Neural Network-Based Drug Abuse Treatment Optimization

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Abstract

In 2009, 2.6 million people in the United States over 12 years of age received treatment for substance abuse at a "specialty facility" . The direct cost of substance abuse treatment was estimated to be $22 billion in 2005, up from $11 billion in 1991. With recent federal health care reform, more clients may seek treatment, but it is unclear how this would affect clinics' costs per client. Although past studies on substance abuse costs find some evidence of economies of scale, they also find wide variation in the average costs of treatment, the reasons for which require further investigation. As a result, state substance abuse agencies and other payers face difficulty in determining how to pay providers, in fact, very often funding is inadequate or wasted. The drug abuse treatment process can be viewed as a complex adaptive system in which system inputs such as workers, physical capital and other materials are converted into outputs such as treatment completions and outcomes. Treatment clinics desire the most cost efficient input mix to generate desired outputs. Although substance abuse researchers are ahead of many other fields in developing and refining instruments such as the Drug Abuse Treatment Cost Analysis Program, many of these instruments are restricted by the fact that databases have many omissions making it difficult to answer research questions that might otherwise be informed by economic analysis. Additionally, due to the large numbers of variables involved, trade-offs are difficult to explore. Questions such as "what are the relationships between costs and case-mix?" or "what are reasonable reimbursement rates for substance abuse treatment and how do they differ for specialized populations such as heroin users?" are difficult to answer. The work reported in this paper provides significant insight that can help policymakers to decide where to focus funding through 1) prediction of missing treatment data and 2) identification of critical variables.

Keywords: complex adaptive systems; drug abuse treatment; neural networks; total functional cost; sensitivity analysis

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1. Introduction

Some of the most difficult decisions that government policymakers face are which substance abuse treatment programs to fund and where to set reimbursement rates. Similarly, a challenge facing both Federal and State policymakers is how to efficiently allocate limited public funds while avoiding either over or under treating substance-abusing patients. In principle, only programs that meet some minimum set of performance standards should be funded, and reimbursement rates should be linked to the economic cost of service provision, clinical outcomes, and economic benefits. In 2009, 2.6 million people at least 12 years of age received treatment for substance abuse at a "specialty facility" [1]. The direct cost of substance abuse treatment was estimated to be $22 billion as of 2005 [2] up from $11 billion in 1991 [3]. In 1998, community-based specialty drug treatment costs were about $4.9 billion [4]. State substance abuse agencies and other payers face difficulty in determining how to pay providers, typically resulting in either inadequate or over allocation of resources. Quality and effectiveness of drug abuse treatment is important because of current difficult fiscal conditions in many states that necessitate directing limited resources in the most efficient manner. Treatment outcomes are a good indicator of quality and effectiveness since these focus on whether clients have successfully completed their treatments and achieved specific results. Efficient drug abuse treatment is plagued by two major problems: 1) incomplete data on treatment variables and costs; 2) large number of hard-to-track variables that determine total functional cost of treatment. The work reported in this paper provides significant insight that can help policymakers to decide where to focus funding by (i) predicting crucial missing data with a high degree of statistical confidence and (ii) identifying those variables that are most critical in determining system cost.

2. Description of Data

Data employed for this work was obtained from IRS 990 forms [5] submitted by the drug treatment facilities. It consists of a huge database of alcohol and chemical dependency data for 300 clinics in Minnesota over a 5-year period (2007-11) as well as financial information for a subset of these clinics. Operating expenses were matched with annual clinic-level client counts, completions, and outcomes data from state agencies. Furthermore, a database of geographical information on the distance between pairs of clinics was created. The data was organized in three categories as described below.

I. Patient Profile Data
This data consists of 34 items of background information about each patient obtained on admission to treatment. Examples of items in this category (see table 1) include: i) gender, age, race; ii) primary substance - alcohol, heroin, cocaine; iii) source of referral - self, family, employer, criminal justice system; iv) source of income - job, retirement, family, friends, no income.

II. Treatment Outcome Data
This data describes 11 different conditions in which the patient leaves treatment providing information at discharge regarding patient's status in critical domains of living. Examples of items in this category (see table 2) include: i) patient completed program; ii) patient left without approval; iii) patient judged inappropriate; iv) death; v) % age change in # homeless after versus before treatment; vi) % age change in # of arrests after versus before treatment; vii) % age change in # drug use after versus before treatment.

III. Financial Cost Data
This data consists of 42 measures of employee and clinic-related expenses. Examples of items in this category (table 3) include i) employee-related expenses - compensation, salaries and wages, employee benefits; ii) clinic-related expenses - accounting, professional fees, postage/shipping, telephone, legal fees; iii) total functional expenses; iv) property value - land, buildings, equipment; v) grants and special assistance - cash and non-cash.