accepted both public and private funding. Male clients remained in the treatment an average of 25.3 fewer days than female clients in drug-free programs that only accepted public funds, but males stayed about the same time as females if the programs received mixed funding.

Finally, Sonnefeld and Orwin (in progress) are re-analyzing the outcome data from the NIAAA Cooperative Agreement Program for Homeless Substance Abusers. This program had 23 intervention groups and 13 comparison groups distributed across 14 sites and will support a three-level hierarchical model to assess intervention effects on alcohol and drug use, economic well-being, and residential stability, and will explore their influences (clients within groups within sites). A detailed project-level database has been developed to capture site- and group-level characteristics for use in the multilevel modeling.

3. THE ORIGINAL NTIES CLIENT OUTCOME ANALYSIS

The appendix contains a general description of the National Treatment Improvement Evaluation Study (NTIES). The NTIES final report (National Opinion Research Council

(NORC), 1997) included a multivariate analysis of treatment outcomes at the client level and a separate analysis of treatment effectiveness at the SDU level, adjusted for differences in case mix.

3.1 Client-Level Analysis

The original client-level analyses were conducted by performing multiple regressions on measures of improvement (pre-post change) in each of six severity domains: drug use, alcohol use, criminal activity, psychiatric problems, medical problems, and employment problems. To create the severity scales, items were selected from each domain that reflected both objective behavior and subjective assessments by the respondent. These items were combined and transformed into scale values ranging from 0-100 (see NORC, 1997, for details).

Exhibit I-1 lists the client-level explanatory variables entered into the regression analyses, together with the six outcome variables considered by NORC in their original analysis. Each of these explanatory variables had shown a significant bivariate relationship with one or more treatment outcomes. Analyses for each of the six severity change scores were conducted across all treatment modalities and separately within five modalities: methadone, outpatient non-methadone, short-term residential, long-term residential, and correctional.

The cross-modality model was most successful in predicting change in medical severity (19 percent variance accounted for), with much of the variance explained by demographic predictors; specifically, black, Hispanic, female, and older clients showed greater improvement. In the analysis of drug severity (12 percent variance accounted for), clients who had a high school diploma, completed treatment, had more frequent treatment sessions, and stayed in treatment longer showed greater improvement, while clients in treatment because of legal pressure showed less improvement. On alcohol severity (11 percent variance accounted for), older clients, those with more treatment experiences, treatment completers, and clients with more frequent sessions showed greater improvement, while females, clients who stayed in treatment longer, and clients in treatment because of legal pressure did not fare as well. The variables were not good at predicting change in criminal severity (8 percent variance accounted for) and even worse at predicting change in psychiatric and employment severity (5 percent and 3 percent of variance, respectively).

EXHIBIT I-1
BACKGROUND VARIABLES USED IN THE ORIGINAL ANALYSIS
DESCRIPTION
<p>EXPLANATORY VARIABLES:</p> <p>Age (years) Black/Non-Hispanic Hispanic (<i>based on self-reported ethnicity, or language preference or spoken during childhood</i>) Gender High School Diploma Treatment Completion Number of Prior Treatment Episodes (<i>self-reported at intake</i>) Legal Pressure to Seek Treatment Length of Stay</p> <p>Pre-Treatment Drug Use Severity Scale Pre-Treatment Alcohol Use Severity Scale Pre-Treatment Crime Activities Severity Scale Pre-Treatment Psychiatric Problems Severity Scale Pre-Treatment Medical Problems Severity Scale Pre-Treatment Employment Problems Severity Scale</p> <p>Drug of Choice—Cocaine Drug of Choice—Heroin Drug of Choice—Other Drug</p> <p>OUTCOME VARIABLES:</p> <p>Change in Drug Use Severity Change in Alcohol Use Severity Change in Crime Activities Change in Psychiatric Problems Change in Medical Activities Change in Employment Problems</p>

Across the 30 models run within modality (6 outcomes by 5 modalities), client-level predictors accounted for 0 percent (alcohol severity in the methadone modality) to 27 percent (medical severity in the short-term residential modality) of the variation. For details on which variables were most predictive of success on each outcome within each modality, see the NTIES Final Report (NORC, 1997).

3.2 SDU-Level Analysis

The original case mix adjusted, SDU-level analysis was conducted in two stages. The first stage modeled client outcomes based on client characteristics, including pre-treatment severity. This produced a model-predicted outcome for each client, which was then averaged within SDUs (this procedure was performed for each of the six outcomes). The averaged value represented the predicted outcome for the SDU, based on the SDU's case mix. The second stage

compared the actual aggregated outcomes for each SDU with the predicted outcome using SDU-level variables to model the comparison. SDU-level variables examined were:

- # Treatment modality
- # Whether the SDU was selected for a Critical Populations grant
- # Whether the SDU was selected for a Target Cities grant
- # Average administrative, medical, and therapeutic costs per client per day
- # Average length of stay
- # Completion rate.

The dependent variables were the predicted minus the actual average level of severity for each SDU in each outcome domain. Positive values meant the SDU did not perform as well as predicted from its case mix, and vice versa.

The analyses found no effect of treatment modality on the case-mix-adjusted means, with the exception of drug severity, where methadone treatment SDUs did less well than other types. Participation in Target Cities did not show any effects but participation in Critical Populations did show an effect on drug severity; specifically, case-mix adjusted drug use severity outcomes were better for SDUs receiving Critical Populations funds. Finally, the remaining SDU level characteristics—average administrative, medical, and therapeutic costs per client per day; average length of stay; and completion rate—also affected only the drug severity outcomes. In sum, drug use severity was the only outcome measure that the SDU-level variables predicted to a statistically significant degree, yet even on this outcome it explained only an additional 3 percent of variance beyond the 18 percent already explained by case mix.

4. REANALYZING THE NTIES OUTCOME DATA IN A MULTILEVEL, RANDOM EFFECTS FRAMEWORK

The original NTIES outcome analysis had several limitations, including the following:

- # Client-level multiple regression analyses were based on pooled cases across SDUs. Thus they did not account for the intraclass correlations or design effects caused by the clustering of clients within SDUs. While this did not effect overall estimates of treatment effectiveness, standard errors were biased downward and effect coefficients for client characteristics were more likely to appear statistically significant as a result.

- # The SDU-level analysis was limited in the SDU characteristics it examined. Specifically, it examined modality, type of CSAT grant support, cost variables, and retention. It did not examine other variables that the literature suggests also might influence treatment effectiveness, such as whether the treatment program (1) provided case management (Cox, Mejer, Carr, & Feng, 1993; Mejita et al. 1994; Orwin et al. 1994); (2) matched clients to counselors or services (CSAT, 1994; 1995); or (3) tailored their program to specific populations (Westermeyer, 1990; Polinsky, Hser, & Grella, 1998). To some extent, the number of factors that could be examined was limited by the use of the SDU as the unit of analysis ($n=71$).
- # There are limitations inherent to the two-stage approach, as noted in the report. Key among them is the limited ability of the case-mix variables to reliably predict client outcomes in Stage 1, because most of the outcome variance remains unaccounted for. This in turn alters the average SDU outcome, which serves as the dependent variable in stage 2.
- # Since the client-level and SDU-level analyses were conducted separately, it was impossible to examine interactions between client-level and SDU-level factors, e.g., given an individual's pre-treatment characteristics profile, what program characteristics offer the best chance of effective treatment for that individual?

The present re-analysis will address all these issues. First, clients will be nested within SDUs so that intraclass correlations are properly accounted for in the computation of standard errors and effect sizes. Second, a broader range of SDU-level variables will be examined, and examined separately by modality as described below. Third, the multilevel, random-effects approach is not dependent on how well client demographics and pre-treatment severity predict outcomes. Fourth, because the client-level and SDU-level characteristics are analyzed together in a single multilevel model, interactions between client-level and SDU-level factors can be tested.

5. STUDY QUESTIONS

The present study is primarily a methods demonstration. Its main purpose is to illustrate the application of multilevel modeling to the analysis of multisite treatment outcome data. However, we also discuss substantive questions using these methods. These are:

- # What SDU-level factors appear to improve client outcomes, and how do these relationships vary by modality?
- # Interactions between SDU-level and client-level variables provide important insights into measures that providers can take in response to client characteristics.

- # What interactions occur between client-level and SDU-level factors?
- # Model fit statistics quantify the reduction of error or the improvement in predictive precision, afforded by each successive model. To what degree does the inclusion of SDU-level factors and SDU-client interactions improve overall model fit?
- # What are the implications for further analysis, policy, and practice?

II. METHODS

II. METHODS

1. OUTCOME VARIABLES

The outcome variables used in this reanalysis were the same six dependent variables used in the original analysis. Because the pretreatment severity scores were subtracted from the posttreatment scores to create the change scores, a negative improvement is a given domain.

2. PREDICTOR VARIABLES

Client-level variables were the same as those used by the National Opinion Research Council (NORC) in the original analysis, with some slight modifications. Service delivery unit (SDU)-level variables used in our analyses are listed in Exhibit II-1. The choice of these variables was guided by two primary criteria: the amount of (non)missing data in the variable and the variability of the variable across SDUs. The first criterion excluded variables whose values were missing for more than half of the observations. The second criterion excluded variables that have little or no variation and therefore low explanatory power due to their flat distribution.

EXHIBIT II-1	
SDU-LEVEL VARIABLES USED IN MIXED MODELS	
DESCRIPTION	
SDU Has Staff Designated as Case Manager(s)	
SDU Has Staff Training Specialists	
Client Defines Own Treatment Plan	
Ways Clients Participate in Development of Treatment Plan:	
Client Signs Treatment Plan	
Client Develops Treatment Plan Contents	
Client Develops Time for Treatment Plan	
Client Asks for Changes to Treatment Plan	
Other Client Participation in Treatment Plan	
SDU Matches Clients and Providers	
Share of Clients Matched	
SDU Tailors to Populations	
How Often Clients Attend Individual Counseling	
Average Length of Individual Counseling Sessions	
SDU Provides Residential Therapy Services	
SDU Does Urinalysis	
How Often Urinalysis Done	
Vocational Services Provided On-Site	
Academic Services Provided On-Site	

3. MODELING PROCESS

As noted above, multilevel random-effects models were used to reanalyze the data for each of the six outcome variables. These models can be generally fit with the flexible SAS procedures for mixed models, PROC MIXED, and we used this software for all analyses discussed here. As demonstrated in Kreft et al. (1994) and in the SAS documentation for PROC MIXED (Chapter 7), this approach is equivalent to the hierarchical linear modeling approach of Bryk and Raudenbush (1992).

We illustrate the model with a simple example using one single client-level variable, X , and no interactions. The notation gets more complex, of course, once we move to the more general cases considered in our analyses. With a formulation analogous to that presented in Singer (1999), for example, the model expresses the outcome Y_{ij} for client _{i} in SDU _{j} as a function of a vector Z of SDU-level variables:

$$\begin{aligned}
 Y_{ij} &= a_j + b_j X_{ij} + e_{ij} \\
 a_j &= c + \sum_k \{d_{j,k} Z_{j,k}\} + E_j \\
 b_j &= C + \sum_k \{g_{j,k} Z_{j,k}\} + F_j
 \end{aligned}$$

where a_j is a random intercept for SDU _{j} , and b_j is a random slope coefficient that relates the covariate X to the outcome Y . The latter two equations connect the random coefficients, a and b , to the SDU-level variables, Z . The error structure specifies that e_{ij} is normally distributed with mean 0 and standard deviation s and E_j, F_j have a joint bivariate normal distribution with mean 0.

This approach allows the introduction first of client-level variables for each modality, then SDU-level variables. Client-level variables were sex, ethnicity, attainment of a High School Diploma, severity scales for alcohol use, medical problems, psychiatric problems, criminality and employment, length of stay, treatment completion, the number of prior treatments, legal pressure to enter treatment, and whether clients were in treatment for heroin, cocaine and other drugs. All models included a term for a random intercept (a_j) identifying SDU. Models were run first with all client-level variables, then with client-level and SDU-level variables, and finally with client-level variables, SDU-level variables, and interaction terms. With the addition of SDU-level variables for each modality, we can assess the improvement in the model fits. For this purpose, we used goodness of fit measures that take into account the number of parameters used in the models. That is, these measures (e.g., Akaike Information Criterion (AIC)) adjust the log-likelihood to favor more parsimonious models. Thus, our

comparisons did not unduly or unfairly favor the more complete, 2-level models including SDU-level variables and cross-level interactions. Because each outcome was examined in each modality, there were $6 \times 5 = 30$ models in all. However, the introduction of SDU-level variables into the models for the correctional modality decimated the number of SDUs and cases due to missing data in the SDU-level variables. Specifically, the number of SDUs was reduced from 9 to 3, and the number of cases was reduced by approximately 90 percent (601 to 67). Consequently, further analyses on the correctional modality could not be performed.

The next step in the analysis was the examination of interactions between program-level variables and client-level variables (i.e., cross-level interactions). Due to the large number of potential variables in these models, we first identified a subset of variables that were statistically significant in the previous models. Using these criteria along with the requirement for adequate variability and completeness, models were limited to a subset of SDU-level variables and all interactions between these and a subset of the client-level variables. SDU-level variables finally selected for the models were the following:

- # Whether the SDU has staff designated as case managers,
- # Whether the SDU has staff training specialists,
- # The share of clients matched by the SDU (none, some, most or all),
- # Whether the SDU tailors to specific populations,
- # How often clients attend individual counseling, and
- # Average length of individual sessions.

Client-level variables that were investigated for their interactions with SDU-level variables were limited to length of stay, treatment completion, number of prior treatments, legal pressure to enter treatment, treatment for heroin, treatment for cocaine, and treatment for other drugs.

These blocks of variables representing client-level characteristics, SDU-level program variables, and forty-two (seven client-level and six SDU-level) selected interactions were used for all outcomes and modalities. Again, we looked at each outcome variable within each modality to identify significant interactions, and assessed the improvement in model fit over the main effects models.

III. RESULTS

III. RESULTS

1. MODEL FIT STATISTICS

Exhibit III-1 summarizes the modality-specific model fits performed with PROC MIXED. This table contrasts the level 1 models with the level 2 models, first without and then with cross-level interactions. By necessity, the SDU-level and client-level sample sizes in the left column include only complete cases (i.e., cases for which all client-level and SDU-level variables were non-missing). This keeps the sample sizes constant as SDU-level factors and client-by-SDU interactions are added, to ensure “apples-to-apples” comparisons. As noted above, high missing value rates on SDU factors precluded running models for the correctional modality.

As noted above, the fit statistics are Akaike Information Criterion (AIC)—measures that take into account the number of parameters used in the model (i.e., AIC penalizes models that are less parsimonious). Smaller absolute values represent better fits, so improvements in model fit may be inferred. As shown in Exhibit III-1, adding SDU-level main effects made very little difference in the methadone or short-term treatment modalities. With methadone, the largest improvement in absolute value was 15 (drug severity outcome), but the improvement in “pseudo-R²” was only than 1 percent.² Changes in the short-term treatment modality were even smaller. The non-methadone outpatient modality showed greater improvements in absolute change, but still very small in proportional change (less than 1 percent on all six outcomes). The improvements were only modestly larger in the long-term residential modality.

In contrast, the addition of client-by-SDU interactions consistently improved model fit across all dependent variables and modalities. Improvements in pseudo-R² ranged from a low of 1.4 percent (e.g., short-term residential, medical severity) to a high of 7 percent (e.g., long-term residential, drug severity). In general, the largest improvements in fit were in the long-term residential modality, with the second largest fit noted in the methadone modality.

² In ordinary least squares regression the coefficient of determination, or R², describes the percentage of total variance that is explained by the model. A pseudo R² (Mittlebock and Schemper, 1996) can be derived from differences in likelihood ratios or AICs between full and reduced models. In standard linear regression, R² results from a clear and complete partition of total variance into model and residual variance components, so that model variance can be expressed as a percentage of the total. However, in a mixed model, coefficients can contribute to variance in more than one level (Kreft and de Leeuw, 1998). This means that different levels can share an unknown amount of variance, confounding the total variance. The sum of variance from random and fixed levels would overestimate the total, and any single level would underestimate it. For simplicity, the pseudo R² was derived for fixed effects only. (Note that all the SDU variables and interactions appear in the model as fixed effects even though SDU is modeled as a random term.)

EXHIBIT III-1
SUMMARY MODEL FIT STATISTICS FOR MIXED MODELS
AKAIKE INFORMATION CRITERION (AND PERCENT IMPROVEMENT IN PSEUDO R²)

DEPENDENT VARIABLE MODALITY	MODEL	DRUG SEVERITY	ALCOHOL SEVERITY	CRIMINAL SEVERITY	MEDICAL SEVERITY	EMPLOYMENT SEVERITY	PSYCHIATRIC SEVERITY
Methadone (5 SDUs; 334 clients)	Client	-1548	-1340	-1191	-1222	-1561	-1418
	Client+SDU	-1533 (1.0)	-1331 (.07)	-1184 (0.6)	-1214 (0.7)	-1548 (0.8)	-1406 (0.9)
	Client+SDU+ Client* SDU	-1463 (5.5)	-1284 (4.2)	-1144 (3.9)	-1170 (4.3)	-1473 (5.6)	-1341 (5.5)
Non-Methadone Outpatient (17 SDUs; 954 clients)	Client	-4019	-4218	-3125	-3382	-4623	-3958
	Client+SDU	-4002 (0.4)	-4199 (0.4)	-3111 (0.5)	-3372 (0.4)	-4600 (0.5)	-3944 (0.4)
	Client+SDU+ Client* SDU	-3908 (2.8)	-4109 (2.6)	-3068 (1.8)	-3314 (2.0)	-4490 (2.9)	-3855 (2.6)
Short-Term Residential (4 SDUs; 452 clients)	Client	-1934	-2024	-1572	-1722	-2157	-1942
	Client+SDU	-1928 (0.3)	-2018 (0.3)	-1568 (0.3)	-1720 (0.1)	-2149 (0.4)	-1937 (0.3)
	Client+SDU+ Client* SDU	-1898 (1.9)	-1988 (1.8)	-1545 (1.7)	-1698 (1.4)	-2114 (2.0)	-1908 (1.8)
Long-Term Residential (12 SDUs; 449 clients)	Client	-1924	-2005	-1598	-1631	-2152	-1908
	Client+SDU	-1902 (1.1)	-1988 (0.8)	-1587 (0.7)	-1617 (0.8)	-2131 (1.0)	-1890 (0.9)
	Client+SDU+ Client* SDU	-1789 (7.0)	-1866 (6.9)	-1512 (5.4)	-1546 (5.2)	-2011 (6.6)	-1792 (6.1)

Note: The fit statistics are Akaike Information Criterion (AIC) measures that take into account the number of parameters used in the model (i.e., AIC penalizes models that are less parsimonious). Like the log likelihood, the AIC is affected by overall dispersion and the number of observations, but has not defined range or scale. Percent improvement in pseudo-R² based on reduction in AIC when compared with "Client" model.

2. MAIN EFFECTS MODELS

Exhibit III-2 summarizes the variables with significant coefficients ($p < 0.10$) for each modality. The relatively liberal type 1 error rate of 0.10 was selected for two basic reasons: the tests were frequently underpowered, particularly for modalities with fewer SDUs (e.g., methadone) and the analyses were exploratory in attempting to find SDU-level factors that might be important in explaining outcomes, rather than confirmatory tests of specific hypotheses.

Note that a negative sign in the change outcome translates into increased improvement for each increasing level of the independent variable, and that a positive sign means reduced improvement in the severity scores. This direction follows from the way the change scores are constructed as post- minus pre-severity scores.

No significant main effects were found for the short-term residential modality. Only one significant effect was found for the methadone modality, where SDU tailors-to-population was associated with reduced improvement on drug severity. It is worth noting, however, that both the methadone and short-term residential models had marginal degrees of freedom due to missing data and too few SDUs (five or fewer). In the methadone modality, the effects of staff training specialists could not be tested because none of the included SDUs reported using them (i.e., lack of variation in the variable). In the short-term residential modality, the effects of case managers, staff training specialists, frequency of counseling, and tailoring to populations could not be tested due to absence of variability on those dimensions.

The other two types of facilities had a range of significant coefficients that vary by outcome for each modality. For non-methadone outpatient facilities, alcohol, drug, and criminal severity changes are significantly explained by whether the SDU has designated case managers. Specifically, case management was associated with increased improvement in each of these domains. In addition, tailoring to population was associated with increased improvement in the criminal and medical domains, as was frequency of individual counseling in the medical domain. On the other hand, the average length of individual sessions was associated with reduced improvement in the medical and employment domains, as was the use of staff training specialists in the alcohol and criminal domain.

EXHIBIT III-2
SIGNIFICANT SDU-LEVEL MAIN EFFECTS IN MIXED MODELS FOR EACH
MODALITY AND OUTCOME VARIABLE

DEPENDENT VARIABLE MODALITY	DRUG SEVERITY	ALCOHOL SEVERITY	CRIMINAL SEVERITY	MEDICAL SEVERITY	EMPLOYMENT SEVERITY	PSYCHIATRIC SEVERITY
Methadone	Tailors to Pop. (-)					
Non-methadone Outpatient	Case Management (+)	Case Management (+) Training Specialists (-)	Case Management (+) Training Specialists (-) Tailors to Population (+)	Tailors to Population (+) Average Individual Session Length (-)	Frequency of Individual Counseling (+) Average Individual Session Length (-)	
Short-term residential						
Long-term residential	Training Specialists (+) Frequency of Individual Counseling (-)				Tailors to Population (-)	

Note: Coefficients that are significant at the 0.10 level are indicated, together with the sign (direction in parentheses) of the relationship. Plus signs indicate greater improvement in outcome.

For long-term residential facilities, there are two significant SDU-level main effects for drug severity change: the use of staff training specialists and the frequency of individual counseling. The former was associated with increased improvement, the latter with reduced. In addition, tailoring to population was associated with reduced improvement in the employment domain.

3. MAIN EFFECTS PLUS INTERACTIONS MODELS

Next, we computed mixed models including interactions between client-level and SDU-level variables. Because of the large number of possible interactions obtained by crossing all variables of the two types, we limited the client variables to a subset of seven “most meaningful” variables (usually treatment-related rather than demographic).

Generally, there are a remarkable number of significant interactions, and the patterns vary substantially by modality. Exhibits III-3 through III-6 present the significant interactions found for each modality and each outcome variable. As with the main effects, interaction terms involving SDU-level variables showing no variance in the methadone and short-term residential modalities could not be tested.

3.1 Methadone Facilities

For methadone facilities, frequency of individual counseling interacted significantly with whether the client had prior treatment episodes and whether the client reported a cocaine problem in explaining change in psychiatric severity. Note that since all clients in methadone clinics are heroin users by definition, clients reporting a cocaine problem have problems with both drugs. Specifically, clients with prior treatment appeared to benefit less from more frequent individual counseling, while cocaine users appeared to benefit more. In addition, clients who completed treatment appeared to benefit more in the employment domain from SDU tailoring to populations.

EXHIBIT III-3 SIGNIFICANT INTERACTIONS FOR METHADONE FACILITIES		
OUTCOME: SEVERITY CHANGE	INTERACTIONS	
Drug		
Alcohol		
Criminal		
Medical		
Employment	Tailors to Population* Treatment Completed	(+)*
Psychiatric	Frequency of Individual Counseling* Prior Treatment	(-)**
	Frequency of Individual Counseling* In Treatment for Cocaine	(+)**
* p#0.10	** p#0.05	*** p#0.01

3.2 Non-Methadone Outpatient Facilities

Significant SDU-level interactions with client-level variables also extend to this modality, where two or more interactions were observed for each of the six dependent variable models. For example, both employment and psychiatric severity changes are significantly explained by the interaction of treatment completion with client-matching; however, on both outcomes, clients from SDUs reporting more matching appeared to benefit less from completing treatment (see Exhibit III-4). At the same time, clients from SDUs with staff training specialists benefitted more from completing treatment. For the drug severity outcome, treatment completion interacted with individual counseling frequency and session length; clients who completed their programs appeared to benefit more from these more intensive programs than those who did not. This is particularly revealing because there were no main effects of program intensity on drug outcomes in this modality after controlling for client-level variables. Finally, treatment completers appeared to benefit more from the presence of staff training specialists in reducing alcohol and psychiatric severity. Taken together, this pattern suggests that SDU-level factors may have increased treatment completion, which in turn mediated successful outcomes in this modality (alternative explanations are also possible, as always).

EXHIBIT III-4		
SIGNIFICANT INTERACTIONS FOR NON-METHADONE OUTPATIENT FACILITIES		
OUTCOME: SEVERITY CHANGE	INTERACTIONS	
Drug	Share Clients Matched* Prior Treatment	(+)*
	Training Specialists* In Treatment for Cocaine	(+)**
	Tailors to Population* In Treatment for Cocaine	(-)*
	Share Clients Matched* In Treatment for Heroin	(-)**
	Training Specialists* In Treatment for Other Drug	(+)**
	Share Clients Matched* In Treatment for Other Drug	(-)**
	Frequency of Individual Counseling* Treatment Completed	(+)**
	Average Individual Session Length* Treatment Completed	(+)*
Alcohol	Training Specialists* Length of Stay	(-)*
	Training Specialists* Treatment Completed	(+)*
Criminal	Tailors to Population* Legal Pressure for Treatment	(+)*
	Average Individual Session Length* Length of Stay	(+)*
Medical	Training Specialists* Legal Pressure for Treatment	(-)*
	Training Specialists* In Treatment for Heroin	(+)**
	Share Clients Matched* In Treatment for Heroin	(-)**
	Tailors to Population* In Treatment for Other	(+)*
Employment	Share Clients Matched* Length of Stay	(-)*
	Share Clients Matched* Treatment Completed	(-)*
Psychiatric	Case Management* Legal Pressure for Treatment	(+)*
	Training Specialists* Length of Stay	(-)*
	Training Specialists* In Treatment for Cocaine	(+)**
	Share Clients Matched* In Treatment for Cocaine	(-)**
	Share Clients Matched* In Treatment for Heroin	(-)**
	Tailors to Population* In Treatment for Heroin	(+)**
	Average Individual Session Length* In Treatment for Heroin	(-)**
	Training Specialists* Treatment Completed	(+)**
	Share Clients Matched* Treatment Completed	(-)*
* p#0.10	** p#0.05	*** p#0.01

Being in treatment for heroin use interacts with different SDU-level variables for different outcomes. For drug severity and medical severity, heroin users appeared to benefit less from matching than non-heroin users, respectively. For medical severity, heroin users appeared to benefit more from staff training specialists. For psychiatric severity, heroin users appeared to benefit more from population tailoring, but less from matching and session length. Cocaine users and other-drug users also appeared to benefit less from matching, but more from the presence of training specialists. Other-drug users also appear to benefit from population tailoring in the medical domain, potentiating the main effect of tailoring reported earlier. Note that client matching, the presence of staff training specialists, and tailoring to the population

each interacted with client-level variables in four of the six outcome domains. In addition to the drug use and treatment completion interactions noted above, clients with prior treatment episodes appeared to benefit more in the drug domain from SDU matching. Clients in treatment due to legal pressure appeared to benefit more from population tailoring in the criminal domain. The latter interaction potentiates the main effect of population tailoring on criminal severity reported in Exhibit III-2. On the other hand, matching was associated with lower employability gains for clients who stayed in treatment longer and completed their programs. Moreover, the presence of training specialists was associated with reduced improvement in the alcohol and psychiatric domains for clients staying in treatment longer and in the medical domain for clients in treatment due to legal pressure.

3.3 Long-Term Residential Facilities

As seen in Exhibit III-5, the client-level variable length of stay seems to play a prominent explanatory role in the interactions for this modality. Specifically, clients who stayed in treatment longer appeared to benefit more from matching (drug domain), longer session lengths (alcohol domain), and population tailoring (employment domain) than their counterparts who stayed for shorter durations. The latter finding mitigates the negative main effect of population tailoring on employability reported in Exhibit III-2. As in the non-methadone outpatient modality, the drug the client was in treatment for also played prominently. In the drug and alcohol domains, clients in treatment for heroin appeared to benefit more from higher counseling frequencies, client matching, and the presence of training specialists (drug domain only). Clients in treatment for cocaine appeared to benefit from higher counseling frequencies as well. These interactions, therefore, mitigate the negative main effect of counseling frequency for this modality. At the same time, heroin users appeared to benefit less from longer average session lengths in both the alcohol and criminal domains.

EXHIBIT III-5 SIGNIFICANT INTERACTIONS FOR LONG-TERM RESIDENTIAL FACILITIES		
OUTCOME: SEVERITY CHANGE	INTERACTIONS	
Drug	Share Clients Matched* Length of Stay	(-)*
	Training Specialists* In Treatment for Cocaine	(+)*
	Frequency of Individual Counseling* In Treatment for Cocaine	(-)**
	Training Specialists* In Treatment for Heroin	(-)**
	Share Clients Matched* In Treatment for Heroin	(-)**
	Frequency of Individual Counseling* In Treatment for Heroin	(-)**
Alcohol	Case Management* Prior Treatments	(+)*
	Share Clients Matched* Prior Treatments	(+)**
	Tailors to Population* Prior Treatments	(-)**
	Average Individual Session Length* Prior Treatments	(-)**
	Share Clients Matched* Legal Pressure for Treatment	(-)*
	Average Individual Session Length* Length of Stay	(-)*
	Share Clients Matched* In Treatment for Heroin	(-)**
	Frequency of Individual Counseling* In Treatment for Heroin	(-)**
	Average Individual Session Length* In Treatment for Heroin	(+)**
	Share Clients Matched* In Treatment for Other Drug	(+)**
	Training Specialists * Treatment Completion	(+)*
Criminal	Average Individual Session Length* In Treatment for Heroin	(+)**
	Share Clients Matched* In Treatment for Other Drug	(-)**
	Average Individual Session Length* In Treatment for Other Drug	(+)*
Medical		
Employment	Tailors to Population* Length of Stay	(-)*
	Case Management* Treatment Completed	(+)*
Psychiatric	Training Specialists* In Treatment for Heroin	(+)
* p#0.10	** p#0.05	*** p#0.01

Clients with prior treatment episodes and those who completed their treatments appeared to benefit less from case management in the alcohol and employment domains, respectively. At the same time, clients with prior episodes appear to have benefited more from population tailoring and longer average session lengths than clients in treatment for the first time, but those clients benefited less from matching. Clients in treatment due to legal pressure *did* appear to benefit more from matching, while treatment completers benefited less from staff training specialists, at least in the alcohol domain.

3.4 Short-Term Residential Facilities

For this modality, significant interactions are confined to two SDU variables: matching and session length, and two outcome domains: criminal and medical severity (see Exhibit III-6). Clients staying in treatment longer appear more likely to have benefited from longer average session lengths with respect to criminal severity (as was the case for non-methadone outpatient clients), while clients completing treatment were more likely to have benefited in the medical domain from matching. On the other hand, clients with prior treatments or in treatment for a cocaine problem were relatively less likely to benefit from matching.

EXHIBIT III-6	
SIGNIFICANT INTERACTIONS FOR SHORT-TERM RESIDENTIAL FACILITIES	
OUTCOME: SEVERITY CHANGE	INTERACTIONS
Drug	
Alcohol	
Criminal	Share Clients Matched* Prior Treatment (-)** Average Individual Session Length* Length of Stay (+)*
Medical	Share Clients Matched* In Treatment for Cocaine (-)* Share Clients Matched* In Treatment Completed (+)*
Employment	
Psychiatric	
* p#0.10	** p#0.05
	*** p# 0.01

IV. SUMMARY AND DISCUSSION

IV. SUMMARY AND DISCUSSION

1. LIMITATIONS

The following limitations should be considered in interpreting these results:

- # The large amount of missing data has serious repercussions for SDU-level analyses, which must discard an entire SDU where values are missing for one or more of the SDU-level analysis variables (listwise deletion). Consequently, some of the modality-specific mixed models had limited degrees of freedom as we increased the number of (potential) explanatory variables. We compensated for this by making reasonable tradeoffs in limiting the number of independent variables considered at the SDU level as well as the client level. Still (as noted above), the number of nonmissing cases remaining in the correctional modality was too small to support the modeling process. As a consequence, this report cannot speak to the effects of SDU-level factors on clients in correctional treatment facilities. It also cannot speak to the effects of SDU-level factors with no variability in the methadone and short-term residential modalities.
- # While the hierarchical models were specified correctly in Proc Mixed to the extent possible, one simplifying assumption was necessary for the procedure to successfully run. Specifically, it was necessary to assume that regression slopes of client-level predictors were similar across SDUs. The degree to which this assumption was violated, and its effect on the results if it was, are unknown.
- # Some of the counterintuitive findings on SDU-level effects may in fact represent unmeasured selection bias. An example is the negative association between tailoring treatment to populations and outcomes in the methadone and long-term residential modalities. It seems unlikely that population tailoring would actually cause clients to do worse on outcomes; rather, the finding might be reflecting that facilities with the most difficult clients tend to do more tailoring. By including the client-level variables first, outcome variance common to client-level factors and SDU-level factors was “credited” to client-level factors. This offered some measure of protection against the misinterpretation of selection bias as SDU-level factor effects, but only to the extent that the selection bias is captured by the client-level factors that were measured and included in the models.
- # This analysis was based upon the analysis of six outcomes in four treatment modalities, in which 42 interactions were tested for significance along with main events. It should be expected that a portion of the significant results presented here could be due to chance alone.

2. ANSWERS TO STUDY QUESTIONS

2.1 What SDU-Level Factors Appear to Improve Client Outcomes, and How Do These Relationships Vary by Modality?

Significant main effects of SDU-level variables were observed in three of the four modalities in which models could be run: methadone, non-methadone outpatient, and long-term residential. All six outcome domains were affected: drug, alcohol, criminal, employment, medical, and psychiatric. In terms of factors associated with positive client change (i.e., increased reductions in severity scores), all but one were in the non-methadone outpatient modality. Specifically, SDU-level variables associated with *increased* client improvement after controlling for client-level factors were:

- # SDU had a designated case manager (non-methadone outpatient—alcohol, drug, and criminal outcome domains)
- # SDU tailored program to populations (non-methadone outpatient—criminal and medical domains)
- # SDU had staff training specialists (long-term residential*drug domain)
- # Average frequency of individual counseling (non-methadone outpatient—medical domain).

At the same time, SDU-level variables associated with *reduced* client improvement were:

- # SDU tailored program to populations (methadone*drug domain; long-term residential* employment domain)
- # SDU had staff training specialists (non-methadone outpatient*alcohol and criminal domains)
- # Average frequency of individual counseling (long-term residential* drug domain)
- # Average length of individual sessions (non-methadone outpatient—medical and employment domains).

No other SDU-level variable from Exhibit II-1 had any significant main effects, positive or negative. However, this was in part because missing values removed any variation in SDU-level variables so they were not really tested, particularly in the methadone and short-term residential modalities. Taken at face value, the data suggest that SDU-level main effects—as measured by these variables—were consistent across the six outcomes within a given modality, in that no

variable had both positive and negative main effects within the same modality. However, they were inconsistent across modality, and effects representing reduced client improvement were about as likely to occur as effects representing increases. The one exception is having a designated case manager, which showed increases in improvement only, albeit in only one modality (non-methadone outpatient). Also noteworthy in the outpatient modality is the oppositional relationship of the frequency and duration of counseling sessions. This would seem to suggest that frequent, short sessions may be more beneficial than longer, less frequent sessions to clients in outpatient treatment.

2.2 What Interactions Occur Between Client-Level and SDU-Level Factors?

Interactions occurred more frequently than main effects, suggesting that SDU-level characteristics do have a substantial impact on outcomes, but that impact is contingent on client-level characteristics. The pattern of significant interactions varies substantially by modality, as shown in Exhibit III-3 through III-6 and discussed in detail in Chapter 3. As with main effects, some interactions in the methadone and short-term residential modalities could not be tested due to lack of variance (too much similarity) in SDU factors.

- # The non-methadone outpatient modality had the most significant interaction effects (27), and was the only modality in which interactions were found for all 6 outcomes. The long-term residential modality had the next highest number (22), spanning 5 outcomes.
- # Like the main effects, the signs of the interaction effects were consistent across outcomes within a given modality but less consistent across modality.

For example, the drug for which the client sought treatment frequently interacted with SDU-level factors, and did so in all four modalities. This strongly suggests that the client's particular drug problem mediates the effectiveness of SDU-level components, consistent with the literature on this topic (e.g., McLellan, & Alterman, 1991; Thornton, Gottheil, Weinstein, & Kerachsky, 1998; CSAT, 1994b). However, the present study suggests that those mediational relationships may differ across modalities. For example, long-term residential clients presenting with a heroin problem showed increased improvements from client matching in the drug and alcohol domain (relative to non-heroin users), while non-methadone outpatient clients with a heroin problem showed *reduced* improvement from client matching in the drug, medical, and psychiatric domains.

- # Treatment completion interacted positively with SDU-level factors in three of the four modalities (methadone, non-methadone outpatient, and short-term residential).

- # Treatment completers in the methadone modality appeared to benefit more from SDU tailoring to populations than their non-completer counterparts, while treatment completers in the short-term residential modality appeared to benefit more from matching.
- # In the non-methadone outpatient modality, treatment completion interacted with individual counseling frequency and session length on the drug severity outcome: clients who completed their programs appeared to benefit more from these intensive programs than those who did not. This is particularly revealing because there were no main effects of program intensity on drug outcomes in this modality after controlling for client-level variables.
- # Treatment completers in non-methadone outpatient facilities appeared to benefit more from the presence of staff training specialists in reducing alcohol and psychiatric severity. Taken together, this pattern suggests that SDU-level factors may have increased treatment completion, which in turn mediated successful outcomes in these three modalities (alternative explanations are also possible, as always). This would be consistent with the emerging literature on the role of SDU factors in increasing program retention (Battelle, 1998; Orwin, Garrison-Mogren, Jacobs, & Sonnefeld, 1999; Stahler et al., 1993), as well as the role of program retention in improving outcomes (De Leon, 1991; Hser et al., 1991; McKusker, Stoddard, Frost, & Zorn, 1996).
- # The one modality in which interactions with treatment completion ran the opposite way was long-term residential, where treatment completers appeared to benefit less from both training specialists (alcohol domain) and case managers (employment domain).
- # In some cases, SDU-client interactions served to potentiate SDU main effects. For example, in the non-methadone outpatient modality, other drug users benefited most from population tailoring in the medical domain, over and above the main effect of tailoring on medical severity. Similarly, clients in treatment due to legal pressure benefited most from population tailoring in the criminal domain, over and above the main effect of population tailoring on that outcome.

2.3 To What Degree Does the Inclusion of SDU-Level Factors and SDU-Client Interactions Improve Overall Model Fit?

In the four modalities in which models could be tested, the introduction of SDU-level variables generally made little improvement in model fit, as assessed by the AIC statistic. The non-methadone outpatient modality showed increased improvements in absolute change but was still very small in proportional change (less than 1 percent increase in pseudo-R² on all six outcomes). They were only modestly larger in the long-term residential modality, which (as noted above) had the greatest number of significant effects. In contrast, the addition of client-

by-SDU interactions consistently improved model fit across all dependent variables and modalities. Improvements in pseudo- R^2 ranged from a low of 1 percent (e.g., short-term residential, medical severity) to a high of 7 percent (e.g., long-term residential, drug and alcohol severity). In general, the largest improvements in fit were in the long-term residential modality, with the second largest in the methadone modality. While rules of thumb do not exist for interpreting how large an improvement in AIC is “large enough” to be important, we do note that the corresponding -2 log likelihood statistic showed a statistically significant improvement in most cases when the interaction terms were added and the AIC difference was modest.³ For example, for changes in drug severity for the non-methadone outpatient modality, models with and without interaction terms show a difference in -2 log likelihood of 8000 - 7813, or 187, which with 42 additional parameters is significant at $p < .001$. For changes in alcohol severity, the addition of the interaction terms shows a difference in -2 log likelihood of 180, which with 42 additional parameters also is significant at $p < .001$.

3. IMPLICATIONS FOR FURTHER ANALYSIS, POLICY, AND PRACTICE

3.1 Analysis

The results of our mixed model analyses show a range of significant SDU-level main effects and interactions between SDU variables and client-level variables. The results also highlight how these effects and interactions vary across modalities. These findings are possible with the multilevel modeling methodology that extends the multiple regression models previously conducted. The study therefore demonstrated some of the potential benefits in considering program effects in multilevel analyses of cross-site substance abuse treatment evaluations, and in particular for NTIES data analyses. The following are areas for further research that could productively be investigated with the NTIES data:

- # We view this report as a first attempt at applying multilevel random-effects models to the NTIES data, and it may well be that further refinements could yield more readily interpretable results. Given the limitations caused by missing data, however, it might be worth investigating the degree to which missing values on some SDU-level characteristics could be logically or statistically imputed from the response pattern on other, non-missing variables, or even recontacting the original SDU administrators who filled out the NBAR.
- # In principle, a 3-level random effects analysis could be conducted that integrated the different modalities into a single model for each dependent variable. That is, clients

³ Differences in the AICs presented in Exhibit III-1 are approximately equal to the log likelihood, which after multiplying by -2 can be used to test significant differences between models.

and SDUs would still represent levels 1 and 2, respectively, and modality would represent level 3. This would permit a direct test of the effect of modality on outcomes, controlling for differences in both client case mix and SDU-level characteristics, as well as accounting for the intraclass correlations of clients within SDUs and SDUs within modality. It could also address interactions of modality with both SDU-level and client-level factors.

3.2 Policy and Practice

Though this study was primarily a methods demonstration, it nonetheless has substantive implications. In particular, the identification of SDU characteristics with positive effects and SDU-by-client interactions across different modalities and outcomes suggest ways in which the treatment community might refine programs along these dimensions. For example:

- # The finding that positive main effects of SDU characteristics were primarily found in the non-methadone outpatient modality suggests that the likelihood of improving client outcomes through manipulating SDU-level factors (e.g., having a designated case manager and tailoring the program to the population) may be greatest in that modality.
- # The finding that frequent, short sessions may be more beneficial than longer, less frequent sessions in outpatient treatment has implications for structuring outpatient programming.
- # The finding that interactions occurred more frequently than main effects suggests that SDU-level effects are highly contingent on client-level characteristics and modality—confirming that in substance abuse treatment, the question of “what works?” is more productively specified as “what works for whom, and in what setting?”

Other implications can be drawn from the findings highlighted above. However, as noted earlier, some of the significant results presented here could be due to chance due to the large number of main effects and interactions examined. The optimal next step for policy and practice would be new prospective studies that rigorously examined some of the relationships suggested here.

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APPENDIX:
DESCRIPTION OF THE NATIONAL TREATMENT IMPROVEMENT EVALUATION
STUDY AND CENTER FOR SUBSTANCE ABUSE TREATMENT
DEMONSTRATIONS (1990-1992)

APPENDIX

DESCRIPTION OF THE NATIONAL TREATMENT IMPROVEMENT EVALUATION STUDY AND CENTER FOR SUBSTANCE ABUSE TREATMENT DEMONSTRATIONS (1990-1992)

The National Treatment Improvement Evaluation Study (NTIES) was a national evaluation of the effectiveness of substance abuse treatment services delivered in comprehensive treatment demonstration programs supported by the Center for Substance Abuse Treatment (CSAT). The NTIES project (1992-1997) was designed and performed for CSAT by the National Opinion Research Center at the University of Chicago with assistance from Research Triangle Institute. The NTIES project collected longitudinal data between FY 1992 and FY 1997 on a purposive sample of clients in treatment programs receiving demonstration grant funding from CSAT. Client-level data were obtained at treatment intake, at treatment exit, and 12 months after treatment exit. Service delivery unit (SDU) administrative and clinician (SDU staff) data were obtained at two time points, 1 year apart.

1. THE NTIES DESIGN

1.1 The Administrative/Services Component

The NTIES study design had two levels—an administrative or services component and a clinical treatment outcomes component. The administrative component was designed to assess how CSAT demonstration funds were used, what improvements in services were implemented at the program level, and what kind and how many programs and clients were affected by the demonstration awards. Four data collection instruments were used to gather administrative/services data: the NTIES Baseline Administration Report (NBAR), the NTIES Continuing Administrative Report (NCAR), the NTIES Exit Log, and the NTIES Clinician Form (NCF).

The unit of analysis for the administrative component was the SDU, defined by CSAT as a single site offering a single level of care. The classification of *level of care* is based on three parameters:

- # Facility type (e.g., hospital, etc.)
- # Intensity of care (e.g., 24-hour, etc.)
- # Type of service (e.g., outpatient, etc.).

An SDU could be a stand-alone treatment provider, or it could be one component of a multi-tiered treatment organization. For example, a large, county mental health agency may be the *organization* within which the SDU is located. The organization may have multiple substance

abuse treatment components, such as a county hospital and a county (ambulatory) mental health center. The county hospital may have multiple SDUs, such as an inpatient detoxification service, an outpatient counseling service, and a hospital satellite center providing transitional care. In summary, the SDU provided NTIES evaluators with a stable, uniform level of comparison for examining service delivery issues.

A range of key clinician-specific data elements (within the administrative component) were assessed using the NCF. The NCF items were an important adjunct to the facility- (SDU) level instruments; these items assessed clinician training, experience, client exposure, and service provision, and were completed by all counseling and clinical (medical and therapeutic) staff at the individual SDUs.

1.2 Clinical Treatment Outcomes Component

The unit of analysis for the clinical treatment outcomes component was individual client data. NTIES measured the clinical outcomes of treatment primarily through a “before/after” or “pre- to post-treatment” design. This method compares behaviors or other individual characteristics in the same participants, measured in similar ways, before and after an intervention.

Information about clients’ lives for the *before* period were obtained from the NTIES Research Intake Questionnaire (NRIQ), which was administered sometime during the clients’ first 3 weeks of treatment. The specific areas assessed included:

- # Drug and alcohol use
- # Employment
- # Criminal justice involvement and criminal behaviors
- # Living arrangements
- # Mental and physical health.

Information about clients’ lives for the *after* period were obtained from the NTIES Post-discharge Assessment Questionnaire (NPAQ), with the same areas assessed at roughly 12 months post-treatment. Other client data sources included a treatment discharge interview (NTIES Treatment Experience Questionnaire, NTEQ), abstracted client records, urine drug screens collected at the time of the follow-up interview, and arrest reports from state databases.

1.3 The Outcome Analysis Sample

Between August 1993 and October 1994, research staff successfully enrolled 6,593 clients at 71 SDUs to participate in three waves of an in-person, computer-assisted data collection protocol. These SDUs were chosen from the universe of treatment units receiving demonstration grant funding from CSAT. Some of the selected facilities were wholly supported by CSAT awards, while others received only indirect support or none.

Clients were interviewed three times: shortly after admission on their first day of treatment, when they left treatment, and 12 months after the end of treatment. Less than 10 percent of the eligible clients refused or avoided participation, and more than 83 percent of the recruited individuals (5,388 clients) completed a follow-up interview. Additional sample exclusions included:

- # Missing or undetermined treatment exit date
- # Inappropriate length of follow-up interval (less than 5 or more than 16 months)
- # Clients incarcerated for most or all of the follow-up period (nearly all had been treated while incarcerated, and were not yet released).

The additional sample exclusions resulted in a final outcome analysis sample of 4,411 individuals.

2. TREATMENT DEMONSTRATION PROGRAMS

CSAT initiated three major demonstration programs and made 157 multi-year treatment enhancement awards across 47 states and several territories during 1990 through 1992. One objective common to all demonstrations was CSAT's emphasis on the provision of "comprehensive treatment" services to targeted client populations. The recipients of these awards focused special attention on the substance abuse treatment service needs of minority and special populations located primarily within large metropolitan areas. The demonstration programs are briefly described below.

2.1 Target Cities

Under this demonstration, nine metropolitan areas were selected to receive awards, of which half were included in the NTIES purposive sample. The following treatment improvement activities were explicitly provided for in the awards:

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- # Establishment of a Central Intake Unit (CIU) with automated client tracking and referral systems in place
 - # Provision of comprehensive services, including vocational, educational, biological, psychological, informational, and lifestyle components
 - # Improved inter-agency coordination (e.g., mental health, criminal justice, and human service agencies)
 - # Services for special populations—adolescents, pregnant and postpartum women, racial and ethnic minorities, and public housing residents.

2.2 Critical Populations

Under this demonstration program, awardees were required to implement “model enhancements” to existing treatment services for one or more of the following critical populations: racial and ethnic minorities, residents of public housing, and/or adolescents. Special emphasis was given to services provided to the homeless, the dually diagnosed, or persons living in rural areas. A total of 130 grants were awarded, covering services such as vocational support/counseling, housing assistance, integrated mental health and/or medical services, coordinated social services, culturally directed services, and others.

2.3 Incarcerated and Non-Incarcerated Criminal Justice Populations

Under this demonstration program, funds were directed toward improving the standard of comprehensive treatment services for criminally involved clients in correctional and other settings. Some program emphasis was placed on ethnic and/or racial minorities. Nine correctional setting demonstrations were funded: five in prisons, three in local jails, and one across a network of juvenile detention facilities. All projects included a screening component to identify substance-abusing inmates, a variety of targeted treatment interventions (e.g., therapeutic communities, intensive day treatment programs), and a substantial aftercare component.

A total of 10 non-incarcerated projects were funded. Five programs targeted interventions at clients in diversionary programs, three focused services on probationers or parolees, and two programs targeted both populations. Almost all of the funded demonstration projects included the following components:

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- # Basic eligibility determination, followed by systematic screening and assessment
 - # Referral to treatment
 - # Graduated sanctions and incentives while in treatment
 - # Intensive supervision in treatment
 - # Community-based aftercare with supervision and service coordination.

In total, 19 criminal justice projects were funded as part of the CSAT 1990-1992 demonstrations, and as indicated in the next section, these projects were purposively over-sampled in order to obtain a more robust evaluation of this program.

3. DESCRIPTION OF SDUS AND CLIENTS BY TREATMENT MODALITY AND PROGRAM TYPE

The 71 SDUs contributing clients to the outcome analysis sample are characterized by modality and (demonstration) program type in Exhibit A-1 below. Among the 698 SDUs in the NTIES universe: 52 percent (n=365) were Target Cities programs, 39 percent (n=274) were Critical Populations programs, and 9 percent (n=59) were Criminal Justice programs.

In terms of the SDUs sampled for the NTIES outcome analysis, 44 percent were Target Cities programs, 38 percent were Critical Populations programs, and 23 percent were Criminal Justice programs. Criminal Justice SDUs were purposely over-sampled as part of the NTIES evaluation design (CSAT, 1997). Nearly half of the sampled SDUs were (non-methadone) outpatient programs, and about one-quarter were long-term residential programs.

EXHIBIT A-1						
SDUs IN THE OUTCOME ANALYSIS SAMPLE						
Program Title Number of SDUs (% of NTIES Universe) ⁴	NTIES Sample	Methodone	Outpatient	Long-Term Residential	Short-Term Residential	Correctional
Target Cities n=365 (52%)	31 (44%)	6	15	6	4	0
Critical Populations n=274 (39%)	27 (38%)	1	13	10	3	0
Criminal Justice n=59 (9%)	13 (23%)	0	5	0	0	8
Totals N=698 (100%)	71 (100%)	7	33	16	7	8

EXHIBIT A-2					
DISTRIBUTION OF CLIENTS IN THE OUTCOMES ANALYSIS SAMPLE					
Program Title Number of Clients (% of Analysis Sample)	Methodone	Outpatient	Long-Term Residential	Short-Term Residential	Correctional
Target Cities n=2,600 (59%)	377 (89%)	1,214 (78%)	504 (60%)	505 (58%)	0
Critical Populations n=931 (21%)	45 (11%)	220 (14%)	298 (35%)	368 (42%)	0
Criminal Justice n=880 (20%)	0	132 (8%)	39 (5%)	0	709 (100%)
Totals n=4,411 (100%)	422	1,566	841	873	709

As shown in Exhibit A-2, 59 percent of all NTIES clients were sampled from Target Cities SDUs. Slightly over 21 percent of all NTIES clients were sampled from Critical Populations SDUs, and 20 percent were sampled from Criminal Justice SDUs. Outpatient (non-methadone) SDUs treated over one-third (35%) of the clients in the outcomes analysis sample, and almost 80 percent of these were sampled from Target Cities programs.

Readers who are interested in more detailed information about the NTIES project are invited to visit the NEDS Web site at: <http://neds.calib.com>. The NEDS Web site provides the

⁴ The original NTIES universe of SDUs included a program type called *Specialized Services*. Because clients for the outcome analysis sample were not drawn from these SDUs (n=94), they are excluded from the Exhibit.

full-length version of the NTIES Final Report (1997), as well as copies of all data collection instruments employed in NTIES.

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