Medical Marijuana Laws and Suicides by Gender and Age

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Abstract and Introduction

Abstract

Objectives We estimated the association between legalizing medical marijuana and suicides.

Methods We obtained state-level suicide data from the National Vital Statistics System's Mortality Detail Files for 1990–2007. We used regression analysis to examine the association between medical marijuana legalization and suicides per 100 000 population.

Results After adjustment for economic conditions, state policies, and state-specific linear time trends, the association between legalizing medical marijuana and suicides was not statistically significant at the .05 level. However, legalization was associated with a 10.8% (95% confidence interval [CI] = −17.1%, −3.7%) and 9.4% (95% CI = −16.1%, −2.4%) reduction in the suicide rate of men aged 20 through 29 years and 30 through 39 years, respectively. Estimates for females were less precise and sensitive to model specification.

Conclusions Suicides among men aged 20 through 39 years fell after medical marijuana legalization compared with those in states that did not legalize. The negative relationship between legalization and suicides among young men is consistent with the hypothesis that marijuana can be used to cope with stressful life events. However, this relationship may be explained by alcohol consumption. The mechanism through which legalizing medical marijuana reduces suicides among young men remains a topic for future study.

Introduction

Although marijuana remains illegal under federal law, 21 states and the District of Columbia have legalized its use for medicinal purposes, and more than a dozen state legislatures have recently considered medical marijuana bills. There is evidence that the use of marijuana is associated with depression, suicidal ideation, and suicide attempts,[1–3] but no previous study has examined the association between legalizing medical marijuana and completed suicides, the 10th leading cause of death in the United States.[4]

Medical marijuana laws remove criminal penalties for using, possessing, and cultivating marijuana for medicinal purposes. In addition, medical marijuana laws provide doctors immunity from prosecution for recommending the use of marijuana to their patients. Because it is prohibitively expensive for the government to ensure that all marijuana ostensibly grown for the medicinal market ends up in the hands of registered patients, diversion to the recreational market almost certainly occurs. Indeed, the legalization of medical marijuana is associated with a 10% to 26% decrease in the price of high-quality marijuana.[5] It is also associated with increased use of marijuana by young adults accompanied by substantial reductions in alcohol consumption and binge drinking.[5,6]

Animal studies show that, at low doses, synthetic cannabinoid injections can have a potent antidepressant effect,[7,8] and higher dosages reduce serotonin transmission and lead to depression-like behavior.[8,9] Epidemiological studies provide evidence that marijuana use is associated with the symptoms of depression and suicidal ideation.[10,11] However, any association between marijuana use and outcomes such as these could be attributable to difficult-to-measure confounders at the individual level (e.g., personality) or reflect reverse causality stemming from self-medication.[10,12,13]

Using state-level data and an empirical approach designed to account for the influence of difficult-to-measure confounders and reverse causality, we examined the association between legalizing medical marijuana and year-to-year changes in the suicide rate. In addition, because males respond to cannabinoids differently than females,[14–16] and because there are distinct age patterns to substance use,[17] we examined the association between legalizing medical marijuana and suicides by gender and age.

Methods

Suicide data on individuals aged 15 years and older for the 1990–2007 period came from the Mortality Detail Files, produced by the National Vital Statistics System.[18] These data contain information on year of death, gender, age group, and underlying cause of death for US residents and are aggregated to the state level by the National Vital Statistics System. Eighteen years multiplied by 51 (50 states and the District of Columbia) yielded a total of 918 observations. To compute yearly suicide rates, we obtained population estimates from the US Census Bureau.[19]

Information on when the legalization of medical marijuana occurred by state is reported in Table A (available as a supplement to the online version of this article at http://www.ajph.org). During the period under study, 12 states legalized medical marijuana. All 12 of these states allowed home cultivation and permitted patients to register on the basis of medical conditions that are difficult to confirm (e.g., chronic pain and nausea). California listed anxiety as a qualifying condition and New Mexico allowed the use of medical marijuana to treat posttraumatic stress disorder.[20] Roughly half of the medical marijuana states in Table A (available as a supplement to the online version of this article at http://www.ajph.org) permitted collective cultivation, but Alaska, Hawaii, Maine, New Mexico, and Vermont attempted to dampen the supply response to legalization by limiting caregivers to 1 medical marijuana patient or prohibiting home cultivation. In these states, possession limits were easier to enforce and illegal suppliers were easier to identify.[21]

Information on whether a zero-tolerance drunk driving law was in effect, whether a 0.08 blood-alcohol-content law was in effect, and whether marijuana possession was decriminalized came from published sources.[22–24] The state unemployment rate and per capita income came from the Bureau of Labor Statistics and the Bureau of Economic Analysis, respectively.[25,26] Finally, we obtained information on state beer taxes from the *Brewers Almanac*, an annual publication produced by the Beer Institute.[27] Previous studies provide evidence that stricter alcohol policies can reduce suicides.[28–31] There is also evidence that suicide rates are sensitive to measures of economic activity such as the unemployment rate.[32–35]

We graphed unadjusted suicides per 100 000 population in states that legalized medical marijuana by year and gender. We compared these rates with unadjusted suicides per 100 000 population in states that did not legalize medical marijuana during the period 1990 to 2007.

In addition, we estimated the association between an indicator (i.e., a 0/1 variable) of legalization and the natural log of suicides per 100 000 population (the dependent variable) using regression analysis.[36] Following previous studies,[31,37] we weighted the ordinary least squares estimates by the specific population under study.[38] We considered estimated coefficients statistically significant if their 95% confidence interval (CI) did not include the value 0. We corrected standard errors (used to calculate CIs and P values) for clustering at the state level.[36]

We included 50 state indicators as covariates in the regression analysis. These indicators accounted for so-called "state fixed effects" (i.e., time-invariant confounders at the state level). Their inclusion on the right-hand side of the regression model ensured that estimates of the association between legalizing medical marijuana and suicides were identified using only within-state variation over time.[36] Seventeen year indicators accounted for "year fixed effects" (i.e., year-to-year changes in the national suicide rate). We explored the sensitivity of the estimates by adjusting for year-to-year changes in per-capita income, the unemployment rate, and relevant state policies such as the beer tax and whether a 0.08 blood-alcohol-content law was in effect. Finally, we included state-specific linear time trends as covariates. These time trends were intended to capture difficult-to-measure factors such as attitudes that might have evolved differently over time in states that legalized medical marijuana compared with states that did not.

Results

Figures 1 and 2 compare pre- and postlegalization suicide trends by gender. The solid line represents the suicide rate for the treated states (those that legalized medical marijuana). The dashed line represents the suicide rate for the control states (those that did not legalize medical marijuana). Year 0 on the horizontal axis represents the year in which legalization took place.

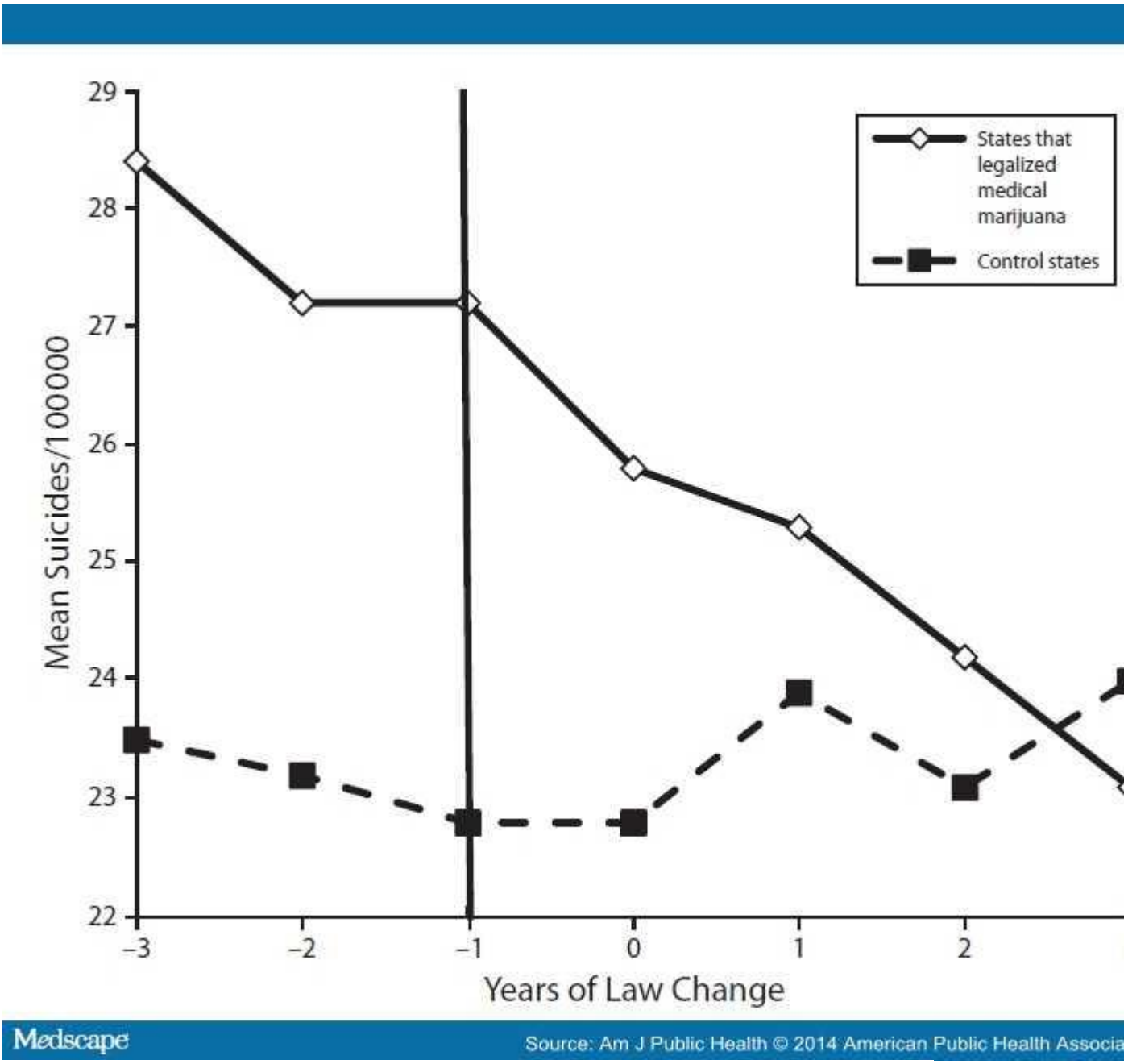

Figure 1.

Trends before and after legalization of medical marijuana in male suicide rates: state-level suicide data from the National Vital Statistics System's Mortality Detail Files, United States, 1990–2007.

Note. On the x-axis, zero represents the year in which medical marijuana was legalized. It was randomly assigned to states that did not legalize marijuana during the study period.

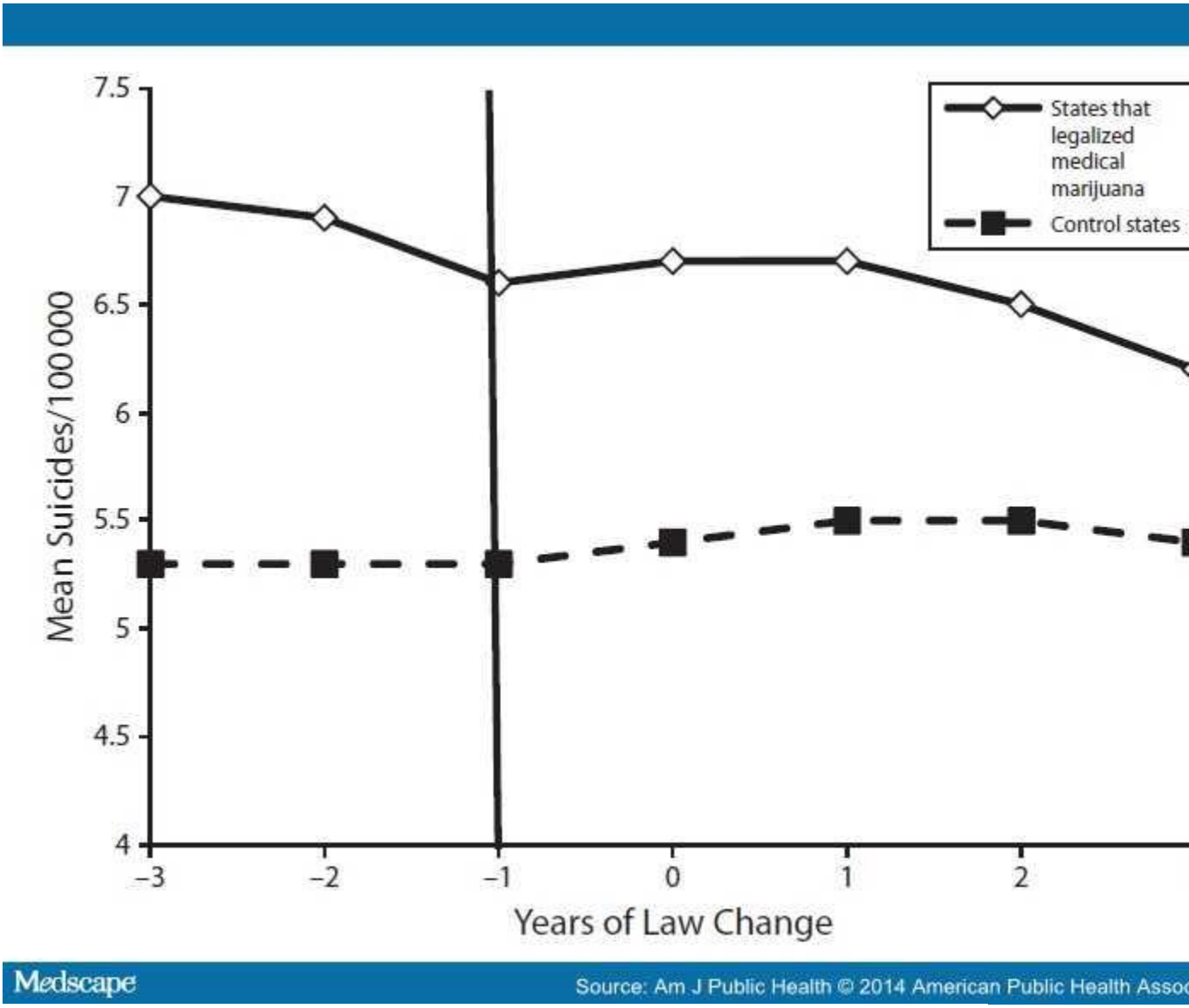

Figure 2.

Trends before and after legalization of medical marijuana in female suicide rates: state-level suicide data from the National Vital Statistics System's Mortality Detail Files, United States, 1990–2007.

Note. On the x-axis, zero represents the year in which medical marijuana was legalized. It was randomly assigned to states that did not legalize marijuana during the study period.

Male suicide rates in the treated states followed a similar path to those in the control states through year −1 (Figure 1). From year −1 to year 0, male suicide rates in medical marijuana states fell, but male suicide rates remained roughly constant in the control states. After year 0, these trends continued. In fact, male suicide rates continued to fall in medical marijuana states, but increased, albeit modestly, in the control states.

Female suicide rates fell by almost 0.04 suicides per 100 000 population before legalization in the treated states, but remained stable in the control states (Figure 2). After the legalization of medical marijuana, female suicide rates increased slightly in the treated states (from year −1 through year 1) and then trended downward. Female suicide rates in the control states followed a very similar trajectory.

The suicide rates in Figures 1 and 2 are unadjusted. We used regression analysis to account for factors such as economic conditions and relevant state policies.

reports ordinary least squares estimates of the relationship between legalizing medical marijuana and suicides per 100 000 population. Because the dependent variable was logged, these estimates can be transformed into percentages by exponentiating, subtracting 1, and multiplying by 100.

Table 1. Estimates of the Relationship Between Legalizing Medical Marijuana and the Natural Log of Suicides per 100 000 Population: State-Level Suicide Data From the National Vital Statistics System's Mortality Detail Files, United States, 1990–2007

Estimate Variable	Suicides Total	Suicides Male	Suicides Female
Adjusted for state and year effects	–0.084 (–0.183, 0.016)	–0.073 (–0.159, 0.014)	–0.106 (–0.247, 0.036)
Adjusted for state and year effects and covariates[a]	–0.072* (–0.143, –0.0002)	–0.065* (–0.128, –0.002)	–0.080 (–0.180, 0.021)
Adjusted for state and year effects, covariates,[a] and state time trends	–0.049 (–0.099, 0.001)	–0.047* (–0.089, –0.005)	–0.060 (–0.144, 0.024)

Note. Each cell represents the results from a separate ordinary least squares regression (n = 918). The dependent variable is equal to the natural log of suicides per 100 000 population. Estimates are weighted by using the relevant population. The 95% confidence intervals are reported in parentheses.

[a]Covariates include the state unemployment rate, per capita income, whether a zero-tolerance drunk-driving law was in effect, whether a 0.08 blood-alcohol-content law was in effect, whether marijuana possession was decriminalized, and the state beer tax.

*P < .05; **P < .01.

After adjustment for state and year effects, the relationship between legalizing medical marijuana and suicides, although negative, was not statistically significant at conventional levels (P = .097). Adjusting for economic conditions and polices such as whether a zero-tolerance drunk-driving law was in effect, the legalization of medical marijuana was associated with a 6.9% decrease in the overall suicide rate ($e^{-0.072} - 1 = -0.069$; 95% CI = –13.3%, –0.02%). When we included state-specific linear time trends, legalization was associated with a 4.8% decrease in the suicide rate ($e^{-0.049} - 1 = -0.048$). However, this estimate was not statistically significant at the .05 level (95% CI = –9.4%, 0.001%).

Also shown in , we estimated the relationship between the legalization of medical marijuana and suicides separately by gender. Legalization was not associated with male suicides after we adjusted for state and year effects. However, it was associated with a 6.3% decrease in the male suicide rate after we adjusted for the influence of economic conditions and relevant state policies ($e^{-0.065} - 1 = -0.063$; 95% CI = –12.0%, –0.2%). When we included state-specific linear time trends in the model, legalization was associated with a 4.8% decrease in the male suicide rate ($e^{-0.047} - 1 = -0.048$; 95% CI

= –8.5%, –0.5%). The estimated relationship between the legalization of medical marijuana and the female suicide rate was negative but not statistically significant at the .05 level.

Table 1. Estimates of the Relationship Between Legalizing Medical Marijuana and the Natural Log of Suicides per 100 000 Population: State-Level Suicide Data From the National Vital Statistics System's Mortality Detail Files, United States, 1990–2007

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Note. Each cell represents the results from a separate ordinary least squares regression (n = 918). The dependent variable is equal to the natural log of suicides per 100 000 population. Estimates are weighted by using the relevant population. The 95% confidence intervals are reported in parentheses.

[a]Covariates include the state unemployment rate, per capita income, whether a zero-tolerance drunk-driving law was in effect, whether a 0.08 blood-alcohol-content law was in effect, whether marijuana possession was decriminalized, and the state beer tax.

*P < .05; **P < .01.

reports the estimated relationship between the legalization of medical marijuana and male suicides by age group. The results suggest that the legalization of medical marijuana was associated with a sharp reduction in suicides among young adult males. Specifically, when we adjusted for state and year effects, legalizing medical marijuana was associated with a 9.2% decrease in the suicide rate of men aged 20 through 29 years ($e^{-0.096} - 1 = -0.092$; 95% CI = –13.7%, –4.4%). Including economic conditions and relevant state polices had very little impact on this estimate. When we included state-specific linear time trends in the regression model, legalization of medical marijuana was associated with a 10.8% decrease in the suicide rate of men aged 20 through 29 years ($e^{-0.114} - 1 = -0.108$; 95% CI = –17.1%, –3.7%).

Table 2. Estimates of the Relationship Between Legalizing Medical Marijuana and the Natural Log of Suicides per 100 000 Population by Gender and Age Group: State-Level Suicide Data From the National Vital Statistics System's Mortality Detail Files, United States, 1990–2007

Estimate Variable	Aged 15–19 Years	Aged 20–29 Years	Aged 30–39 Years	Aged 40–49 Years	Aged 50–59 Years	Aged ≥ 60 Years
Male						
Adjusted for state and year effects	–0.077 (–0.232, 0.078)	–0.096** (–0.147, –0.045)	–0.147** (–0.244, –0.051)	–0.129 (–0.297, 0.039)	–0.030 (–0.155, 0.095)	–0.008 (–0.082, 0.065)
Adjusted for state and year effects and covariates[a]	–0.091 (–0.252, 0.069)	–0.096** (–0.142, −0.050)	–0.129** (–0.193, –0.065)	–0.113* (–0.223, –0.004)	–0.010 (–0.101, 0.080)	–0.010 (–0.079, 0.058)

Adjusted for state and year effects, covariates,[a] and state time trends	–0.118 (–0.348, 0.111)	–0.114** (–0.188, –0.038)	–0.099* (–0.175, –0.024)	–0.060 (–0.149, 0.030)	–0.015 (–0.099, 0.068)	0.036 (–0.020, 0.094)
Female						
Adjusted for state and year effects	–0.069 (–0.388, 0.249)	–0.062 (–0.185, 0.060)	–0.125* (–0.243, –0.007)	–0.120 (–0.332, 0.092)	–0.068 (–0.275, 0.140)	–0.082 (–0.208, 0.043)
Adjusted for state and year effects and covariates[a]	–0.105 (–0.403, 0.225)	–0.044 (–0.174, 0.087)	–0.110* (–0.218, –0.003)	–0.078 (–0.211, 0.056)	–0.019 (–0.164, 0.125)	–0.082 (–0.199, 0.036)
Adjusted for state and year effects, covariates,[a] and state time trends	0.083 (–0.388, 0.554)	–0.008 (–0.138, 0.122)	–0.035 (–0.212, 0.141)	–0.041 (–0.151, 0.069)	–0.104 (–0.225, 0.018)	–0.121* (–0.240, –0.004)

Note. Each cell represents the results from a separate ordinary least squares regression (n = 918). The dependent variable is equal to the natural log of suicides per 100 000 population. Estimates are weighted by using the relevant population. The 95% confidence intervals are reported in parentheses.

[a]Covariates include the state unemployment rate, per capita income, whether a zero-tolerance drunk-driving law was in effect, whether a 0.08 blood-alcohol-content law was in effect, whether marijuana possession was decriminalized, and the state beer tax.

*$P < .05$; **$P < .01$.

After we adjusted for state and year effects, legalizing medical marijuana was associated with a 13.7% decrease in the suicide rate of men aged 30 through 39 years ($e^{-0.147} – 1 = –0.137$; 95% CI = –21.7%, –5.0%). Adjustment for economic conditions and relevant state polices reduced this estimate slightly. When we included state-specific linear time trends, the estimated relationship between the legalization of medical marijuana and suicides among men aged 30 through 39 years was reduced still further but remained statistically significant at the .05 level. Specifically, legalization of medical marijuana was associated with a 9.4% decrease in the suicide rate of men aged 30 through 39 years ($e^{-0.099} – 1 = –0.094$; 95% CI = –16.1%, –2.4%).

Although the estimates reported in were negative for 15- through 19-year-old males, they were never statistically distinguishable from zero. Likewise, the estimates for men aged 40 through 59 years were negative but not precisely estimated. For men aged 60 years and older, estimates were negative in 2 of the 3 specifications, but were not statistically significant.

Table 2. Estimates of the Relationship Between Legalizing Medical Marijuana and the Natural Log of Suicides per 100 000 Population by Gender and Age Group: State-Level Suicide Data From the National Vital Statistics System's Mortality Detail Files, United States, 1990–2007

Estimate Variable	Aged 15–19 Years	Aged 20–29 Years	Aged 30–39 Years	Aged 40–49 Years	Aged 50–59 Years	Aged ≥ 60 Years
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Female						
Adjusted for state and year effects	–0.069 (–0.388, 0.249)	–0.062 (–0.185, 0.060)	–0.125* (–0.243, –0.007)	–0.120 (–0.332, 0.092)	–0.068 (–0.275, 0.140)	–0.082 (–0.208, 0.043)
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[a]Covariates include the state unemployment rate, per capita income, whether a zero-tolerance drunk-driving law was in effect, whether a 0.08 blood-alcohol-content law was in effect, whether marijuana possession was decriminalized, and the state beer tax.

*P < .05; **P < .01.

provides little evidence that legalization of medical marijuana was associated with suicides among females younger than 30 years. The estimated relationship between legalization and suicides was stronger among older females, although it was sensitive to model specification. When we adjusted for state and year effects, the legalization of medical marijuana was associated with an 11.8% decrease in the suicide rate of women aged 30 through 39 years ($e^{-0.125} - 1 = -0.118$; 95% CI = –21.6%, –0.7%). When we adjusted for state effects, year effects, and the covariates, the legalization of medical marijuana was associated with a 10.4% decrease in the suicide rate of women aged 30 through 39 years ($e^{-0.110} - 1 = -0.104$; 95% CI = –19.6%, –0.3%). However, this association lost significance when we included the state-specific linear time trends. After adjustment for state-specific linear time trends, legalization was associated with a statistically significant decrease in the suicide rate of women aged 60 years and older.

Table 2. Estimates of the Relationship Between Legalizing Medical Marijuana and the Natural Log of Suicides per 100 000 Population by Gender and Age Group: State-Level Suicide Data From the National Vital Statistics System's Mortality Detail Files, United States, 1990–2007

Estimate Variable	Aged 15–19 Years	Aged 20–29 Years	Aged 30–39 Years	Aged 40–49 Years	Aged 50–59 Years	Aged ≥ 60 Years
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Female						
Adjusted for state and year effects	–0.069 (–0.388, 0.249)	–0.062 (–0.185, 0.060)	–0.125* (–0.243, –0.007)	–0.120 (–0.332, 0.092)	–0.068 (–0.275, 0.140)	–0.082 (–0.208, 0.043)
Adjusted for state and year effects and covariates[a]	–0.105 (–0.403, 0.225)	–0.044 (–0.174, 0.087)	–0.110* (–0.218, –0.003)	–0.078 (–0.211, 0.056)	–0.019 (–0.164, 0.125)	–0.082 (–0.199, 0.036)
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Note. Each cell represents the results from a separate ordinary least squares regression (n = 918). The dependent variable is equal to the natural log of suicides per 100 000 population. Estimates are weighted by using the relevant population. The 95% confidence intervals are reported in parentheses.

[a]Covariates include the state unemployment rate, per capita income, whether a zero-tolerance drunk-driving law was in effect, whether a 0.08 blood-alcohol-content law was in effect, whether marijuana possession was decriminalized, and the state beer tax.

*P < .05; **P < .01.

We examined pre- and postlegalization trends in suicides by modifying the regression model described previously. Specifically, we replaced the medical marijuana indicator with 3 lead indicators, an indicator for the year of the law change, and 4 lag indicators. None of the lead indicators were statistically significant predictors of male suicides, nor were the lead indicators jointly significant (F = 0.51; P = .68), a pattern of results that was consistent with the prelegalization trends presented in Figure 1. By contrast, the medical marijuana lags were jointly significant predictors of male suicides (F = 9.37; P < .001).

Replacing the medical marijuana indicator with leads and lags provided little evidence that legalizing medical marijuana reduced female suicides. Consistent with the prelegalization trends presented in Figure 2, the lead indicators were negative and jointly significant predictors of female suicides (F = 2.98; P = .04). Moreover, we could not reject the hypothesis that the lag indicators were equal in magnitude to the lead indicators (F = 3.02; P = .09).

Finally, the estimated relationship between unemployment and suicides was consistently positive and significant, a pattern of results consistent with what we know from previous studies.[32,33] Although stricter alcohol policies have been shown to reduce suicides,[28–31] beer taxes, zero-tolerance laws, and 0.08 blood-alcohol-content laws were not good predictors of suicides. In the spirit of a falsification test, we replaced the suicide rate with mortality because of cardiac arrest and mortality because of cancer. There was no evidence that the legalization of medical marijuana was systematically related to these sources of mortality.

Discussion

Opponents of legalizing medical marijuana point to the large number of studies showing that marijuana use is positively associated with depression, the onset of panic attacks, psychosis, schizophrenia, and suicidal ideation.[10,11,39–46] However, the association between marijuana use and outcomes such as these could be attributable to difficult-to-measure confounders such as personality.[12] Moreover, estimates produced by nonprospective studies could reflect reverse causation stemming from self-medication.[10,13,47] Although there have been attempts to account for these potential sources of statistical bias, none have been particularly convincing. In fact, a recent review of the literature noted that the majority of studies in this area "did not adequately address the problem of reverse causation as a possible alternative explanation for any association observed."[11(p325)]

The current study avoided the problems of reverse causality and difficult-to-measure confounders by comparing the change in suicides per 100 000 population that occurred after the legalization of medical marijuana with the change in suicides per 100 000 population for a set of control states. This estimation approach can be thought of as exploiting a "natural experiment" unrelated to comorbidities or personality.

The graphical analysis provided evidence that, before legalization, male suicides in the treated states evolved in a similar fashion to male suicides in the control states. After legalization, these trends diverged. Specifically, the male suicide rate in medical marijuana states fell, but the male suicide rate increased, albeit modestly, in the control states. Formal estimates obtained with regression analysis were consistent with the graphical analysis. These estimates suggested that the legalization of medical marijuana was associated with a 9.2% to 10.8% decrease in the suicide rate of men aged 20 through 29 years, and a 9.4% to 13.7% decrease in the suicide rate of men aged 30 through 39 years. These estimates were generally robust to adjustment for linear time trends at the state level.

The graphical analysis showed that female suicide rates in medical marijuana states and the control states followed very similar trajectories. Estimates obtained with regression analysis confirmed this result. In general, estimates of the relationship between the legalization of medical marijuana and female suicide rates were negative, but these estimates were less precise than the estimates obtained for males and were sensitive to model specification, a pattern of results attributable, perhaps, to gender differences in frequency of substance use,[48–50] physiological responses to cannabinoids,[14–16] or underlying health conditions such as panic and personality disorders.[51] Frequency of marijuana use is associated with social anxiety,[50] and prospective studies have shown that marijuana participation is positively related to panic attacks,[45,46] which in turn are positively associated with suicidal ideation and a history of attempted suicide.[52]

Suicide among adolescents and young adults is often triggered by stressful life events. Stressful life events include, but are not limited to, the breakup of a romantic relationship,[53–56] conflict with a parent or sibling,[54,56] an abortion,[57,58] and legal or disciplinary problems.[54] Among older adults, problems at work, financial difficulties, unemployment, and separation or divorce are common triggers of suicide.[59–64] Among the elderly, suicide is often associated with physical illness and functional impairment.[65–69]

The results of the current study are consistent with the hypothesis that legalizing medical marijuana leads to increased marijuana use, which in turn helps individuals cope with stressful life events. There is anecdotal evidence that much of the medical marijuana crop is diverted to the illegal market, increasing availability and lowering price.[70–72] This anecdotal evidence is supported by recent studies showing that the legalization of medical marijuana leads to increased arrests for marijuana possession

among 18- through 39-year-olds, increased admissions to federally funded treatment centers for marijuana use, and a 10% to 26% reduction in the price of high-quality marijuana.[5,6] However, despite claims that marijuana can be an effective treatment of depression and panic disorders,[73–75] there is no scientific evidence that it can be used to cope with stressful life events.

Alcohol consumption represents an alternative route through which the legalization of medical marijuana could potentially have an impact on suicides. A recent study showed that the legalization of medical marijuana was associated with substantial decreases in alcohol participation and binge drinking among young adults.[5] Binge drinking is considered to have "especially high social and economic costs"[76(p70)] and is associated with suicidal ideation.[77,78] Moreover, alcoholism is more common among individuals with major depression,[79] and is associated with suicidal ideation as well as attempted and completed suicides.[80,81]

Study Strengths and Weaknesses

To our knowledge, this was the first study to examine the relationship between legalizing medical marijuana and suicides. Previous studies have documented a positive association between marijuana use and outcomes such as depression and suicidal ideation.[1–3] However, this association could be attributable to difficult-to-measure confounders or reflect self-medication.[10,12,13] By comparing the change in suicides after the legalization of medical marijuana with the change in suicides for a set of control states, we avoided the problems of reverse causality and difficult-to-measure confounders.

Important study limitations warrant mention. First, the Mortality Detail Files were available only through 2007 when the statistical analysis was conducted. Since 2007, 9 states (Arizona, Connecticut, Delaware, Illinois, New Hampshire, Maryland, Massachusetts, Michigan, and New Jersey) have legalized medical marijuana. These 9 states, although included in our sample, did not contribute to the identification of the estimates reported in and .

Table 1. Estimates of the Relationship Between Legalizing Medical Marijuana and the Natural Log of Suicides per 100 000 Population: State-Level Suicide Data From the National Vital Statistics System's Mortality Detail Files, United States, 1990–2007

Estimate Variable	Suicides Total	Suicides Male	Suicides Female
Adjusted for state and year effects	–0.084 (–0.183, 0.016)	–0.073 (–0.159, 0.014)	–0.106 (–0.247, 0.036)
Adjusted for state and year effects and covariates[a]	–0.072* (–0.143, –0.0002)	–0.065* (–0.128, –0.002)	–0.080 (–0.180, 0.021)
Adjusted for state and year effects, covariates,[a] and state time trends	–0.049 (–0.099, 0.001)	–0.047* (–0.089, –0.005)	–0.060 (–0.144, 0.024)

Note. Each cell represents the results from a separate ordinary least squares regression (n = 918). The dependent variable is equal to the natural log of suicides per 100 000 population. Estimates are weighted by using the relevant population. The 95% confidence intervals are reported in parentheses.

[a]Covariates include the state unemployment rate, per capita income, whether a zero-tolerance drunk-driving law was in effect, whether a 0.08 blood-alcohol-content law was in effect, whether marijuana possession was decriminalized, and the state beer tax.

*P < .05; **P < .01.

Table 2. Estimates of the Relationship Between Legalizing Medical Marijuana and the Natural Log of Suicides per 100 000 Population by Gender and Age Group: State-Level Suicide Data From the National Vital Statistics System's Mortality Detail Files, United States, 1990–2007

Estimate Variable	Aged 15–19 Years	Aged 20–29 Years	Aged 30–39 Years	Aged 40–49 Years	Aged 50–59 Years	Aged ≥ 60 Years
Male						
Adjusted for state and year effects	–0.077 (–0.232, 0.078)	–0.096** (–0.147, –0.045)	–0.147** (–0.244, –0.051)	–0.129 (–0.297, 0.039)	–0.030 (–0.155, 0.095)	–0.008 (–0.082, 0.065)
Adjusted for state and year effects and covariates[a]	–0.091 (–0.252, 0.069)	–0.096** (–0.142, −0.050)	–0.129** (–0.193, –0.065)	–0.113* (–0.223, –0.004)	–0.010 (–0.101, 0.080)	–0.010 (–0.079, 0.058)
Adjusted for state and year effects, covariates,[a] and state time trends	–0.118 (–0.348, 0.111)	–0.114** (–0.188, –0.038)	–0.099* (–0.175, –0.024)	–0.060 (–0.149, 0.030)	–0.015 (–0.099, 0.068)	0.036 (–0.020, 0.094)
Female						
Adjusted for state and year effects	–0.069 (–0.388, 0.249)	–0.062 (–0.185, 0.060)	–0.125* (–0.243, –0.007)	–0.120 (–0.332, 0.092)	–0.068 (–0.275, 0.140)	–0.082 (–0.208, 0.043)
Adjusted for state and year effects and covariates[a]	–0.105 (–0.403, 0.225)	–0.044 (–0.174, 0.087)	–0.110* (–0.218, –0.003)	–0.078 (–0.211, 0.056)	–0.019 (–0.164, 0.125)	–0.082 (–0.199, 0.036)
Adjusted for state and year effects, covariates,[a] and state time trends	0.083 (–0.388, 0.554)	–0.008 (–0.138, 0.122)	–0.035 (–0.212, 0.141)	–0.041 (–0.151, 0.069)	–0.104 (–0.225, 0.018)	–0.121* (–0.240, –0.004)

Note. Each cell represents the results from a separate ordinary least squares regression (n = 918). The dependent variable is equal to the natural log of suicides per 100 000 population. Estimates are weighted by using the relevant population. The 95% confidence intervals are reported in parentheses.

[a]Covariates include the state unemployment rate, per capita income, whether a zero-tolerance drunk-driving law was in effect, whether a 0.08 blood-alcohol-content law was in effect, whether marijuana possession was decriminalized, and the state beer tax.

*P < .05; **P < .01.

Second, the exact date on which any given suicide took place was not available. Therefore, if a state legalized marijuana during the middle of the year (as opposed to January 1 or December 31), then the legalization indicator was assigned a fractional value. For instance, if legalization occurred on June 30, then it took on a value of 0.5. Although standard, this approach could have biased the estimates in and toward 0 by introducing measurement error. In other words, it is possible that the impact of legalizing medical marijuana on suicides is larger than that suggested by the estimates contained in and .

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Table 2. Estimates of the Relationship Between Legalizing Medical Marijuana and the Natural Log of Suicides per 100 000 Population by Gender and Age Group: State-Level Suicide Data From the National Vital Statistics System's Mortality Detail Files, United States, 1990–2007

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Adjusted for state and year effects and covariates[a]	–0.105 (–0.403, 0.225)	–0.044 (–0.174, 0.087)	–0.110* (–0.218, –0.003)	–0.078 (–0.211, 0.056)	–0.019 (–0.164, 0.125)	–0.082 (–0.199, 0.036)
Adjusted for state and year effects, covariates,[a] and state time trends	0.083 (–0.388, 0.554)	–0.008 (–0.138, 0.122)	–0.035 (–0.212, 0.141)	–0.041 (–0.151, 0.069)	–0.104 (–0.225, 0.018)	–0.121* (–0.240, –0.004)

Note. Each cell represents the results from a separate ordinary least squares regression (n = 918). The dependent variable is equal to the natural log of suicides per 100 000 population. Estimates are weighted by using the relevant population. The 95% confidence intervals are reported in parentheses.

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driving law was in effect, whether a 0.08 blood-alcohol-content law was in effect, whether marijuana possession was decriminalized, and the state beer tax.

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*P < .05; **P < .01.

Third, the data on suicides from the Mortality Detail Files are at the state and year level. Although the gender and the age of individuals who committed suicide are available, nothing was known about their mental health before the legalization of medical marijuana nor was there information on whether an individual smoked marijuana or consumed alcohol before the legalization of medical marijuana.

Finally, Alaska, Hawaii, Maine, New Mexico, and Vermont limited caregivers to 1 medical marijuana patient or prohibited home cultivation altogether. Distinguishing between these 5 states and states with less restrictive medical marijuana laws produced estimates that were not sufficiently precise to reject the hypothesis that legalization had a similar impact on male suicides regardless of whether caregivers were limited to 1 medical marijuana patient, a result likely driven by lack of statistical power. Because the majority of states that legalized medical marijuana during the period 1990 to 2007 were located in the western half of the United States, where suicide rates are highest,[82] our results may not extend to other regions of the country. Several northeastern states including Connecticut, Massachusetts, and New Jersey have legalized medical marijuana since 2007. Whether they will experience a reduction in suicides is an open question.

Implications and Conclusions

To date, 21 states have adopted medical marijuana laws. Although these laws almost certainly have important public health implications, we know very little about their effects.

The current study found a strong negative relationship between the legalization of medical marijuana and suicides among young men. This relationship is consistent with the often-voiced, but controversial claim that marijuana can be used to cope with depression and anxiety caused by stressful life events.[42,73–75,83,84] However, it may, at least in part, be attributable to the reduction in alcohol consumption among young adults that appears to accompany the legalization of medical marijuana.[5] Although marijuana and alcohol use are positively correlated in the cross-section,[85,86] there is evidence of a sharp decrease in marijuana use when individuals reach the minimum legal drinking age, suggesting that young adults substitute marijuana for alcohol.[87] There is also evidence that restricting access to alcohol leads to fewer suicides.[29–31,88] The precise mechanism thorough which legalizing medical marijuana is related to suicides among men aged 20 to 39 years remains a topic for future study.

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Contributors

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Human Participant Protection

Because the analysis used publicly available secondary data, it did not require review by an institutional review board committee.

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