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The Incremental Inpatient Costs Associated with Marijuana Comorbidity*

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Abstract

In this paper we examine the incremental cost of marijuana comorbidity for alcohol, mood and thought diagnoses in hospital settings. We use data from the 1993–2000 National Hospital Discharge Survey to examine the effect on length of stay and the 1995–2000 Florida Hospital Discharge Data to examine charges. General Linear Modeling (GLM) and propensity score methods are employed to deal with concerns stemming from the distribution of the dependent variables and statistically significant differences in the baseline characteristics of marijuana users versus non-users. Marijuana comorbidity is associated with longer length of stays and higher charges for patients suffering from a primary diagnosis of an alcohol problem. We also find higher average charges for patients suffering from mood disorders, though the finding is not robust across all model specifications. We do not find any significant effects for thought disorders. Findings from this study suggest that a marijuana comorbidity increases the cost of treating patients with alcohol problems and mood disorder diagnoses, implying that there may be real health consequences associated with marijuana abuse and dependence and more work considering this possibility is warranted.

Keywords

marijuana abuse; length of stay; hospital costs

1.0 Introduction

While the public health costs associated with tobacco, alcohol, cocaine and heroin use have been widely considered and are well documented (Chaloupka and Warner, 2000; Harwood et al., 1998; Caulkins et al., 2002; Mark et al., 2001), very little attention has been given to the health costs associated with marijuana use. This is surprising given that it remains the most widely used illicit substance. Nearly one-fifth of young adults report the use of marijuana in the past month (SAMHSA, 2005).

Hall and Babor (2000) argue that researchers should seriously consider the public health costs associated with marijuana use. They argue that even though only a small proportion of marijuana users adopt patterns of use that pose health risks (1 in 10 according to Hall et al.,

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1999), the growing prevalence of regular (e.g., past month) marijuana users suggests that the actual number of problem users is on the rise. This claim is supported by findings from a study comparing U.S. population estimates from the 1991–1992 National Longitudinal Alcohol Epidemiology Survey and the 2001–2002 National Epidemiological Survey on Alcohol and Related Outcomes. Compton et al. (2004) show that although the fraction of people reporting marijuana use in the past year in the U.S. population has remained fairly constant over the past decade, the proportion of current users who meet DSM-IV criteria for dependence or abuse of marijuana has increased at a statistically significant rate, from 30.2% to 35.6%.

Even with marijuana dependency rates exceeding one third of the using population, treatment admissions for marijuana remain low, although they have risen moderately over the past decade. In 1992, treatment admissions with marijuana listed as the primary drug of abuse represented only 5.9% of all treatment admissions (SAMHSA, 2002). By 2003, marijuana primary admissions represented 15% of all treatment admissions, but over half of these admissions (57%) came from criminal justice referrals and individuals younger than age 19 (SAMHSA, 2005). So, there are some doubts that this rise in treatment admissions truly represents an increase in marijuana dependence. Instead, the rise may have been generated simply by the increase in arrests of users by law enforcement.

In the case of alcohol, the medical consequences associated with harmful use are three times the direct treatment costs of alcohol abuse (Harwood et al, 1998). If marijuana is similar to alcohol, it may be the case that the cost of treating the medical consequences associated with marijuana abuse or dependence could be substantially greater than the cost of treating marijuana dependence alone. There are a few studies supporting the notion that marijuana abuse or dependence increases health care utilization (Polen et al, 1993; Model 1993; Linszen, et al, 1994). No study to date has attempted to quantify the costs associated with this excess utilization. The purpose of this paper is to help fill this void. In particular, we examine the cost of treating a few specific medical problems complicated by marijuana abuse or dependence using a nationally representative sample of hospital patients admitted for non-marijuana primary diagnoses.

2.0 Background

There is a growing literature documenting an association between chronic marijuana use or abuse and specific health problems. However, the issue of causality remains unsettled with respect to many of these health conditions because the samples evaluated in the studies are typically small, non-random, or represent chronic users of other substances (see Hall and Pacula, 2003, for a review).

Even if marijuana abuse is not the cause of particular health problems, it is clear from the literature that marijuana abuse can contribute to the development of some health conditions or complicate the medical treatment of them. For example, researchers find that patients who continue to use marijuana while being treated for their schizophrenia have more psychotic symptoms and worse clinical outcomes than patients who do not use it (Linszen et al, 1994; Jablensky et al, 1992; Cleghorn et al, 1991). Fergusson et al (1997) examine the association between marijuana use and major depression and find in a single birth cohort from New Zealand that 36% of adolescents who used marijuana 10 or more times before age 16 met criteria for a mood disorder at age 16 as compared to 11% of those who had never used marijuana.

The question remains whether marijuana users, because of their marijuana use, incur greater costs in the treatment of particular illnesses. We are aware of only one study that directly contributes to our knowledge of this issue. Polen et al. (1993) compare the health service utilization of 452 Kaiser Permanente enrollees who self-reported that they were daily

marijuana-only smokers and had never smoked tobacco to a demographically comparable group of non-smokers (reported never smoking marijuana or cigarettes). They examine medical care utilization for a number of specific outcomes over a one or two year follow-up period between July 1979 and December 1985. Multivariate analyses control for age, sex, race, education, marital status, and alcohol consumption. They find that marijuana smokers had a 19 percent increased risk of outpatient visits for respiratory illnesses, a 32 percent increased risk of injury and a 9 percent increased risk of other illnesses. Furthermore, marijuana smokers were 50 percent more likely to be admitted to the hospital than non-smokers. Although the study has a number of strengths, it is limited because it does not consider selection effects that would cause some individuals to choose to use only marijuana. Furthermore, the sample is drawn from a fairly small geographical area (the San Francisco Bay Area).

In other work that indirectly considers excess health care utilization, Model (1993) uses a reduced form framework to examine the association between state marijuana decriminalization policies and the incidence of marijuana-related hospital emergency room episodes using data from the 1975–1978 Drug Abuse Warning Network (DAWN). During the mid-1970s, several states chose to reduce the penalties associated with possession of small amounts of marijuana, thus reducing the legal cost of using it. Model (1993) finds that states that chose to reduce their penalties experienced significantly higher rates of marijuana-related emergency room episodes. These findings support the hypothesis that marijuana use generates health problems requiring emergency medical care (e.g., accidents).

Our paper does not attempt to speak to the question of whether marijuana use causes particular health conditions. Instead we focus on the much narrower question of whether the indication of marijuana abuse or dependence complicates the medical treatment of particular health conditions in hospital settings, as indicated through longer lengths of stay and higher average charges. Even if marijuana use does not cause the onset of a particular health problem, it may still exacerbate the symptoms or condition itself leading to an increase in the cost of treating the health problem and an increased burden for those who pay for this treatment. We focus on inpatient hospital utilization because it is the most expensive form of health care services and because toxicology screens, used to verify a marijuana diagnosis, are far more common in hospital settings for the primary diagnoses considered.

3.0 Methods

Although there is a vast literature linking marijuana use to a number of acute and chronic health problems, marijuana abuse or dependence is rarely mentioned as a secondary or subsequent indication in hospital data. Our own analysis of the 1993–2000 National Hospital Discharge Survey (NHDS) showed that less than one half of one percent (0.45%) of all cases involves a marijuana comorbidity. However, we are able to identify three primary conditions where the conduct of toxicology screens is standard procedure and the percentage of cases involving marijuana dependence/abuse as an additional complication is relatively high: alcohol-problem disorders, mood disorders, and thought disorders. For these conditions we evaluate the incremental effect of marijuana comorbidity (abuse or dependence) on the length of stay using data from the NHDS because direct information on cost or charges is not available in these national data. So that we can get a more direct measure of cost and test the sensitivity of our findings, we also analyze the Florida Hospital Discharge Data (FHDD). The FHDD allows us to estimate the relationship between a marijuana comorbidity and the two outcomes, length of stay and charges, within the same data set and thus, provides information on the sensitivity of the national findings for length of stay.

3.1 Empirical Framework

A variety of empirical strategies are employed to deal with concerns stemming from the distribution of the dependent variables (length of stay and charges) and statistically significant differences in the baseline characteristics of marijuana users versus non-users. All of our empirical analyses estimate patient-level models of inpatient length of stay (LOS_{ijh}) or hospital charge ($Charges_{ijh}$), where *i* indicates the patient with primary indication *j* being treated in hospital *h*. Similar to other models of hospital inpatient utilization, our primary outcomes (LOS and Charges) are presumed to be a function of patient level characteristics (X_{ij}) and hospital characteristics (H_h). Our strategy for identifying the effect of marijuana abuse or dependence (MJ_{ij}) on these illness-specific outcome measures is to include in our models an indicator of marijuana abuse or dependence obtained from the non-primary ICD-9-CM codes. To be certain that relationships identified are attributable to marijuana abuse or dependence and not other substance abuse problems, the full models also include indicators of non-primary dependent or non-dependent abuse of tobacco, alcohol, and other illicit drugs (X_{ij}). The full equation model estimating length of stay for patient *i* with condition *j* in hospital *h* can therefore be written as:

$$E\{LOS_{ijh}\} = \alpha + \beta_1 X_{ij} + \beta_2 H_h + \beta_3 MJ_{ij} \quad (1)$$

The statistical significance and magnitude of β_3 indicates the degree to which marijuana is a contributing factor to the cost of treating the particular primary diagnoses examined. Obtaining an unbiased estimate of β_3, therefore, is critical for us to determine the incremental cost associated with marijuana comorbidity. Therefore, several empirical strategies, discussed below, are used to assess the strength of the relationship.

3.2 Data

The two primary data sources used in this analysis are the National Hospital Discharge Surveys (NHDS) and the Florida Hospital Discharge Data (FHDD). The NHDS is an annual survey of hospital discharge records from U.S. non-institutional short-stay hospitals, excluding Federal hospitals. A random sample of records is included from all hospitals with 1000 beds or more and from a subset of hospitals with fewer than 1000 beds. For the current study, we use data from 1993 through 2000. The selection of these years is significant because it covers a period when adolescent and young adult marijuana use was first on the rise (from 1992 through 1997) and then leveled off (1998 through 2000) (Johnston et al, 2005). The NHDS data includes information on hospital characteristics such as size, ownership status, and which of four regions in the country the hospital is located in. It also includes patient-level socio-demographic and clinical data. The demographic data includes gender, race, age, marital status and insurance coverage. The clinical data includes up to seven ICD-9-CM diagnostic codes describing the patients' primary condition and comorbidities, and the patients' discharge status.

The FHDD is a census of hospital discharges in Florida, excluding Federal hospitals, and contains an average of 2 million observations per year. We use the FHDD as a comparison to the NHDS because the sample size is substantially larger even though we have fewer years of data (1995 through 2000 in the FHDD versus 1993 through 2000 in NHDS). And while the FHDD contains many of the same variables as the NHDS, it also contains some important information not available in the national data: hospital identifiers and list charges by cost center. It is therefore possible to test the sensitivity of our main findings by examining, for example, the impact of including hospital fixed effects on results for length of stay and the consistency of findings between length of stay and charges.

3.3 Construction of Condition-specific Samples

Even when we examine conditions that have been shown in the literature to be correlated with marijuana use, the number of cases identified in national data is fairly small: 7.95% in alcohol-related mental disorder, 4.99% in mood disorder, 4.06% in thought disorder, 0.49% in complications from pregnancy, 0.25% in normal pregnancy and delivery, and 0.12% in respiratory disease. The relatively low incidence with which marijuana use is identified for respiratory disease and pregnancy admissions could indicate that marijuana use is not a common comorbidity for these conditions or it may reflect the fact that toxicology screens are not a standard procedure for patients admitted with these primary diagnoses.

In both data sets, patients with alcohol problems, mood disorders, and thought disorders are identified by collapsing the primary diagnosis ICD-9-CM codes using the Clinical Classification Software (CCS). The CCS was developed by the Agency for Healthcare Research and Quality to assist non-medical personnel in the aggregation of diagnoses and procedures into clinically homogeneous categories that can be used for statistical analysis and reporting. Specific conditions included in our definition of alcohol problem include acute alcohol intoxication, alcohol dependence, nondependent alcohol abuse, and other alcohol-related mental disorders. Specific conditions included in our definition of mood disorders include major depressive disorder (both single and recurrent episodes), neurotic depression, bipolar affective disorder, manic-depressive psychosis, and other affective disorders. Thought disorders is comprised of all those illnesses related to schizophrenia (paranoid schizophrenia, schizo-affective type, other schizophrenia) and other psychoses (e.g. paranoia, systematized delusions, paraphrenia, paranoid states, depressive type psychosis, excitative type psychosis, reactive confusion, psychogenic paranoid psychosis, other and unspecified pychosis). A complete list of all included ICD-9-CM codes is provided in the Supplemental Material.

3.4 Data Cleaning

For the period 1993 through 2000, the NHDS contains 21,642 alcohol problem admissions, 46,385 mood disorder admissions, and 23,889 thought disorder admissions. We impose several sample restrictions that reduce the number of observations used in our analyses. First, we drop observations with length of stay over 30 days to avoid estimation problems associated with extreme outliers. This reduces the alcohol sample by 187, the mood sample by 1,480, and the thought sample by 1,458. Additionally, we limit our analysis sample to people age 12 and older because very young marijuana users are likely to be very different from the non-marijuana using population. As a result, our alcohol sample is reduced by an additional 14 observations, the mood sample by 825 observations, and the thought sample by 200 observations. Next, to make the comparison group more similar to the marijuana using group we drop Diagnosis Related Groups (DRGs) that do not contain both marijuana users and non-users. For each primary condition, we had a few DRGs that contained a small number of non marijuana using patients and no marijuana using patients.[1] Dropping patients with these DRGs reduces our samples by 61, 2, and 128 for the alcohol, mood, and thought samples, respectively. Finally, we drop cases that are transferred to other hospitals because for these observations length of stay does not represent a completed spell and thus does not capture the information of interest. This exclusion results in a loss of 1,089, 3,152, and 2,674 observations for the alcohol, mood, and thought conditions, respectively. In total, we lose 6.2 percent of the alcohol problem admissions, 11.8 percent of the mood disorder admissions, and 18.7 percent of the thought disorder admissions.

[1]Although one may be concerned with bias caused by excluding these observations, for these cases there is no within-DRG variation in drug use and therefore these observations offer no information to the statistical model beyond capturing a potential selection effect. In our case, because so few observations fall into these DRGs, the selection effect is trivial. Analyses conducted including these cases are substantively identical to those presented in this paper. We present analyses dropping these variables so that we can focus on how outcomes with marijuana patients for otherwise similar patients.

Similar data cleaning steps are taken with the 1995–2000 FHDD data. The resulting sample sizes are 56,579 for alcohol problems, 253,158 for mood disorders, and 136,264 for thought disorders.

3.5 Dependent variable

While we are primarily interested in the incremental costs associated with a marijuana comorbidity, the primary outcome variable in the analyses of the NHDS is length of stay in the hospital because the data set does not include a direct measure of cost. For those who are admitted and discharged on the same day, length of stay is coded as half a day. The dependent variable is thus strictly positive and its distribution is positively skewed.

The direct positive relationship between length of stay and hospital charges (i.e., holding all else constant, the longer the stay the higher the charge) makes length of stay a reasonable proxy for charges. It is important to note, however, that hospital charges incorporate other aspects of hospital treatment such as procedures conducted and medications administered. Therefore, if a marijuana comorbidity effects one of these other elements of inpatient treatment and not length of stay, then results based on length of stay may not capture the full effect of a marijuana comorbidity.

The FHDD data includes both length of stay and hospital charge information, which allows us to analyze both variables shedding some light on the value of length of stay as a proxy for hospital charges. Hospital charge data reflects list charges, which are not necessarily equivalent to the reimbursed amount or the actual cost.[2] Summary statistics for both these dependent variables are shown in Table 1.

3.6 Independent variables

The key independent variable is whether or not a patient is identified as having a marijuana comorbidity. We use the secondary ICD-9-CM codes on each record (six in the NHDS and nine in the FHDD) to identify the cases in each sample where marijuana was noted as a contributing factor. Marijuana dependence is given by an ICD-9-CM code between 304.30 and 304.33 while non-dependent abuse of marijuana is indicated by an ICD-9-CM code of 305.2. For all analyses, we combine information on dependence and abuse to generate an indicator for any marijuana involvement (i.e., marijuana abuse or dependence is noted in the discharge record). We can similarly identify dependence and non-dependent abuse of other drugs (using all 304 codes except 304.3, 305.3 through 305.9), and do so for alcohol (using codes all 303 codes and 305.0), and tobacco (using codes 305.1) as well.

The other independent variables can be arranged into three broad groups. The first group contains patient characteristics, such as gender, age[3], marital status, and race. The second contains patient medical information including discharge status, Diagnosis Related Group (DRG) category (a measure of severity), and indicators for alcohol dependence or non-dependent abuse, tobacco dependence, and other illicit drug dependence or non-dependent abuse. The third group contains hospital and survey characteristics, including hospital ownership type, hospital size, region of the country, and year of survey. The FHDD do not include information on hospital characteristics, however, they do include hospital identifiers allowing us to include hospital fixed effects in some of our model specifications, which is arguably a more comprehensive way to control for differences in hospital characteristics. The

[2]Charges generally exceed actual costs. Cost-to-charge ratios can be used to deflate charges to better reflect the actual value of the resources used to provide the health services.

[3]Age is entered into the regression as dummies rather than as a quadratic due to the bimodal shape of the age distribution of cannabis users.

descriptive statistics for all variables included in the analysis are presented by primary diagnosis and marijuana involvement in Table 1 for the NHDS and Table 2 for the FHDD.

In the NHDS, as with all surveys, there is some amount of missing data. For some of the demographic variables such as race (29% missing) and marital status (50% missing) the problem is quite large. To address this problem, for all categorical variables we include "missing" as one of the categories (e.g., for race we have: white, black, other race, and missing race). Missing data is less common in the FHDD and hence additional variables to capture missing information are not necessary.

3.7 Estimation Procedure

A variety of empirical strategies are employed to deal with concerns stemming from the distribution of the dependent variables (length of stay and charges) and statistically significant differences in the baseline characteristics of marijuana users versus non-users. Three different statistical methods are used to estimate the relationship between marijuana abuse/dependence and length of stay for each of the three conditions (alcohol problems, mood disorders, and thought disorders). The three methods are ordinary least squares (OLS), generalized linear models (GLM), and propensity score matching. When examining hospital charges in the FHDD data, empirical tests suggest only two methods are necessary: OLS regression and propensity score matching.

We begin the assessment of all models by estimating OLS models with heteroskedasticity robust standard errors. Though OLS has significant limitations in our length of stay models due to the skewed distribution of the outcome variable, it serves as a good starting point on which to evaluate possible differences in average length of stay associated with marijuana abuse/dependence.

Next, in the case of the length of stay variable, we employ generalized linear models that can more directly account for the skewed distribution of the dependent variable. We test both the conditional mean and mean-variance relationship of length of stay for each of the three conditions to determine both the appropriate transformation and to ensure the proper modeling of the mean-variance relationship (Deb et al., 2003). We use a Box-Cox test to determine the appropriate transformation of the dependent variable. Findings from this test are confirmed using Pregibon's link test (Pregibon, 1980). We then determine the relationship between the transformed dependent variable's mean and its variance using a modified Park test.[4] Based on the findings from our specification tests, we estimate a general linear model of length of stay (*LOS*) for each condition (*j*) of the form:

$$g\{E(LOS_{ijh})\} = \alpha + \beta_1 X_{ij} + \beta_2 H_h + \beta_3 MJ_{ij} \quad LOS_{ijh} \sim Gamma \tag{2}$$

where the link function, g, is the log, gamma is the distributional family, X_{ij} is a vector of individual-level characteristics (including in some specifications other substance abuse or dependence), H_h is a vector of hospital-level characteristics, and MJ_{ij} is an indicator for whether there is a secondary diagnosis of marijuana dependence or abuse.

To make the results from the GLM models comparable with the OLS estimates we calculate and report the marginal effect of marijuana dependence/abuse on length of stay. Two alternative methods for calculating marginal effects are employed. The first calculation of the marginal effects uses the mean values of the independent variables for the whole sample. The results

[4]To perform a modified Park test, one runs a regression of y (raw scale) on x, keeping both the residuals and the predicted value of y. Then one regresses the ln(residuals squared) on ln(yhat) and a constant. The value of the coefficient on the ln(yhat) term gives information regarding the nature of the relationship between the variance and the mean. For example, if the coefficient is 0 (or not significantly different from zero), then it implies a Gaussian distribution (which has constant variance).

from these models can be directly compared to the OLS estimates to determine the extent to which skewness of the dependent variable impacts estimation results. The second calculation of marginal effects uses the mean values of the independent variables based on just the subsample of marijuana users. By calculating the marginal effects based on the average characteristics of users, we can directly compare results from our GLM models to those obtained using propensity score methods.

As can be seen in Tables 1 and 2, there are significant differences in mean characteristics between the marijuana involved and non-marijuana involved cases across all three conditions. In particular, people with a marijuana comorbidity are much younger and more likely to use other drugs than people who do not have a secondary marijuana diagnosis. In light of these differences in observable characteristics, it is possible that the parametric models will generate biased estimates. As an indirect test of this possibility we also examine the relationship between marijuana comorbidity and each outcome using the propensity score.

The propensity score methodology consists of three basic steps: (1) estimate the probability that conditional on observable characteristics an individual has a secondary diagnosis of marijuana dependence/abuse (i.e., estimate the propensity score), (2) match marijuana-involved cases (the treated) to non-marijuana involved cases (the controls) based on the estimated propensity score, and (3) calculate the average difference in outcomes between the matched pairs. We use a probit model to estimate the probability of a secondary diagnosis of marijuana dependence/abuse. Because we are trying to obtain a balance of the covariates between the treated and the controls we include all of the individual- and hospital-level variables used in the OLS and GLM analyses in our probit model. Patients admitted for marijuana dependence or abuse are disproportionately admitted to certain types of hospitals which may have different discharge criteria so it is important to match on these characteristics in addition to the individual level characteristics. After estimating the propensity score, we determine whether the balancing property is satisfied by testing for differences in mean characteristics between the treatment and controls overall and within blocks of the propensity score distribution.

A variety of methods are available to match treatment to controls. We tried several methods and all provided results that were qualitatively similar. Therefore, we will limit our discussion to the nearest neighbor matching methodology. Using the nearest neighbor approach, each marijuana-involved case (treated) is matched to a non-marijuana-involved case (control) with the closest propensity score. The matching of controls occurs with replacement so that one non-marijuana-related case may serve as the control for numerous observations in the treatment group.

The effect of marijuana dependence/abuse on length of stay for a particular condition (e.g., alcohol problems) is calculated as the average difference in length of stay between the marijuana-involved cases and their matched control. The propensity score method provides an estimate of the average treatment effect on the treated. Therefore, the estimates from this model are not directly comparable to those obtained via OLS or standard GLM methods. Instead, it is most appropriate to compare the propensity score estimates to the marginal effects from the GLM evaluated at the mean values of the independent variables for the sample of people with a secondary diagnosis of marijuana dependence or abuse. Comparing the GLM estimates with the propensity score estimates provides insight into how sensitive the regression estimates are to model choice.

4.0 Results

4.1 Length of Stay (LOS)

Table 3 presents estimates of the effect of marijuana comorbidity on LOS among those admitted for an alcohol problem (top panel), a mood disorder (middle panel), and thought disorder (bottom panel). Each table entry represents a separate model specification. The coefficients on the control variables are not shown, but are available from the authors upon request. Columns 1 through 4 of Table 3 contain the results generated from the NHDS using an OLS specification (1), GLM specification evaluated at mean values for the full sample (2), GLM specification evaluated at mean values for the subset with marijuana mentions (3), and propensity score matching methods (4). Columns 5 through 8 present findings from similar models run on the FHDD. The rows within each panel indicate whether the other substance use variables and hospital fixed effects were included in the model.

Focusing first on alcohol problems (top panel of Table 3), the estimates of the relationship between marijuana dependence/abuse and LOS are fairly stable across model specifications, statistical methods, and data sets, showing that patients with marijuana comorbidity have lengths of stay that are longer by 0.5 to 1.5 days. The inclusion of omitted variables, first the tobacco and illicit drug use measures and then the hospital fixed effects, appears to reduce the association between marijuana comorbidity and length of stay. When the base model is run ignoring the concurrent identification of tobacco or other illicit drug abuse/dependence (first row of top panel), we see that marijuana comorbidity is associated with an increased length of stay of more than a day. In the NHDS data, all of the statistical models yield surprisingly similar estimates of about 1.5 days. The estimates from the Florida data are somewhat smaller and centered around 1.2 days.

When tobacco and other illicit drug use are also included in the model (second row), most of the estimates generated from the various models decrease in magnitude, with the notable exception of the GLM models with the NHDS. In these cases, the estimates get slightly larger, but are not statistically different from the estimates excluding tobacco and other illicit drug use. The largest reduction in the marijuana coefficient is seen with the propensity score method (PSM), where in both data sets, the association between marijuana abuse/dependence and length of stay is reduced by about 30 to 40 percent. The findings remain statistically significant however, demonstrating that marijuana disorders are positively associated with length of stay. The fact that the estimates obtained from the PSM are consistently lower then those reported using other methods in both data sets suggests that the parametric models may suffer from selection bias. Nonetheless, estimates from models that try to correct for this selection effect still show that marijuana abuse/dependence is associated with an increase in length of stay of approximately three-quarters of a day, holding other substance use constant.

When hospital fixed effects are added to the models estimated on the FHDD data (third row of top panel), we see that the association between marijuana abuse/dependence and length of stay for alcohol problems declines again, but it still remains statistically significant. We can use information on the magnitude of the reduction in estimates from the FHDD to determine the probable effect this omission has on the national estimates. If we assume that the inclusion of hospital fixed effects would impact the national estimates in the same proportion they do the Florida estimates, that would suggest the national estimates would fall in the range of 0.79 to 0.95 (i.e., a 45% reduction) and remain statistically significant.

The results for mood conditions are presented in the second panel of Table 3. We find no significant effect of marijuana dependence or abuse on the average length of stay among people admitted to the hospital for mood conditions in any of the specifications or data sets.

In the bottom panel of Table 3 we present the results for thought disorders. All specifications from both data sets that exclude controls for alcohol, tobacco and other illicit drug use (row (1) of the bottom panel) suggest that LOS for marijuana users is actually shorter than for non-marijuana users. The estimates center around −0.8 days in the NHDS and around −0.5 days in the FHDD. For both samples, however, the inclusion of indicators for alcohol, tobacco and other illicit drug comorbidity (rows (2) of bottom panel) reduces the difference by about one half and causes many of the estimates to become statistically insignificant. When hospital fixed effects are incorporated into the analyses using the FHDD (row (3) of bottom panel), the negative and statistically significant associations actually increase. However, it is uncertain if similar findings would be obtained in the national data if hospital fixed effects models could be estimated in light of the inconsistent findings with regard to significance of the estimates when tobacco and other illicit drugs were included in the model.

In summary, the results presented across the various models in Table 3 are surprisingly consistent in terms of the magnitude of associations implied, with estimates from the propensity score method being generally the most conservative. Similarly estimates obtained from the Florida data are generally smaller than those observed nationally. We find that marijuana dependence or abuse is statistically associated with longer lengths of stay for alcohol problem disorders, even after we account for other substance abuse, with conservative estimates suggesting an increase in a half of a day in length of stay. We find no association between marijuana abuse/dependence and length of stay for mood disorders, and we find inconsistent evidence of a negative association between marijuana abuse/dependence and length of stay for thought disorders.

4.2 Hospital Charges

Table 4 presents OLS and PSM estimates of the effect of marijuana use on hospital charges for all three conditions in the FHDD. The dependent variable of interest is measured in logarithmic scale. Looking first at the findings for alcohol problem disorders, we again see a positive association between marijuana comorbidity and the cost of care (as indicated by log charges). Although the association is reduced in magnitude when other substances and hospital fixed effects are incrementally added, the findings consistently show a positive and statistically significant association. The positive association between charges and marijuana comorbidity is consistent with findings for length of stay and reinforce the general conclusion that for alcohol problems, marijuana comorbidity is associated with an increase in the cost of care. On average, hospital charges for cases with a secondary marijuana diagnosis are between 7% and 19% higher depending on the model specification. Based on the preferred models (hospital fixed effects with additional substance abuse measures included) the range is somewhat smaller at 7% – 8%.

In the case of mood disorders, we also find a positive and generally significant association between marijuana comorbidity and hospital charges. This is in contrast to findings with respect to length of stay presented in Table 3, where no statistical association was identified. However, the results using charges presented in Table 4 are not robust across all specifications, raising some doubt as to the reliability of the finding of a positive association. Using standard OLS techniques, we find a positive and statistically significant effect that remains even when other substance abuse and hospital fixed effects are included in the model. When propensity score matching is used to try to account for observable differences in treatment and control group, we find similar results to OLS until hospital fixed effects are included in the matching. When hospital fixed effects are included, the estimated effect gets smaller and becomes statistically insignificant. The fact that it is unobservable hospital characteristics that cause the PSM estimate to become statistically insignificant is interesting, as it suggests that idiosyncratic

differences in hospital behavior, rather than individual behavior, causes nonrandom differences to exist between treatment and control groups.

In the case of thought disorders, we again find an inconsistency between the length of stay (Table 3) and charge results (Table 4). According to results in Table 4, marijuana comorbidity has no statistically significant association with hospital charges once other substance abuse is taken into account and/or hospital fixed effects considered. Thus, even though Table 3 suggests that marijuana comorbidity is associated with a reduced length of stay for patients with thought disorders, this reduction in length of stay does not appear to translate into a reduction in charges. The difference in results between length of stay and charges suggests that the reduction in length of stay is offset by an increase in another element of the inpatient stay such as medications or procedures. As evidence of this, among people with primary diagnosis of a thought disorder the mean number of procedures for people with a marijuana comorbidity is significantly higher than for those without (0.65 vs. 0.37 – see Table 1). Because charges are a more direct proxy for cost, the concept of interest, than length of stay we focus on the charge results when the effect of a marijuana comorbidity differs between the two outcomes.

4.3 Sensitivity Analyses

Although the final models control for other substance abuse and dependence diagnoses, it is possible that the association between a marijuana comorbidity and the outcomes of interest merely reflects the effect of a secondary drug diagnosis and not marijuana specifically. To address this issue we conducted two types of sensitivity analyses. First, we estimated models where indicators for cocaine, heroin, methamphetamine, alcohol (for mood and thought disorders), tobacco, and marijuana were entered separately. The associations between marijuana and the outcomes of were qualitatively unchanged (results available from the authors upon request). Second, we ran the model with an indicator for cocaine abuse/dependence as the main drug and added an indicator for marijuana abuse/dependence incrementally. The findings for cocaine remain statistically significant when marijuana is included in the model but the coefficient estimates falls in absolute magnitude quite a bit with the inclusion of marijuana as an additional control (results available from the authors upon request). Furthermore, the coefficient on the marijuana variable is statistically significant and quite similar to those from the final models presented in Table 3. These results suggest that marijuana is not just capturing some sort of comorbidity, medical complexity, or self-medicating effect in the alcohol and mood equations.

5.0 Limitations

There are several limitations of the study that need to be kept in mind. First, as noted before, the results presented here should not be interpreted as showing a causal relationship between marijuana and the condition of interest (i.e., alcohol problems, mood disorders, thought disorders) nor between the presence of a marijuana comorbidity and the outcome of interest (i.e., length of stay and charges). Though the results remain as we include controls for a wide range of characteristics at the individual and hospital level and when we use propensity score matching methods, it is still possible that the identified relationships reflect a spurious correlation.

Second, it is possible that marijuana comorbidity is underreported in the hospital discharge records and thus bias our results. This could occur if toxicology screens are not conducted in all cases for the conditions considered here. While it is quite likely that there are cases where a toxicology screen does not occur, we have consulted with physicians about this issue and have been assured that it would be a rare occurrence. Regardless, we expect that underreporting of marijuana would tend to attenuate the association between marijuana comorbidity and length

of stay or charges biasing us toward not finding any significant relationship. Thus, it is possible that underreporting contributes to the inconclusive findings for mood and thought disorders.

Third, the study is not comprehensive in that it only evaluates a few relatively specific conditions treated in general short-stay hospital settings. In addition, it ignores treatment received for these conditions in other settings (e.g. specialty hospitals and outpatient settings) as well as costs associated with other illnesses that might similarly be affected by marijuana abuse or dependency. Thus it is reasonable to assume that the total economic burden of marijuana comorbidity is likely to be substantially higher than that suggested by these relatively small effect sizes identified here and further work is warranted to identify these costs.

Finally, while the results presented here suggest that marijuana comorbidities increase the costs of treating alcohol problems and mood disorders, they do not provide any information regarding the mechanisms through which the relationship works. That is, this paper is focused primarily on demonstrating that associations exist and leaves for future research the question of why the association exists.

6.0 Discussion and Conclusions

In this study, we explore the relationship between marijuana comorbidity and the cost of treating three different primary conditions: alcohol problems, mood disorders, and thought disorders. We have used two different data sets, each with their own advantages and disadvantages. The primary advantage of the NHDS is that the data are nationally representative. However, the survey does not contain all of the information we would like, specifically hospital identifiers and cost per discharge. As a result, we turn to length of stay as a proxy for cost in the NHDS. At the same time, we use the FHDD, which are not nationally representative, but do include more of the desired information.

The results shown in Table 3 for length of stay are qualitatively similar across the two data sets when the same methodology and control variables are used. The FHDD estimates, however, tend to be slightly smaller in magnitude and more precise. Findings from the FHDD also show that controlling for hospital fixed effects is important and substantially reduces the magnitude of the estimated effects. Because of this, and because we prefer to err on the conservative side, we take the fixed effect estimates from the FHDD as our preferred specification for interpreting findings with respect to length of stay and charges.

When comparing the length of stay and charge results for the FHDD, we find inconsistencies in the direction of the effect of marijuana comorbidity for two of the three conditions considered. The inconsistencies can likely be explained by differences in the utilization of other hospital inputs that are not perfectly correlated with length of stay and not specifically examined here, such as type or number of procedures or medications. Assuming that charges are a more direct proxy for costs than length of stay, we put more weight on findings with respect to charges as the primary indication of the effect of marijuana comorbidity.

We conclude from our results that marijuana comorbidity is associated with an increase in length of stay of approximately 0.5 days per patient admitted for an alcohol condition based on analyses of the FHDD. The effect may be even larger, possibly up to 0.95 days, if we extrapolate the effect of adding hospital fixed effects to the NHDS results. While we find that a marijuana comorbidity increases the cost of treating patients admitted with mood disorder by about 2%, the results are not robust to all model specifications. For thought disorders, we find no statistically significant associations between marijuana and length of stay or charges. As such, we focus the remainder of our discussion on the robust findings for alcohol problems.

Although the associations for alcohol problems may appear small, the effect sizes can translate into rather large costs. For example, the national average inpatient LOS for patients suffering from alcohol problems is 4.8 days, with a mean daily cost of $671 for this condition (HCUP, 2000). Increasing LOS for this group of alcohol patients by 0.5 to 0.95 days is equivalent to spending an additional $335 to $637 per patient in 2000 dollars. Based on the estimated effect on charges from the FHDD the increase associated with a marijuana comorbidity is somewhat smaller, $226 per patient in 2000 dollars.[5] Although this may pale in comparison to the incremental cost of treating alcohol-related diabetes (estimated to be $2,183 per patient), it comes close to the incremental cost of treating alcohol-related hypertension (estimated to be $724 per patient) (French at al., 2005).

With the increasing trend of current users who meet DSM-IV criteria for dependence and abuse of marijuana (Compton et al., 2004), findings from our study suggest that researchers should take a more serious look at the medical costs associated with marijuana comorbidity as well as marijuana treatment. Contrary to public opinion, this study provides some initial evidence suggesting that there are health care costs associated with marijuana abuse and dependency that are being overlooked and need to be considered if we want to carefully evaluate the appropriateness of our current policy toward marijuana. Clearly, these findings do not suggest that the public health costs are sufficient to warrant a change in the current U.S. policy toward marijuana. However, this study shows that we need to actually take a look and stop assuming that they are zero or trivial before we can do an honest assessment of the costs and benefits of our current policy.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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[5]This represents a 7% increase in average cost for treatment of alcohol problems with a secondary marijuana diagnosis.

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Table 1

Descriptive Statistics by Cannabis Use for Admissions from NHDS 1993–2000[a]

	Alcohol Problem		Mood Disorders		Thought Disorders	
	No Cannabis	Cannabis	No Cannabis	Cannabis	No Cannabis	Cannabis
Characteristics	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
Demographics						
Age of patient in year	**43.044**	**30.312**	**40.305**	**27.159**	**41.898**	**30.705**
% male	0.753	0.739	**0.378**	**0.550**	**0.539**	**0.784**
% white	**0.572**	**0.409**	**0.693**	**0.640**	**0.573**	**0.402**
% black	**0.133**	**0.082**	**0.088**	**0.106**	**0.211**	**0.337**
% other race	0.027	0.029	0.028	0.021	0.045	0.030
% race unknown	**0.268**	**0.480**	**0.191**	**0.233**	0.171	0.231
% married	**0.158**	**0.107**	**0.186**	**0.102**	**0.098**	**0.036**
% single	**0.214**	**0.237**	**0.256**	**0.406**	0.380	0.466
% widowed/divorced/separated	**0.132**	**0.068**	**0.130**	**0.060**	**0.126**	**0.049**
% marital status unknown	0.496	0.588	0.429	0.432	**0.396**	**0.449**
Medical-related info						
% alcohol dependence	**0.848**	**0.924**	**0.098**	**0.253**	**0.063**	**0.224**
% alcohol abuse	**0.118**	**0.070**	**0.052**	**0.273**	**0.048**	**0.234**
% tobaco dependence	**0.083**	**0.155**	**0.023**	**0.091**	**0.025**	**0.079**
% other illicit drug dependence	**0.128**	**0.206**	**0.053**	**0.104**	**0.037**	**0.085**
% other illicit drug abuse	**0.054**	**0.144**	**0.065**	**0.217**	**0.076**	**0.227**
% discharged home	**0.845**	**0.814**	0.912	0.913	0.875	0.893
% left against medical advice	**0.095**	**0.118**	**0.028**	**0.032**	0.025	0.021
% dead	**0.002**	**0.000**	**0.001**	**0.000**	**0.001**	**0.000**
% discharge status unknown	0.059	0.067	0.060	0.055	0.099	0.086
% public payment	0.419	0.395	**0.464**	**0.364**	**0.727**	**0.695**
% private payment	0.335	0.332	0.409	0.429	0.162	0.142
% self-payment	**0.176**	**0.159**	**0.066**	**0.126**	**0.051**	**0.104**
% no charge and other	**0.045**	**0.091**	**0.038**	**0.046**	0.037	0.035
% source of payment unknown	0.024	0.023	0.024	0.034	0.023	0.025
Hospital characteristics						
% proprietary ownership	0.139	0.093	**0.206**	**0.207**	0.124	0.122
% government	**0.098**	**0.075**	0.058	0.050	**0.104**	**0.141**
% non-profit	0.762	0.831	**0.736**	**0.744**	**0.772**	**0.737**
% 6–99 bed	**0.297**	**0.431**	**0.266**	**0.290**	0.278	0.264
% 100–199 bed	**0.270**	**0.301**	**0.275**	**0.387**	0.268	0.293
% 200–299 bed	**0.169**	**0.078**	0.186	0.141	0.151	0.151
% 300–499 bed	**0.191**	**0.164**	**0.187**	**0.128**	**0.214**	**0.194**
% 500 plus bed	**0.074**	**0.027**	**0.085**	**0.054**	0.089	0.097
% North East	**0.250**	**0.201**	**0.262**	**0.273**	**0.368**	**0.427**
% Mid West	**0.293**	**0.474**	**0.268**	**0.343**	0.214	0.249
% South	**0.345**	**0.241**	0.380	0.327	**0.305**	**0.245**
% West	**0.111**	**0.084**	**0.090**	**0.057**	**0.113**	**0.078**
Outcomes						
Length of Stay (days)	**5.903**	**8.988**	**9.021**	**8.128**	11.825	10.924
Procedure Counts	**0.808**	**0.905**	**0.443**	**0.546**	**0.372**	**0.652**

[a] All statistics are weighted and nationally representative; Sample mean in bold font indicates significant difference in means between marijuana users and non-users.

Table 2

Descriptive Statistics by Marijuana Use for Admissions from FHDD 1995–2000[a]

	Alcohol Problem		Mood Disorders		Thought Disorders	
	No Marijuana (N=54,699)	Marijuana (N=2,130)	No Marijuana (N=256,938)	Marijuana (N=8,738)	No Marijuana (N=139,626)	Marijuana (N=4,245)
Characteristics	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
Demographics						
Age of patient in year	**46.38**	**34.81**	**43.74**	**28.74**	**44.41**	**32.59**
% male	**0.721**	**0.767**	**0.418**	**0.561**	**0.564**	**0.781**
% white	**0.852**	**0.787**	**0.777**	**0.798**	**0.554**	**0.516**
% black	**0.074**	**0.108**	**0.098**	**0.122**	**0.248**	**0.356**
% Hispanic	**0.056**	**0.089**	**0.100**	**0.056**	**0.169**	**0.097**
Medical-related info						
% alcohol dependence	**0.308**	**0.219**	**0.097**	**0.179**	**0.044**	**0.142**
% alcohol abuse	**0.036**	**0.022**	**0.053**	**0.249**	**0.041**	**0.273**
% tobaco dependence	**0.108**	**0.181**	**0.046**	**0.130**	**0.057**	**0.156**
% other illicit drug dependence	**0.069**	**0.238**	**0.054**	**0.098**	**0.025**	**0.070**
% other illicit drug abuse	**0.058**	**0.253**	**0.077**	**0.294**	**0.069**	**0.372**
% admitted through ER	**0.454**	**0.488**	**0.260**	**0.404**	**0.328**	**0.467**
% with Medicare	**0.208**	**0.111**	**0.366**	**0.195**	**0.518**	**0.417**
% with Medicaid	**0.061**	**0.086**	**0.154**	**0.204**	**0.263**	**0.308**
% with Private insurace	**0.103**	**0.085**	**0.097**	**0.103**	0.030	0.035
% in HMO	0.117	0.113	0.137	0.141	0.066	0.057
% in PPO	**0.122**	**0.145**	**0.123**	**0.169**	**0.036**	**0.044**
% Charity care	**0.062**	**0.146**	**0.007**	**0.010**	**0.008**	**0.012**
Outcomes						
Length of Stay (days)	**4.49**	**5.48**	**8.44**	**6.90**	**11.28**	**9.97**
List Charges	6357.05	6482.97	**9012.65**	**7356.18**	**10690.39**	**9573.02**
Procedure Counts	**0.648**	**1.148**	0.259	0.272	**0.361**	**0.701**

[a]Sample meanin bold font indicates significant differences in means between marijuana users and non-users

Table 3

Estimated Effect of Marijuana Dependence or Abuse on Length of Stay

	NHDS Data[a]				FHD Data[b]			
	(1) OLS	(2) GLM (1)[c]	(3) GLM (2)[c]	(4) PSM	(5) OLS	(6) GLM (1)[c]	(7) GLM (2)[c]	(8) PSM
Primary Diagnosis of Alcohol-related Mental Health Problem								
Base Model	1.46 (0.22)**	1.46 (0.22)**	1.69 (0.25)**	1.54 (0.29)**	1.20 (0.11)**	1.28 (0.10)**	1.19 (0.10)**	1.05 (0.13)**
Base + Tobacco and Other Drugs (TOD)	1.44 (0.22)**	1.49 (0.22)**	1.72 (0.25)**	0.83 (0.31)**	0.92 (0.11)**	0.96 (0.10)**	0.95 (0.10)**	0.72 (0.14)**
Base + TOD + Hospital Fixed Effects	na	na	na	na	0.57 (0.10)**	0.51 (0.08)**	0.54 (0.09)**	0.52 (0.15)**
Primary Diagnosis of Mood Disorder								
Base Model	−0.18 (0.15)	−0.24 (0.16)	−0.21 (0.15)	−0.05 (0.15)	−0.07 (0.05)	−0.1 (0.06)	−0.09 (0.05)	−0.12 (0.06)
Base + Alcohol, Tobacco & Other Drugs (ATOD)	−0.07 (0.15)	−0.11 (0.17)	−0.1 (0.15)	−0.07 (0.16)	0.04 (0.05)	0.03 (0.06)	0.03 (0.05)	−0.04 (0.07)
Base + ATOD + Hospital Fixed Effects	na	na	na	na	0.03 (0.05)	0.00 (0.06)	0.00 (0.05)	−0.04 (0.07)
Primary Diagnosis of Thought Disorder								
Base Model	−0.68 (0.31)*	−0.84 (0.34)*	−0.81 (0.33)*	−0.81 (0.31)*	−0.45 (0.09)**	−0.51 (0.10)**	−0.46 (0.09)**	−0.49 (0.10)**
Base + Alcohol, Tobacco & Other Drugs (ATOD)	−0.31 (0.32)	−0.44 (0.36)	−0.41 (0.33)	−0.66 (0.36)	−0.19 (0.10)*	−0.24 (0.11)*	−0.21 (0.10)*	−0.23 (0.12)
Base + ATOD + Hospital Fixed Effects	na	na	na	na	−0.36 (0.09)**	−0.39 (0.10)**	−0.36 (0.09)**	−0.31 (0.14)*

Note: Standard errors are reported in parentheses.

* indicates significant at the 5% level;

** significant at the 1% level.

[a] Additional regressors include patient characteristics (gender, race/ethnicity, age category, marital status) and case characteristics (discharge status, DRG and insurance type), hospital characteristics (ownership, size, region), and year dummies.

[b] Additional regressors include patient characteristics (gender, race/ethnicity, age category, marital status), case characteristics (discharge status, DRG and insurance type), and year dummies

[c] GLM(1) indicates that the marginal effects from this model are evaluated at mean values for full sample. GLM(2) evaluates the marginal effects at the means at the values for just marijuana users.

Table 4

Estimated Effect of Cannabis Use on Hospital Charges[a] from FHDD 1995–2000

	Coefficient from OLS	Average Difference from Propensity Score Matching
Primary Diagnosis of Alcohol Problem Disorders (n=56,579)		
Base Model	0.19 (0.015)**	0.16 (0.180)**
Base + Tobacco and Other Drugs (TOD)	0.15 (0.016)**	0.11 (0.022)**
Base + TOD + Hospital Fixed Effects	0.07 (0.014)**	0.08 (0.020)**
Primary Diagnosis of Mood Disorders (n=253,158)		
Base Model	0.032 (0.008)**	0.032 (0.008)**
Base + Alcohol, Tobacco & Other Drugs (ATOD)	0.019 (0.008)*	0.021 (0.008)*
Base + ATOD + Hospital Fixed Effects	0.023 (0.007)*	0.015 (0.011)
Primary Diagnosis of Thought Disorders (n=136,264)		
Base Model	0.027 (0.011)*	0.023 (0.012)*
Base + Alcohol, Tobacco & Other Drugs (ATOD)	0.006 (0.012)	−0.001 (0.015)
Base + ATOD + Hospital Fixed Effects	−0.016 (0.011)	−0.007 (0.016)

[a] Charges are in logs. Additional regressors include the patient characteristics (gender, race/ethnicity, age category, marital status), medical case characteristics (discharge status, DRG and insurance type), and year dummy variables. Standard errors are reported in parentheses. Statistical significance is indicated as follows:

* significant at the 5% level (two-tailed test);

** significant at the 1% level (two-tailed test).