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Between 1973 and 1978, 12 states with collectively over one-third of the total U.S. population enacted laws that decrimmahzed the possession of marijuana. This article uses standard metropolitan statistical area (SMSA) level data on hospital emergency room drug episodes collected by the Drug Abuse Warning Network to measure the effect of changes in drug penalties on substance abuse crises. The regression models demonstrate that marijuana decriminalization was accompanied by a significant reduction in episodes involving drugs other than marijuana and an increase in marijuana episodes. Although possible biases in the data preclude firm conclusions, the results suggest that some substitution occurs towards the less severely penalized drug when punishments are differentiated.

KEY WORDS: Drug Abuse Warning Network; Drug policy; Marijuana decriminahzation; Substitution.

Drug control policy in the United States is generally formulated under the assumption that such policies are effective in influencing drug use. This is accomplished through traditional economic channels; the fact that the possession or sale of an illegal substance carries the risk of arrest and conviction serves to increase the cost of these goods. As penalties increase, the cost of the substance may rise as sellers require greater compensation for dealing in illegal goods, while buyers must also incorporate possible penalties into their full costs of use. Thus U.S. policy proceeds on the assumption that the demand for drugs will vary inversely with the severity of penalties, because these penalties serve to increase costs.

The decriminalization of marijuana by 12 states between 1973 and 1978 is one of the few instances where penalties for an illegal substance were actually reduced. Decriminalization maintained marijuana's illegality but designated first-offense possession as a civil (not criminal) offense. Prison sentences were abolished and replaced with small fines (typically $100) for first offense possession of (usually) less than 1 ounce of marijuana. The reduced penalties also signalled a decreased priority for marijuana possession arrests and thus served to divert police attention away from these offenses. States that decriminalized marijuana experienced a dramatic reduction in possession arrests (National Governor's Conference 1977). Marijuana use thus became "cheaper" as a result of both the decline in probability of apprehension as well as the reduction in possible penalties imposed.

Empirical research concerning the effect of decriminalization on drug **use** is scarce. Analysis of data from *Monitoring the Future,* an annual survey of the values and life-styles of high school seniors, found that seniors in decriminalized states reported using no more marijuana than did their counterpart in control states (Johnston, O'Malley, and Bachman 198 1). This study did not, however, control for demographic characteristics of subjects and did not examine the use of substances other than marijuana. Also, high school youth represent a sample that may not respond to new legislation in the same manner as the general population.

Standard economic analysis would predict that legal changes impact the use of marijuana by changing its full use price. Also, one must consider the possibility of related effects on the use of substitute or complement goods. Changes in marijuana policy may affect not only marijuana use, but also the use of other intoxicating substances.

DiNardo and Lemieux (1992) also used *Monitoring the Future* data to analyze the impact of increased minimum drinking ages (which can similarly be interpreted as imposing increased costs on seniors' alcohol consumption on both alcohol and marijuana use. They found that higher drinking ages are associated with reduced alcohol consumption, but increased marijuana use. This result lends support to the existence of substitution in consumption between marijuana and alcohol.

This article analyzes the effects of marijuana decriminalization on drug mentions in hospital emergency room (ER) episodes between 1975 and 1978. The outcome studied here is an ER drug mention. A drug mention occurs when medical staff at a reporting ER detect drug use in an ER patient (though substance abuse need not be the cause of, or even related to, the ER visit). Section 1 describes the medical and demographic data assembled for use in this study. Section 2 outlines a simple statistical model used to identify the effect of marijuana decriminalization on hospital emergency room drug episodes. Section 3 presents the results of estimation of this model. All regression specifications confirm that decriminalized cities experienced a statistically significant increase in marijuana mentions as well as a significant reduction in the mention of other drugs relative to nondecriminalized standard metropolitan statistical areas (SMSA's). Section 4 discusses these results and offers some concluding remarks.

I. DATA FROM THE DRUG ABUSE WARNING NETWORK

The Drug Abuse Warning Network (DAWN) has collected data on drug-related ER episodes in 24 major SMSA's since 1972 (though data at the level necessary for the analysis here

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were not available until 1975). DAWN is a large-scale nationwide drug abuse data collection program sponsored by the National Institute on Drug Abuse (NIDA) and the Drug Enforcement Administration (DEA) . Participating ER's report all drug abuse ER episodes using a standardized questionnaire. DAWN records data on all ER episodes involving illicit drugs as well as "the use of prescription drugs in a manner inconsistent with accepted medical use" (National Institute on Drug Abuse 1976). Episodes involving alcohol are recorded only when alcohol was used in conjunction with another illicit drug or with a prescription drug used for nonmedical purposes. (For this reason, the analysis that follows does not examine alcohol-related episodes separately since they are not recorded in the data.)

DAWN reports refer to ER drug episodes directly related to substance abuse (such as overdoses) as well as incidents in which evidence of drug use was obtained. For example, a victim in a motor vehicle accident exhibiting evidence of drug use would be interviewed and tested for possible inclusion as a DAWN drug abuse episode. The DAWN documentation states that for each drug abuse episode, "the drug's causal involvement can range from being directly and totally responsible for the emergency room episode, acting in combination with other abused drugs to bring about the crisis, or have no causal relationship even though abused and present during a given episode." The data are also periodically updated when a previously unrecorded episode is found to have involved drug abuse (National Institute on Drug Abuse 1976).

One potential problem with the DAWN data is that patients may not cooperate in disclosing drug use if ER physicians do not detect the possibility of use independently. This self-reporting impediment could result in nonreporting or misreporting of information. One recent study polled current marijuana users (members of the National Organization for the Reform of Marijuana Laws [NORML]) as to the conditions under which they would report marijuana use to health care professionals. Although the overall response rate was low, 95% of the respondents reported that they would disclose information regarding marijuana use to a doctor or a nurse if they had suffered a major health problem believed to be caused by marijuana (Mathre 1988). Because most DAWN respondents have suffered major medical crises, this study indicates that the majority would respond accurately to physicians' inquiries about their marijuana use (though NORML members are certainly not a representative population sample). But the fact that individuals are more likely to divulge drug use when they believe it to be related to their medical condition may indicate that DAWN data more accurately measures drug abuse-caused episodes as opposed to drug abuse-related episodes. Additionally, because DAWN reports are also determined by doctors' and nurses' observation of crisis occurrences, these data should not reflect quite such substantial reporting prejudice as are found in purely self-reporting interview settings (though they are likely not as accurate as chemical tests of blood and/or urine). Issues of reporting bias will be discussed at length in the next section.

The unit of analysis in this study is what is referred to in DAWN reports as a *drug mention.* An ER *episode* can involve the *mention* of up to six drugs, so that each drug mention is not necessarily associated with a separate individual. Also, the same individual may visit an ER more than once in any reporting period (quarter). DAWN does not record personal identifiers for specific ER episodes, so it is impossible to identify the fraction of repeat ER patients (NIDA 1977). Only quarterly SMSA-level data are published. Micro-data are collected at the hospital level but not released.

One issue that arises when using such "drug abuse indicator" data is the way in which DAWN ER mentions translate into actual drug use in the population as a whole. Based on aggregate trend data from NIDA's National Household Survey on Drug Abuse and relevant SMSA population data, past month marijuana use prevalence is estimated as approximately 12.7% of the population over the years relevant to the current study. Applied to the mean SMSA in the sample (and ignoring the issue of multiple visits), this suggests approximately 400,000 past month marijuana users per DAWN SMSA in any given quarter, indicating that on average each user is associated with .000 1 mentions per quarter (or, conversely, that generating one additional marijuana mention requires 9,500 additional users in an SMSA per quarter). Overall prevalence of any illicit drug use is approximately 13.9%, or 420,000 users per SMSA each with an average of .003 mentions per quarter (and requiring 325 additional users to generate one extra DAWN mention of any drug) (NIDA 1989). Although the population drug use prevalence figures are interesting in and of themselves, it is clear that DAWN medical crises occur in only a minute fraction of the drug abusing population. Additionally, not all ER visits are actual emergencies, and all emergencies that occur may not be reported to the local ER. Thus this article more accurately identifies changes in ER drug mentions for the ER-using population, which may not be equivalent to the population at large.

DAWN attempted to include all *eligible* ER's in all but three of the sampled SMSA's. A random sample of eligible ER's was used in New York, Chicago, and Los Angeles, because these SMSA's have larger populations than the other participant SMSA's. Eligible ER's are defined as "ER's which are open 24 hours a day; located in non-federal, short term general hospitals; and which have at least 1000 patient visits to the ER in a year. Specialty hospitals, hospital units of institutions, and pediatric hospitals are excluded (NIDA 1977, p. 2).

Data inconsistencies arise because the ER's in the DAWN sample change over time; occasionally new reporting facilities are added and others are dropped (NIDA, 1977). This article analyses drug mentions recorded by "consistently reporting" ER's only. Consistent reporters are defined as those having reported on at least 90% of the possible reporting days since January 1974 (NIDA 1976). Data on numbers of drug mentions are supplemented with information on the total number of consistently reporting ER's in the SMSA each quarter, as well as the percent of all ER's in the SMSA participating in the DAWN system; this participation percent is referred to

Table 1. Marijuana Decriminalization in States with DAWN Cities

	Maximum penalties for possession	
	Before decriminalization	*After decriminalization*
California: **Enacted 1 /1/76 (San Diego, Los Angeles, San Francisco)**	**1st: NMT' 1 yr. 2nd: NMT 20 yrs. 3rd: 5 yrs.-life**	**<1 oz: $100 >1 oz: O-6 mos. and $500**
Colorado: **Enacted 7/1/75 (Denver)**	**≤ 1 oz: NMT 1 yr. and NMT $500 > 1 oz: 2-I 5 yrs. and $10,000**	**<1 oz: $100 >1 oz: O-6 mos. and $500**
Minnesota: **Enacted 4/1/76 (Minneapolis/St. Paul)**	**≤ 1½ oz: NMT 1 yr. and NMT $1.000 > 1½ oz: NMT 3 yrs. and NMT $3,000**	**<1.5 oz: $100 > 1.5 oz: O-3 yrs. and $3,000**
New York: **Enacted 7/29/77 (New York, Buffalo)**	**≤ 25 oz: NMT 1 yr. ≤ 1 oz: 3-7 yrs. ≤ 8 oz: 5-15 yrs. > 1 lb: 15 yrs.-life**	**1st: ≤ $100 2nd: ≤ $200 3rd: ≤ $250 and/or 0-15 days**
Ohio: **Enacted 11/22/75 (Cleveland)**	**1 st: NMT 1 yr. and NMT $1,000 2nd: NMT 10 yrs.**	**<100 grams: $100**

NOTE: Information on law changes and penalties from National Governor's Conference (1977). Marijuana: A Study of State Policies and Penalties; Richard J. Bonnie (1979). Marijuana Use and Criminal Sanctions: and Harvey Levine (1974). Legal Dimensions of Drug Abuse in the United States.
▪ NMT signifies "not more than."

here as the *saturation rate.* Of the 24 DAWN SMSA's, 21 participated in the data collection effort for the entire period 1975-1978. It should also be noted that the *bulk* of changes to the ER reporting base (i.e., ER's that stopped reporting, new ER's added to the sample) occurred many years after the sample period studied here.

The data set also incorporates supplementary information on SMSA characteristics obtained from the Current Population Survey (CPS). Data on total population, race, gender, age, income, and employment and unemployment rates of each DAWN SMSA are used to control for population characteristics such as racial diversity and income differences, as well as changes in population size. These data are taken from the March CPS files for each year and interpolated between years using a constant rate of growth. The resulting quarterly information is then matched to the existing DAWN data. It is assumed that quantities such as race and gender composition (percent black and percent male) in an SMSA varies sufficiently little that values interpolated between years should closely approximate true variation in population composition.

I finally collect information on the status of marijuana laws in each SMSA at the time of each DAWN report (quarterly). Eight of the 2 1 DAWN SMSA's in the sample are located in states that decriminalized marijuana possession between 1975 and 1977. Decriminalization involved roughly the same penalty reductions in every state-from severe fines and prison terms to minor civil assessments. State penalties both before and after decriminalization are summarized in Table 1.

The complete data set contains 318 records with information on the number of mentions involving marijuana, the total number of mentions of other drugs, the number and percentage of ER's to which these mentions are attributable (consistent reporters) ▪ demographic information on the SMSA population, and variables that indicate the status of the associated state's marijuana laws for each quarter during the years 1975-1978. Eighteen records lacked some of this information and were deleted. On average, each SMSA recorded 1,300 DAWN mentions of drugs other than marijuana and about 41 mentions of marijuana per quarter. Summary statistics for all variables are presented in Table 2.

2. THE MODEL

A drug mention occurs as the result of four events. An individual must use a drug or drugs (USE). He or she must also experience some crisis (CRISIS), which need not be a direct consequence of the drug use but which does result in a visit to a participant ER (ER). Finally, ER physicians or administrators must identify the episode as pertinent to a DAWN drug mention and report the incident as such (REPORT). All of this must happen to an individual who is a member of the *population at risk* for DAWN drug mentions; that is, living in an area within a sampled SMSA that directs medical crises to a consistently reporting DAWN ER. Every individual has some probability of being involved in a drug mention. Formally,

$$\Pr(\text{MENTION}) = \Pr(\text{REPORT, ER, CRISIS, USE}), \quad (1)$$

which can be written as

$$= \Pr(\text{REPORT} \mid \text{ER, CRISIS, USE}) \cdot \Pr(\text{ER}|\text{CRISIS, USE}) \cdot \Pr(\text{CRISIS}|\text{USE}) \cdot \Pr(\text{USE}). \quad (2)$$

This identity highlights the fact that many factors contribute to generating a DAWN mention. Also note that (2) generates

Table 2. Summary Statistics: Means (Standard Deviations in Parentheses)

	All DAWN SMSA 's	*Never-decriminalized* SMSA 's	*Ever-decriminalized SMSA'S*
DAWN variables:			
Total ER drug mentions (marijuana excluded)	1,289 *(788)*	1,323 (778)	1,134 (711)
Marijuana mentions	41 (50)	47 (50)	33 (49)
Number consistently reporting DAWN ER's	22 (10)	24 (12)	20 (7)
Percent DAWN (saturation)	72 (15)	74 (12)	70 (19)
CPS demographic variables:			
SMSA population (in thousands)	3,057 (2,330)	2,733 (1,789)	3,552 (2,912)
Household income	18,545 (2,526)	18,699 (2,743)	18.313 (2,144)
Percent employed	44 (11)	45 (10)	42 (12)
Percent unemployed	4 (1)	3 (1)	4 (1)
Percent black	14 (9)	17 (9)	10 (6)
Percent male	48 (2)	48 (2)	49 (2)
Percent age 18-34	*29* (7)	29 (6)	28 (8)
Marijuana law status indicator:			
Decriminalized (= 1 if marijuana decriminalized)	.26 (.44)	0 (0)	.67 (.47)

NOTE: All figures refer to SMSA level quarterly averages over 1975 Q1–1978 Q4. DAWN figures are based on quarterly data published by the Drug Abuse Warning Network. Demographic information was calculated from annual Current Population Surveys (March). Information on marijuana laws was obtained from Rid J. Bonnie (1979). Marijuana Use and Criminal Sanctions.

a log-linear model,

$$\log \Pr(\text{MENTION}) = \log \Pr(\text{REPORT} \mid \text{ER, CRISIS, USE}) + \log \Pr(\text{ER} \mid \text{CRISIS, USE}) + \log \Pr(\text{CRISIS} \mid \text{USE}) + \log \Pr(\text{USE}), \quad (3)$$

which is suitable for estimation.

An increase in the number of observed drug mentions can thus arise from a number of behaviors. Drug laws are assumed to effect the probability of drug use (Pr(USE)). But laws may also affect the intensity of use by a given individual, prompting changes in the probability of crisis occurrence (Pr(CRISIS(USE)) stemming from such drug use. Thus if policy is effective, then changes in the number of mentions may be a result of either changes in the number of users or varying intensity of use by existing users. Both of these effects, however, would indicate that policy influences drug-taking behavior.

Still, the nature of DAWN reporting leads to some confounding of underlying causes for observed changes in the data. If ER visitation habits are systematically different between states that have and states that have not decriminalized, then an observed change in ER drug episodes may in fact be generated by a change in emergency room visitation practices (Pr(ER | CRISIS, USE)). Also, nonreporting or misreporting of patients' drug use to and by medical staff upon arrival at the ER, (Pr(REPORT)ER, CRISIS, USE)), may influence the number of mentions recorded in that ER. Both of these reporting variables may be systematically affected by changes in drug penalties. Similar changes in observed numbers of drug mentions over time can thus be generated by many behavioral responses that may be affected by policy. This muddling of effects is important, because the probability components that generate drug mentions may differ between decriminalized and nondecriminalized SMSA's. Unfortunately, the data do not allow for distinction between the various responses.

To interpret estimates of the effect of marijuana decriminalization on ER drug mentions, (3) is parameterized using the following statistical model. Terms in (3) are jointly assumed to be a function of fixed SMSA and period effects, δ_j and γ_t, demographic characteristics of the individual, X_{ijt}, the status of marijuana laws in SMSA j at the time of the observation, d_{jt}, as well as a random error component.

Define $\mathbf{ER}_{ijt}$ as a dichotomous variable that indicates whether or not individual i in SMSA j at period t participates in a DAWN drug mention. The statistical model is

$$\log \Pr(\mathbf{ER}_{ijt} = 1) = \delta_j + \gamma_t + \beta d_{jt} + \lambda X_{ijt} + \varepsilon_{ijt}, \quad (4)$$

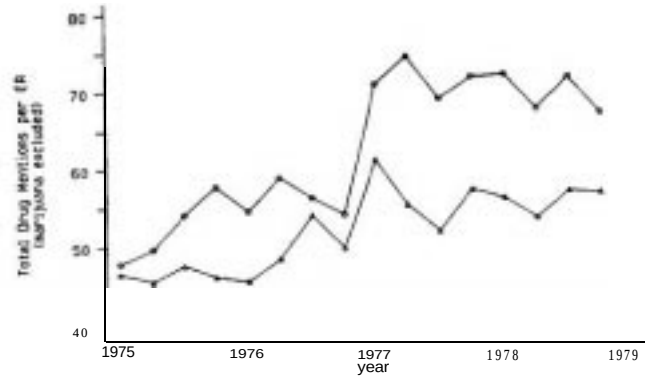

Figure 1. Total Drug Mentions Per *ER (marijuana excluded) 1975- 1978. 0, Never Decriminalized* SMSA's; A, *Ever Decriminalized* SMSA's.

where β_1 represents the effect of a change in law (from d_{jt} = 0 to d_{jt} = 1) and λ is the vector of effects for individual characteristics on ER drug outcomes. But direct estimation of (4) requires data on individuals, ER_{ijt} and X_{ijt}. In practice, the unit of observation in aggregate DAWN data is the SMSA; so X_{ijt} is replaced by mean SMSA values $\bar{X}_{jt}$ and $\Pr(ER_{ijt} = 1)$ is replaced with the empirical probability of participating in a DAWN ER drug mention P_{jt} = (1/n) $\sum_i ER_{ijt}$ where n is the number of people in the population at risk for ER drug mentions. The grouped model is

$$\log Pjt = \delta j + \gamma t + \beta d j t + \lambda \bar{X}_{jt} + \bar{\epsilon}_{jt} \quad (5)$$

Note that this model is not equivalent to simple aggregation of (4) due to the nonlinearity of the log probability model. Instead, aggregate data are substituted for individual level variables in the model due to data availability constraints. In the next section, the log-linear model (1.4) is used to directly estimate the effect of decriminalization on hospital ER drug episodes. Poisson regression models for counts of ER drug mentions are also estimated.

3. DATA ANALYSIS

Figure 1 plots the total number of drug mentions and Figure 2 the number of marijuana mentions weighted by the number of consistently reporting emergency rooms for SMSA's located in states that eventually decriminalized marijuana possession ("ever decriminalized" SMSA's) versus SMSA's whose states never decriminalized. This simple

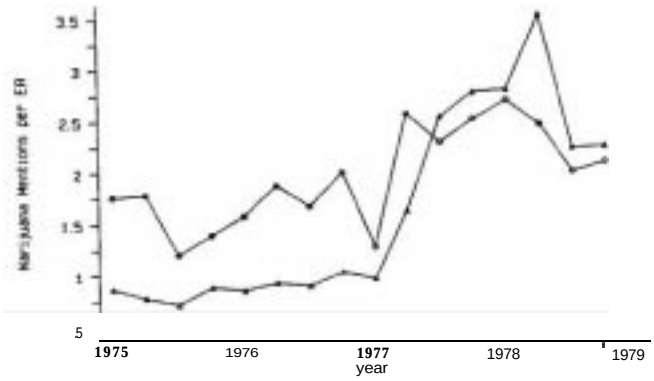

Figure 2. Marijuana Mentions Per ER, 1975- 1978.0, Never Decriminalized SMSA's; A, *Ever Decriminalized SMSA's.*

comparison of average SMSA drug mentions per ER shows important differences between the two groups, especially in periods following decriminalization. Nondecriminalized SMSA's experienced a dramatic rise in total mentions per ER beginning in 1977, while ever decriminalized SMSA's had noticeably smaller and more irregular increases. Ever decriminalized SMSA's also had fewer marijuana mentions before 1977, but they had substantially more marijuana mentions per ER thereafter when compared with nondecriminalized SMSA's. Various regressions are estimated later to quantify and confirm these apparent changes.

All the regression specifications estimated use both total drug mentions (excluding marijuana) and marijuana mentions alone as dependent variables. The first set of regressions uses these two DAWN outcome variables in combination with SMSA population statistics and Percent DAWN to calculate the empirical probability of participating in an ER drug mention for the population covered by DAWN reporting facilities. Note that the dependent variable, P_{jt}, is estimable at the grouped SMSA level by the number of mentions per SMSA population at risk. Because not all SMSA ER's reported consistently to DAWN, I weight the SMSA population in the denominator by "Percent DAWN"-the number of consistently reporting ER's divided by the total number of ER's in the SMSA; that is,

$$\hat{P}_{jt} = \frac{\text{Number of Mentions}}{\text{SMSA Population} \cdot \frac{\#\,DAWN\ ER's}{\text{Total SMSA ER's}}}$$

This variable defines the population at risk for visits to DAWN ER's as the total SMSA population multiplied by the Percent DAWN. Defining this population as all persons living in an area serviced by a DAWN ER ignores the fact that people travel as well as the fact that all persons may not be at equal risk for drug mentions. Demographic characteristics of patients, for example, may impact one's risk for drug crises. But, the aggregate data available from DAWN do not allow us to observe these variables for patients by SMSA. Using percent DAWN to define the population at risk also assumes that all DAWN-eligible ER's are identical; thus knowing how many hospitals participate in reporting is sufficient. Although participant hospitals may vary, DAWN's criterion for participation in the data collection (see Sec. 2) does lead the sample to be more homogeneous than a true random sample of all hospitals.

In log regressions, the population and reporting facility variables in the denominator can also be moved to the right side and have their coefficients estimated in an unconstrained model. Regressors include SMSA level averages of demographic variables, full sets of SMSA and period dummies, and a "law dummy" equal to 1 if marijuana was decriminalized at the time of the observation and to 0 otherwise. Coefficient estimates for the equations for drug mentions other than marijuana are presented in Table 3; those for marijuana mentions are presented in Table 4.

All regressions are estimated by weighted least squares for the log-linear probability model. (Weights are described in the notes to Tables 3 and 4.) The first three regressions-(l), (2), and (3)-use the log probability of a drug mention as the dependent variable. Equation (1) fits log $\hat{P}_{jt}$ full

Table 3. *Log-Linear Regression Coefficients (Standard* Errors *in* Parentheses)

Dependent *variable: LOG* TOTAL *DRUG* MENTIONS (marijuana *excluded)*						
Regressor	*(1)*	*(2)*	(3)	(4)	(5)	(6)
Log SMSA population				-.034 (.074)	−.031 (.074)	−.037 (.074)
Log number DAWN emergency rooms				.232*** (.080)	.252***1 (.080)	.242***1 (.081)
Log number non-DAWN emergency rooms				−.061 (.052)	−.051 (.053)	−.053 (.054)
Average household income		2.38e-05 (2.32e-05)	9.44e-05 (2.44e-05)		−.0001 (.000)	−.000 (.000)
Percent employed		-.516 (.855)	−.461 (.858)		−.281 (.734)	−.144 (.739)
Percent unemployed		5.825*** (2.331)	4.940*** (2.439)		4.016** (1.986)	3.810* (2.118)
Percent black		-.104 (.467)	−.214 (.468)		−.606 (.378)	−.659 (.381)
Percent male		-.455 (1.308)	−.023 (1.345)		−1.820' (1.077)	-1.567 (1.115)
Percentage 18-34		.238 (1.338)	.365 (1.343)		.245 (1.141)	.133 (1.154)
Law (= 1 if marijuana decriminalized)	-.112** (.054)	-.097* (.066)		−.123**1 (.053)	−.128**1 (.053)	
Law passed this year			-.057 (.066)			−.151**1 (.061)
Law passed last year			-.169*** (.071)			−.147**1 (.066)
Law passed 2 years ago			-.173*** (.083)			−.076**1 (.077)
Law passed 3 years ago			-.013 (.136)			−.024 (.116)

NOTE: (1), (2), and (3) are log-linear models with population variables constrained on the left side, $\log p_y = \beta X_y + u_y$, estimated by weighted least squares, $w_y = (n_y p_y)(1 - p_y)]^{1/2}$. (4), (5), and (6) are identical log-linear models with population at risk variables transferred to the right side, also estimated by weighted least squares. See the text for a discussion of constrained and unconstrained model derivations. (3) and (5) use four law variables to indicate timing of law passage. All regressions include constants and a full set of city and year/quarter dummies. ***, **, and * indicate significance at the .99, .95, and .90 levels.

set of SMSA dummies, period dummies, and a single decriminalization indicator. Equation (2) adds all CPS covariates to this specification, and Equation (3) decomposes the decriminalization indicator into four variables defined according to the time elapsed since enactment of the new law. These are four dummy variables; the first is equal to 1 if decriminalization was enacted in the current year, the second is equal to 1 if decriminalization was enacted 1 year prior to the observation, and so on. These dummy variables are mutually exclusive; when decriminalization has been in effect for longer than 1 year, the variable Law Passed This Year is equal to 0 and Law Passed 1 Year Ago is equal to 1. Equations (4), (5), and (6) are identical regressions with population at risk variables from the denominator (Log SMSA Population, Log Number of Consistently Reporting ER's, and Log Number of Non-DAWN ER's) moved to the right side and their coefficients estimated, leaving only Log Total Drug Mentions (marijuana and other) as the dependent variables.

All specifications result in similarly estimated coefficients, indicating a robust result. The most consistently significant variables in explaining both other drug mentions and marijuana mentions are the Log Number of DAWN ER's (in the unconstrained population at risk model) and the SMSA unemployment rates. Also, the law variable is significant in all equations regardless of the choice of dependent variables, but the effects of decriminalization on total drug mentions are of opposite sign than the effects on marijuana mentions alone. For total drug mentions the law effect is consistently negative, so that decriminalization of marijuana is associated with a decrease in the mention of drugs other than marijuana. On the other hand, the effect of decriminalization on marijuana mentions is significantly *positive* and appears to be larger with the more time elapsed since the law change. If changes in DAWN mentions indicate any change in actual drug use, then these results suggest that some substitution may have occurred towards marijuana when marijuana was decriminalized.

One difficulty in interpreting these results involves the issue of causality. Although new drug legislation may influence drug taking behavior, the converse may also hold true. Nonetheless, the direction of the bias induced by such "reverse causality" is not clear. High levels of marijuana use, for example, might induce tighter controls if policy makers believe this use to be indicative of a serious drug problem. Conversely, high levels of marijuana use may indicate an underlying permissiveness of drug use that could lead to de-

Table 4. Log-Linear Regression Coefficients (Standard Errors in Parentheses)

	Dependent variable: LOG MARIJUANA MENTIONS					
Regressor	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Log SMSA population				.011 (.160)	.018 (.165)	.030 (.165)
Log number DAWN emergency rooms				.786*** (.177)	.843*** (.180)	.789*** (.182)
Log number non-DAWN emergency rooms				−.220 (.117)	−.134 (.119)	−.093 (.122)
Average household income		−7.58e-05 (4.56605)	−8.900e-05 (4.86e-05)		-.000 (.000)	-.000 (.000)
Percent employed		−.180 (1.708)	.025 (1.734)		−.483 (1644)	−.755 (1.654)
Percent unemployed		22.432** (4.437)	20.131** (4.614)		17.183** (4.447)	13.992** (4.739)
Percent black		−.214 (.924)	−.253 (.931)		−.468 (646)	−.426 (.851)
Percent male		-4.067 (2.695)	-3.456 (2.759)		-3.998 (2.412)	-2.941 (2.493)
Percentage 18-34		-4.196 (2.675)	-3.430 (2.710)		-2.016 (2.555)	-1.157 (2.581)
Law (= 1 if marijuana decriminalized)	.896*** (.115)	.713*** (.118)		.642*** (.112)	.559*** (.118)	
Law passed this year			.710*** (.138)			.501.** (.136)
Law passed last year			.802*** (.144)			.619*** (.148)
Law passed 2 years ago			.644*** (.177)			.683*** (.172)
Law passed 3 years ago			1.013** (.270)			1.007** (.260)

NOTE: (1). (2). and (3) are @-linear models with population variables constrained on the left side [log n_i] = $\beta X_i + u_i$] estimated by weighted least squares [$w_i = \ln p_i p_i / [1 - p_i p_i]^{1/2}$. (4). (5). and (6) are identical log-linear models with population at risk variables transferred to the right side] also estimated by weighted least squares [See text for a discussion of constrained and unconstrained model derivations. (3) and (5) use four law variables to indicate timing of law passage. All regressions include constants and a full set of city [and year [quarter] dummies.] "*", "**", and "*" indicate significance at the .99 [.95] and .90 levels.

criminalization. Use of SMSA fixed effects should partially account for these potential biases.

As a specification test, I run regressions, replacing the standard decriminalization indicators with all possible lags (variables indicating that decriminalization went into effect one quarter ago, two quarters ago, and so on) and leads (indicating that decriminalization will go into effect one period ahead, two periods ahead, and so on). If changes in ER drug mentions are caused by changes in drug laws (as opposed to changes in laws being caused by changes in substance abuse crises), then greater numbers of marijuana mentions (for example) should not appear until after decriminalization took effect. Only current and lagged values of the decriminalization dummy should be significant. Joint F tests on the full set of decriminalization leads do not reject their being equal to 0 at the 95% significance level. (This is a variation on the specification test for panel data suggested by Chamberlain [1983]). The test implies that information on whether or not an SMSA would decriminalize in the future does not help to explain current ER drug mentions for either marijuana or other drugs. But, it is possible that individuals anticipate decriminalization prior to its enactment as law and adjust their behavior prior to the actual decriminalization period. In fact, the model for total drug mentions (excluding marijuana) is the only specification in which any of the predecriminalization indicators attained significance. Using this specification, the variable indicating that decriminalization will occur in the subsequent period is negative and statistically significant, indicating that there was already some decline in other drug consumption prior to decriminalization. Another variable indicating that decriminalization would go into.effect two periods in the future was not significant.

Last, the model is estimated using Poisson regression, treating SMSA level data on drug mentions as count data—an appropriate specification given the lack of information on individuals. I assume that drug episodes occur in each SMSA with some arrival rate λ_i which can be estimated as a function of the previously used explanatory variables. Formally, the basic Poisson regression model is

$$\Pr(Y_i = y) = \exp(-\lambda_i)[\lambda_i^y / y!],$$

where $\lambda_i = \exp(X_i\beta)$ and β is the vector of estimated regression coefficients. The model is directly interpretable, because it implies that $E[y_i] = \lambda_i$. The Poisson coefficient on the decriminalization indicator variable thus represents the predicted proportionate change in mentions per SMSA resulting

Table 5. Poisson Regression Coefficients (Standard Errors in Parentheses)

Dependent variable: TOTAL DRUG MENTIONS PER SMSA (marijuana excluded)			
Regressor	*(1)*	*(2)*	*(3)*
Number DAWN emergency rooms		.012*** (5.44604)	.012*** (5.50e-04)
SMSA population		1.96e-05*** (5.76e-06)	1.56e-05*** (5.78e-06)
Average household income		−1.64e-05*** (2.90e-06)	−2.89e-05*** (3.02e-06)
Percent employed		−.265*** (.108)	−.208*** (.109)
Percent unemployed		5.166** (.288)	4.481** (.304)
Percent black		−.583*** (.057)	−.670*** (.057)
Percent male		-2.092** (.164)	-1.717** (.168)
Percentage 18-34		.029 (.170)	.100 (.171)
Law (= 1 if marijuana decriminalized)	−.119*** (.007)	−.138*** (7.35e-03)	
Law passed this year			−.139*** (.009)
Law passed last year			−.187*** (.009)
Law passed 2 years ago			−.206*** (.010)
law passed 3 years ago			−.019 (.017)

NOTE: Poisson regression model estimated by maximum likelihood, with probability distribution given by $\Pr(Y = y) = \exp(-\lambda_i)[\lambda_i^y/y!]$, where $E[y] = \lambda$. See G. S. Maddala, Limited Dependent and Qualitative Variables in Econometrics, pp. 51–54, for derivation of the Poisson model. All regressions include constants and a full set of city and year/quarter dummies. ***, **, and * indicate significance at the .99, .95, and .90 levels.

from the change in law, similar to the interpretation of log-linear regression coefficients because $\log \lambda_i = X_i\beta$.

Again, I estimate three specifications: a model without covariates other than state and year dummies, a model adding demographic covariates, and a model with decriminalization indicators decomposed to indicate timing. The effect of the change in law on total drug mentions (Table 5)–unweighted by population, because the Poisson model is for absolute counts-is again negative and significant in all of the Poisson specifications. Poisson estimation for total drug mentions also results in a greater number of significant demographic variables than in any of the preceding specifications, all with sensible signs. This is consistent with the work of Hausman, Hall, and Grilliches (1984), who used Poisson regression to model counts of patents per firm. The results of their Poisson specification provided coefficients of a magnitude similar to those obtained using OLS, but generally had lower standard errors than their OLS counterparts. For the total drug mentions model, all of the demographic variables except Percent Aged 18 to 34 have significant effects on the number of mentions of drugs other than marijuana per SMSA. As in prior regressions higher SMSA unemployment rates contribute to a significantly greater number of drug mentions. Note that the consistent significance of the unemployment variable may in fact be due to increased utilization of ER's by unemployed individuals ($\Pr(ER \mid$ CRISIS, USE)) as they are not covered by an employer's health insurance.

Poisson estimates for marijuana mentions alone (Table 6) also provide results that are strikingly similar to those obtained in the initial specifications. Again the Poisson specification results in greater significance of the demographic variables. The coefficients on the decriminalization dummies are significant and almost identical in size to those obtained in the log linear models. The coefficient in the model including all covariates and a single decriminalization indicator suggests that decriminalization resulted in a 6290 increase in marijuana mentions. Because each SMSA recorded an average of only 4 1 marijuana mentions, the coefficient implies an average increase of 25 mentions per quarter per SMSA.

Poisson specifications were also estimated using the negative binomial model, derivable from the Poisson but allowing for overdispersion of the data (variance substantially greater than the mean). Models demonstrating overdispersion will generally underestimate standard errors, resulting in inflated significance levels (as were obtained earlier). The negative binomial coefficients do not differ significantly from the Poisson results discussed later, though the larger standard errors lead the decriminalization indicator to lose significance in the models using total drug mentions as the dependent

Table 6. *Poisson Regression Coefficients (Standard Errors in Parentheses)*

Dependent variable: MARIJUANA MENTIONS PER SMSA			
Regressor	*(1)*	*(2)*	*(3)*
Number DAWN emergency rooms		.038*** (.003)	.037*** (.003)
SMSA population		−4.68e-05 (3.44e-05)	−3.18e-05 (3.47e-05)
Average household income		−7.04e-05*** (1.78e-05)	−7.52e-05*** (1.88e-05)
Percent employed		−1.326** (675)	-1.329* (.683)
Percent unemployed		23.473*** (1.594)	22.479*** (1.636)
Percent black		−.643** (.332)	−.617* (.337)
Percent male		-5.882*** (1.055)	-5.581*** (1.075)
Percentage 18-34		-2.158*** (1.048)	-1.846 (1.058)
Law (= 1 if marijuana decriminalized)	1.010*** (.046)	.623*** (.052)	
Law passed this year			.629*** (.059)
Law passed last year			.740*** (.062)
Law passed 2 years ago			.596*** (.079)
Law passed 3 years ago			.927*** (.117)

NOTE: Poisson regression model estimated by maximum likelihood with probability distribution given by $\Pr(Y = Y)$ $= \exp(-\lambda)\lambda^{E[y]}/[y!]$ where $E[y] = \lambda$ [See G. S. Maddala, Limited Dependent and Qualitative Variables in Econometrics, pp. 51-54, for derivation of the Poisson model. All regressions include constants and a full set of city and year/quarter dummies.] ***, **, and * indicate significance at the .99, .95, and .90 levels.

variable. (Results are available on request from the author.) The decriminalization indicators remain statistically significant in all regressions for marijuana mentions.

Table 7 presents a summary of the estimated effect of decriminalization in terms of both absolute numbers of mentions as well as percentage changes evaluated at the mean for each of the models estimated earlier. Note that the different models lead to estimates of roughly the same magnitude. The significant effect of marijuana decriminalization on both total and marijuana ER drug mentions is robust to a multitude of estimation strategies.

A key issue in interpreting these results is whether legal change actually impacts drug taking behavior or simply reflects heterogeneous behavioral norms. For example, states that are more tolerant of drugs and consequently exhibit higher levels of use may be more likely to decriminalize. Thus the omission of a "prodrug sentiment" variable would result in an overstatement of the effect of decriminalization on drug use. We would expect such prodrug sentiment to be positively correlated with all drug use. This argument is countered somewhat by the earlier empirical findings-although decriminalization is associated with an increase in marijuana crises, it is associated with ***decreases*** in other drug crises. Prodrug sentiment would be expected to positively influence all types of drug use.

The opposite signed effect of decriminalization on marijuana mentions and other drug mentions also lends credence to the assumption that the observed changes in ER drug mentions can be attributed to actual changes in the use of these substances. A change in the probability of visiting an ER after having used any illegal drug is likely to be positively correlated with decriminalization; that is, those living in states with less restrictive marijuana laws might be less inhibited to visit an ER after having used any substance. Thus, the negative effect of decriminalization on drug mentions other than marijuana supports the assumption that these changes in outcomes are at least partially motivated by actual changes in drug use habits and not simply by changes in ER visitation. But decriminalization may induce those in treatment states to misreport their drug use as marijuana to ER staff, which could also explain the observed increase in marijuana mentions and corresponding reduction in other mentions. These interpretation issues stem primarily from the manner in which DAWN data are collected and deserve further investigation.

4. SUMMARY AND CONCLUSIONS

There is a clear association between marijuana decriminalization and the number of hospital ER drug episodes in

Table 7. Model Comparisons

		Percent	Absolute (mentions/SMSA/qt.)
Estimated change in **Total Drug** *Mentions (marijuana excluded) due to decriminalization*			
Log-linear model (constrained pop. at risk)	no covariates:	-11%	-142
	add covariates:	-9%	-116
	timed-l st yr:	-5%	-64
	2nd yr:	-17%	-219
	3rd yr:	-17%	-219
	4th yr:	-1%	-13
Log-linear model (unconstrained pop. at risk)	no covariates:	-12%	-155
	add covariates:	-13%	-166
	timed-l st yr:	-15%	-193
	2nd yr:	-15%	-193
	3rd yr:	-6%	-103
	4th yr:	-2%	-26
Polsson model	no covariates:	-12%	-156
	add covariates:	-14%	-160
	timed-l st yr:	-14%	-160
	2nd yr:	-19%	-245
	3rd yr:	-21%	-271
	4th yr:	-2%	-26
Estimated change *in Marijuana Mentions due to decriminalization*			
Log-linear model (constrained pop. at risk)	no covariates:	+90%	+37
	add covariates:	+71%	+29
	timed-l st yr:	+71%	+29
	2nd yr:	+80%	+33
	3rd yr:	+64%	+26
	4th yr:	+ 100%	+41
Log-linear model (unconstrained pop. at risk)	no covariates:	+64%	+26
	add covariates:	+56%	+23
	timed-1 st yr:	+50%	+21
	2nd yr:	+62%	+25
	3rd yr:	+68%	+28
	4th yr:	+100%	+41
Poisson model	no covariates:	+ 100%	+41
	add wvariates:	+62%	+25
	timed-l st yr:	+63%	+26
	2nd yr:	+74%	+30
	3rd yr:	+60%	+25
	4th yr:	+93%	+38

the mid to late 1970s. Changes in marijuana's legal status were accompanied by both an increase in the number of ER marijuana episodes and a decrease in the number of mentions of other drugs. This finding suggests that the drastic reduction in penalties associated with marijuana use may have precipitated a substitution towards marijuana and away from other drugs.

There are at least two possible explanations for the increase in marijuana mentions and the decrease in other drug mentions. First, if the drug abusing population is stable, so that new users arise only to replace former users, then the effect can be interpreted as the pure substitution of marijuana for other drugs. This would indicate that drug users substitute towards the drug with less severe penalties when punishments are differentiated. Alternatively, if the drug abusing population is not stable, then the observed increase in marijuana mentions may be due in part to an actual increase in the marijuana abusing population. Decriminalization may precipitate an increase in the absolute number of marijuana users. If new drug users originate over time, and if these new users choose marijuana as opposed to other drugs when marijuana is decriminalized, then this model can also explain the concurrent decrease in other drug mentions as a result of the choices of a stream of new users.

That these results differ from previous analysis of *Monitoring the Future* data remains disturbing. It is possible that the behavior of high school populations is less affected by drug legislation, because most high school students are under age 18. DiNardo and Lemieux (1992) found that high schoolers do, however, respond to higher drinking ages (a policy that more directly affects them) by shifting towards marijuana use. If decriminalization does induce substitution. then alcohol is a likely candidate for substitution in consumption with marijuana. DAWN does not record episodes due solely to alcohol abuse, so this possibility cannot be investigated here. Finally, if DAWN is so sensitive to reporting bias that all effects identified here are solely due to changes in ER visitation and the reporting of episodes, then serious thought must be given to the usefulness of the data collection.

This article has demonstrated that policy innovation-prompted changes in the relative costs of illegal drugs are associated with significant changes in DAWN ER drug men-

tions. Unfortunately, DAWN data are reported in a way that makes it impossible to separate the effects of policy on drug use from effects on crisis occurrence, ER visitation, and changes in reporting. These differences may be resolved by using other data sets as well as further studying the validity of DAWN data.

As with any regulatory program, the relative costs and benefits of drug and alcohol policies must be measured with respect to their impact on many outcomes. If lenient marijuana laws cause shifts towards marijuana use and away from the use of alcohol and other drugs, and if changes in alcohol regulations can cause similar shifts in drug use, policy makers should justify their preferences for the use of these alternative intoxicants by comparing their social costs. Costs could include medical emergencies, lost productivity, actual money spent on substances, and the cost of drug-related crime. More empirical research is required for a fuller understanding of the relationships between drug policy, the use of controlled substances, and the costs of abuse.

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