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The Impact of Medical Marijuana Laws on the Labor Supply and Health of Older Adults: Evidence from the Health and Retirement Study

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ABSTRACT

We study the effect of state medical marijuana laws (MMLs) on labor supply and health outcomes among older adults; the demographic group with the highest rates of many chronic conditions for which marijuana may be an effective treatment. Using 1992 - 2012 Health and Retirement Study data to estimate differences-in-differences models, we find that MML implementation leads to increases in labor supply among older adults along with improvement in health for older men and mixed health effects for women. These effects should be considered as policymakers determine how best to regulate access to medical marijuana.

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1 Introduction

Legalization of marijuana, for either medicinal or recreational use, is one of the most controversial issues in Federal and state drug policy. As of 2016, 25 states and the District of Columbia (DC) have passed laws legalizing use of marijuana for medical purposes (we refer to such laws as medical marijuana laws or MMLs). Critics of medical marijuana legalization argue that any legalization will promote marijuana addiction, misuse of related substances, crime, traffic accidents, and healthcare costs associated with complications of long-term marijauana use. Advocates, on the other hand, highlight the potential health benefits of expanded access to medical marijuana. Given this tension, policymakers must have a solid evidence base on both the potential costs and benefits of legalization as they determine how best to regulate medical marijuana.

Medical marijuana offers a new treatment option for patients with a number of health conditions. Although clinical evidence is limited,[1] in randomized control trials marijuana has been shown, at least within some populations, to be an effective treatment for pain, anxiety, depression, nausea, psychosis, sleep disorders, and spasticity (Hill, 2015; Whiting et al., 2015; Joy, Watson, & Benson, 1999; Lynch & Campbell, 2011).[2] Supporting this clinical evidence, observational studies suggest that individuals do in fact use medical marijuana to treat chronic conditions (Nunberg, Kilmer, Pacula, & Burgdorf, 2011; Troutt & DiDonato, 2015). The most commonly cited health conditions among patients seeking medical marijuana include chronic pain, mental health conditions, nausea, and sleep disorders. The majority of medical marijuana patients report using the product as a substitute for prescription medications and that medical marijuana is more effective than their previous treatment (Nunberg et al., 2011; Troutt & DiDonato, 2015).

Although most economic studies of medical marijuana legalization have focused on teenage and working-age populations, older adults are more likely to suffer from many of the chronic conditions that may be effectively treated with medical marijuana (Gordon et al., 2002; Morgan, 2003; Leske et al., 2008; Unruh et al., 2008; Nahin, 2015). Older adults are also likely to stop working as a result of poor health (Dwyer & Mitchell, 1999; McGarry, 2004; Case & Deaton, 2005; Datta Gupta & Larsen, 2010).

Chronic pain is particularly important in the context of the medical marijuana debate.

[1] The limited clinical research on medical marijuana is likely due to marijuana's classification as a Schedule 1 drug, this classification sharply limits clinical researchers access to such drugs for research purposes. Other Federal regulations further limit clinical study of medical marijuana's effectiveness.

[2] However, researchers note that more evidence is needed to provide clinical guidance to healthcare providers wishing to recommend marijuana to patients (Hill, 2015).

This condition is one of the most commonly reported conditions among medical marijuana patients and is often listed as a 'qualifying' health condition in state MMLs (Sabia, Swigert, & Young, 2015; Bradford & Bradford, 2016a). In 2012 over 126 million American adults reported experiencing some form of pain in the previous 3 months (Nahin, 2015). Older adults, however, are more likely to report chronic pain than younger adults (Rustoen et al., 2005; Wong & Fielding, 2011; Nahin, 2015). For example, Ferrell (2004) reports that the prevalence of pain among community-dwelling older adults ranges from 25% to 50%. Garthwaite (2012) documents that removal of Vioxx, a highly effective prescription medication designed to treat chronic pain symptoms, from the U.S. healthcare market in 2004 lead to a sharp reduction in labor supply among older adults (the primary users of Vioxx). Many pain medications, in particular opioids, relieve pain symptoms but also expose patients to side effects that may impede work such as cardiovascular problems, dizziness, respiratory problems, and sedation (Swegle & Logemann, 2006; Chau, Walker, Pai, & Cho, 2008). Moreover, recent clinical evidence suggests that opioids may be less effective than indicated by early research or as preceived by providers (Fallon & Colvin, 2008; Compton, Boyle, & Wargo, 2015).

To study the impacts of MMLs on older adult labor supply and health conditions, we draw data from the Health and Retirement Study (HRS) between 1992 and 2012. We estimate differences-in-differences regressions of respondent-level outcomes on state law changes. We exploit within-state variation in the timing of MMLs to study how legalization of marijuana for medical use impacts labor supply and health outcomes. We consider the impact of any MML law and legal access to medical marijuana through home cultivation and dispensaries[3] (Pacula, Powell, Heaton, & Sevigny, 2015).

Our findings suggest that MML implementation leads to increases in labor supply among older adult men and women. We find mixed evidence of a relationship between health and MMLs, which is consistent with the clinical literature. We conclude from our analysis of chronic health conditions that MMLs are more effective in improving health status (likely by reducing the experience of symptoms related to health conditions rather than improving the underlying health conditions themselves) among older men than among older women, but the health improvements experienced by both groups permit increased participation in the labor market.

This manuscript is organized as follows: Section 2 provides background, related literature, and a conceptual framework considering ways that medical marijuana access may impact labor supply and health of older adults. Data and methods are outlined in Section 3. In

[3]Dispensaries are specific locations where users can legally purchase medical marijuana.

Section 4 we present our main findings and Section 5 reports robustness checks. Finally, Section 6 concludes.

2 Background and related literature

2.1 Federal and state regulation of marijuana

Marijuana (used medically or recreationally) is a controlled substance under Federal law, thus its possession and distribution are illegal. Indeed, the Controlled Substances Act of 1970 classifies marijuana as a Schedule 1 drug; this is the strictest drug classification in the U.S., reserved for 'Drugs with no currently accepted medical use and a high potential for abuse. Schedule 1 drugs are the most dangerous of all the drug schedules with potentially severe psychological or physical dependence.' Schedule 1 drugs include ecstasy, heroin, and lysergic acid diethylamide (LSD). For comparison, cocaine is a Schedule II drug, Valium is a Schedule IV drug, and Robitussin cough syrup is a Schedule V drug.

Schedule 1 status severely limits researchers' capacity to utilize marijuana for clinical trials. This barrier has lead to a very small set of U.S.-based marijuana clinical trails (Williams, Olfson, Kim, Martins, & Kleber, 2016; Stith & Vigil, 2016). In addition, clinical trials, again due to Federal regulations, are only permitted to test low potency tetrahydrocannabinol (THC)[4] marijuana, which is markedly weaker than the medical marijuana available to patients from dispensaries or home cultivation, raising questions regarding the extent to which clinical trial findings generalize to actual patients' experiences and thus the extent to which these findings can inform clinical practice (Stith & Vigil, 2016).

In 2009 the Department of Justice (DOJ) amended its position on marijuana used for medical purposes. More specifically, the DOJ stated that Federal enforcement resources would no longer be used to prosecute individuals using or distributing medical marijuana in compliance with state laws (Hoffmann & Weber, 2010).[5]

At the state level, as of 2016, 25 states and DC have implemented MMLs. To legally use marijuana, patients must receive a recommendation from a medical doctor indicating their need for this treatment and provide evidence of legal residence within the state. State laws differ in terms of the specific conditions that qualifying patients for medical use of marijuana, the most common qualifying conditions are cachexia, cancer, epilepsy, HIV/AIDS, muscle

[4]THC is the principle psychoactive constituent of marijuana.

[5]However, the extent to which the DOJ actually changed its position is subject to debate as the DOJ continued to raid dispensaries, operating in compliance with state law, at least through 2011.

spasms, multiple sclerosis, and pain (Bradford & Bradford, 2016a; Sabia et al., 2015).

Table 1 outlines the MML effective date for each of these states and policy specifics through December 2013 (the end of our study period, described later in the manuscript). The first state to legalize medicinal use of marijuana was California in 1996. Other early adopting states include Alaska, Oregon, and Washington (1998). Early MMLs tended to be implemented through voter initiatives which provided legal protection for users, but generally offered few details for regulators on medical marijuana manufacturing, dispensing, and labeling. Recent MMLs tend to be implemented through legislative acts and provide more guidance for regulators and, in particular, offer protection for legal access to marijuana (Williams et al., 2016). All state MMLs passed since 2009 includes guidance for a marijuana dispensary program (O'Keefe, 2013).

2.2 Use of medical marijuana by older adults

Although states do not release individual-level data, based on our analysis of available data 20% to 60% of all registered medical marijuana users in U.S. states reporting demographic information are over age 50, or are 'older adults.'[6] Recent studies of registered users in seven states (Fairman, 2016), and convenience samples of medical marijuana patients (Nunberg et al., 2011; Reinarman, Nunberg, Lanthier, & Heddleston, 2011; Ilgen et al., 2013) provide comparable evidence that older adults represent a substantial share of medical marijuana patients.[7] 6.1% of older Americans aged 55-64 reported any form of marijuana use in the past month in 2014, since 2002 rates of use have increased 455% among this group and 333% among those 65 and above (Azofeifa, 2016). These statistics suggest that older adults are using medical marijuana, perhaps to a greater exetent that younger adults, to treat chronic health conditions.

2.3 Economic analyses of state medical marijuana laws

A series of economic studies has explored the effect of expanded access to medical marijuana through MMLs on recreational use of marijuana (Anderson, Hansen, & Rees, 2015; Pacula et al., 2015; Wen, Hockenberry, & Cummings, 2015; Chu, 2014; Choi, 2014) and the use

[6]Authors' calculation using data from the eleven states (Alaska, Arizona, California, Colorado, Delaware, Hawaii, Illinois, Minnesota, Montana, Nevada, and Oregon) that require patients to register with the state to legally use medical marijuana and publicly report patient demographics.

[7]There are differences across studies, which is not unexpected given that these studies generally rely on very small samples of individuals seeking medical marijuana in select locations, e.g., San Francisco.

of other substances (Chu, 2013; Anderson, Hansen, & Rees, 2013; Choi, Dave, & Sabia, 2016), and the impact of these laws on health outcomes (Anderson, Rees, & Sabia, 2014; Sabia & Nguyen, 2016).[8] Broadly, the economic literature suggests that passage of an MML increases recreational use among adult populations, but the impact of MML passage among youth populations is unclear. Moreover, passage of an MML impacts the use of some related substances (alcohol, heroin, and tobacco use declines following passage of an MML, while cocaine use is not impacted) among adults.

Among teen and working populations, researchers have found that BMI declines, self-assessed health improves, and mental health problems decline following passage of some MMLs.[9] While a full consensus has not yet been reached, studies that consider specific attributes of state MMLs suggest that laws which provide a mechanism through which patients can legally access the product (e.g., home cultivation, dispensaries) are associated with more substantial changes in marijuana use and associated outcomes (e.g., Pacula et al. (2015)).

To date, few studies explore the effect of MML implementation on labor market outcomes, focusing on the working age population with mixed labor market evidence. Sabia and Nguyen (2016) document that passage of an MML may decrease wages and Ullman (2016) shows that passage of such a law reduces work absences.

2.4 Medical marijuana, health, and labor supply

Medical marijuana access may impact patients' health and labor supply, following changes in health, in several ways.[10] It may improve health by alleviating symptoms that are not responding to other treatments or provide similar symptom relief with a lower side effect profile. Alternatively, patients may experience worse health if marijuana is less effective than their previous treatment and/or use of marijuana reduces contact with healthcare providers.

Access to medical marijuana should only impact health and labor supply if patients use medical marijuana instead of or in addition to their current treatment regime (which could include no treatment). In a recent study, Bradford and Bradford (2016b) analyze prescribing patterns among Medicare patients (this population is similar to the one we examine in our study). The authors document declines in prescriptions for therapeutic

[8] See Pacula et al. (2015) for an excellent discussion of the mechanisms through which MMLs may lead to changes in recreational marijuana use.

[9] In an extension to their main analysis, Sabia et al. (2015) examine the impact of MML passage on older adult BMI. Mental health problems, measured by suicides, decline for young adult men only (Anderson et al., 2014).

[10] We focus our discussion on patients using marijuana medically.

substitutes after MML passage for a number of conditions including pain, anxiety, depression, nausea, psychosis, seizures, and sleep disorders.[11] The magnitude of the prescription declines is non-trivial, for example, 5.7% for pain medications, 5.0% for anxiety medications, 5.4% for nausea medications, and 4.5% for psychosis medications. Relatedly, Bachhuber, Saloner, Cunningham, and Barry (2014) document that the passage of an MML leads to a substantial decline (24.8%) in the number of opioid-related overdose deaths, suggesting that passage of an MML allows patients to address pain symptoms through less harmful treatment options (i.e., medical marijuana vs. perscription opioid pain relievers). Powell, Pacula, and Jacobson (2015) have similar findings, although the authors highlight the importance of legal access. Collectively, these findings suggest that passage of an MML leads to substitution towards medical marijuana and away from more conventional treatment options, including away from medications with side effects that can preclude work (Swegle & Logemann, 2006; Panchal, Muller-Schwefe, & Wurzelmann, 2007; Chau et al., 2008).

The extent to which substitution to medical marijuana improves patient health outcomes is *ex ante* ambiguous. If medical marijuana is more effective than a patient's previous treatment program, or similarly effective with less burdensome side effects, then we expect health outcomes to improve. Side effects of anti-anxiety medications include, among others, addiction, confusion, headaches, irritability, trouble concentrating, and worsening of depressive symptoms (Longo & Johnson, 2000; Stewart, Ricci, Chee, Morganstein, & Lipton, 2003) while patients using opioid pain relievers often suffer from cardiovascular problems, central nervous system problems, constipation, impaired judgment, itching, nausea or vomiting, and respiratory problems (Szarvas, Harmon, & Murphy, 2003; Swegle & Logemann, 2006; Chau et al., 2008). However, the relative effectiveness of medical marijuana and traditional treatment options (e.g., opioid pain relievers in the context of pain) is unclear. Available clinical evidence provides, at best, modest evidence on the effectiveness of medical marijuana (Hill, 2015; Whiting et al., 2015; Joy et al., 1999; Lynch & Campbell, 2011; Bradford & Bradford, 2016b), though observational studies suggest that patients perceive medical marijuana as more effective than their previous treatment (Troutt & DiDonato, 2015).

If medical marijuana is less effective than other treatment options, substitution away from more effective treatment may lead to worsening of patient health. For example, Anderson et al. (2014) find limited evidence that passage of an MML leads to improvements in mental health as measured by suicides (indeed modest-sized effects are only observed among

[11] The authors find no evidence that prescriptions for glaucoma or spasticity disorders are altered following passage of an MML. The authors argue that the clinical effectiveness evidence for these conditions is relatively weak.

younger men). Medical marijuana has known side effects as well: difficultly with thinking and problem solving, hallucinations, increased heart rate, memory problems, paranoia, and respiratory problems among others (Hill, 2015). These side effects may also harm health and/or reduce labor supply.

Switching to medical marijuana may also have adverse patient health effects if this substitution induces patients to terminate treatments addressing a broader set of symptoms. For instance, the treatment of chronic pain is often characterized by utilization of both prescription medications designed specifically to minimize pain symptoms and anti-depressants (Sansone & Sansone, 2008). Healthcare providers prescribe these medications in combination because some anti-depressants directly act on a different set of pain receptors than typical pain relievers, and because depression and pain can co-occur, especially for patients whose pain causes them to withdraw from normal activities. Patients who opt to use medical marijuana may lose access to valuable secondary treatments. Moreover, regular interactions with healthcare providers − who may be better able than patients themselves to diagnose worsening of health status and/or emergence of new symptoms − may also decline as patients withdraw from conventional healthcare.

While improved health may allow older adults to continue to work, there are several factors that may mute any medical marijuana-attributable work promotion effects. For example, in addition to the above noted mechanisms related to health outcomes, the intoxicating effects of marijuana and side effects (Hill, 2015) may lower productivity in the labor market, and hence the earned wage, which should reduce labor supply. Additionally, if use of medical marijuana improves health, the increased value of leisure time may decrease the desire to work, particularly among patients approaching standard retirement ages. The implication of expanded access to medical marijuana for labor supply is ultimately an empirical question.

3 Data, variables, and methods

3.1 Health and Retirement Study

We draw data from the Health and Retirement Study (HRS). The HRS is a nationally representative panel survey of Americans over 50 and their spouses that has been administered biennially since 1992. The HRS originally included individuals from the 1931 through 1941 birth cohorts and those born prior to 1923 in the Assets and Health Dynamics of the Oldest Old (AHEAD) cohort. In 1998, the HRS and AHEAD cohorts were merged, and the 1942 to

1947 birth cohort was added. Younger cohorts are added regularly so that the HRS remains representative of the over 50 population. The survey is designed to track health and labor supply outcomes among older adults, and is therefore well suited to our research questions. We use the core HRS supplemented with indicators from the RAND HRS Version N for all HRS waves conducted between 1992 and 2012.[12] Through the 2012 wave, the HRS includes 247,233 interviews with 38,008 older persons.

We exclude 8,561 respondents who reside outside the U.S. or having missing state of residence information, and 16,220 respondents whose interviews are completed by a proxy informant. Proxy informant interviews are typically conducted when the respondent's physical or cognitive functioning precludes interview completion. Many of our outcomes rely on the respondents' assessment of their own health and symptoms, which may not be correctly reported by proxies. Our analysis sample includes 183,032 respondent/year observations. Due to missingness patterns in our outcome variables, sample sizes vary to some extent across regressions.

The HRS spans nearly all of the MML changes that have occurred within the U.S. A limitation of the HRS is that it does not collect information on marijuana use, either for medical or recreational purposes. Therefore, we cannot explore the first stage relationship; that is the effect of MMLs on older adult medical marijuana use, giving our results an intent-to-treat (ITT) interpretation.[13]

3.2 State medical marijuana laws

In the main analysis, we use state policy data collected by Pacula et al. (2015) to assess the medical marijuana policy environment.[14] We construct indicator variables for 1) any MML and 2) an MML that allows any legal access to medical marijuana through an operating dispensary or home cultivation. We view any state that has an operating dispensary as

[12]HRS interview waves frequently span multiple years, as a result our data include respondents interviewed during the calendar year 2013. We accurately match these respondents to 2013 MMLs.

[13]The HRS is not unique in this regard, to the best of our knowledge there are no nationally representative panel or repeated cross-sectional dataset capturing medical marijuana use.

[14]We thank Rosalie Pacula for sharing an updated version of this coding scheme from the RAND Drug Policy Database with us. One exception to our exclusive use of the Pacula et al. (2015) coding scheme is Maryland. Pacula et al. (2015) code this state as implementing an MML in 2003. Based on our reading of this state's statues, we code the law as effective June 1^{st}, 2014, which is outside our study window (1992 to early 2013). In 2003, Maryland adopted laws that provided some weak protection for medical marijuana users, but the scope of these laws, relative to other state laws, was much narrower and therefore we chose to treat Maryland as not having an MML during our study period.

permitting dispensaries, regardless of whether the dispensaries are legally protected.[15] We match MMLs to the HRS data based on the month and year of the law passage.

3.3 Outcome variables

Our objective is to study the impact of MMLs on older adult labor supply outcomes and health outcomes. Our measures of labor supply are as follows: 1) any work in the past year (0/1), 2) whether currently working full-time (0/1, we define full time work as working 35 or more hours per week for at least 36 weeks of the year), and 3) usual hours worked per week among those who report any work. We take the logarithm of usual hours worked to address skewness in this variable, thus coefficient estimates have the interpretation of an approximation of the percent change.

We examine several health outcomes for which there is some evidence that medical marijuana is an effective treatment that also have a plausible link to labor supply. In terms of pain, we consider indicators for reporting: any pain, whether pain limits a respondents' activities, whether the respondent has a health condition that limits work, and self-assessed excellent or very good health (versus good, fair, or poor health). We consider two measures of depressive symptomatology. First, we take a count of the number of depressive symptoms as measured by an abbreviated Center for Epidemiologic Studies - Depression Scale used in the HRS (CES-D, 8 items). The CES-D asks respondents to report whether or not in the past week they felt depressed, happy, lonely, sad, etc. Second, we use the CES-D to construct an indicator for clinical depression based on the CES-D (reporting three or more depressive symptoms) (Turvey, Wallace, & Herzog, 1999; Schane, Woodruff, Dinno, Covinsky, & Walter, 2008).

The HRS survey items mirror questions that clinicians would use to diagnose and treat conditions such as pain and depression; conditions whose symptoms are subjective by nature (NIH, 2011). Self-assessed health has been shown to predict, even after conditioning on observable characteristics, more objective measures of health status such as mortality and healthcare utilization (Miilunpalo, Vuori, Oja, Pasanen, & Urponen, 1997; Benjamins, Hummer, Eberstein, & Nam, 2004; Nielsen, 2016). This measure is believed to capture aspects of both mental and physical health (Apouey & Clark, 2015), and an individual's stock of health (Grossman, 2000). The CES-D measures of depressive symptomatology have been validated

[15] In unreported analyses, we have used other definitions for dispensaries and results are not appreciably different. We do not have an effective month for some states. When there is no available effective month, we assume the first dispensary opened in January.

in numerous settings (Radloff, 1977; Turvey et al., 1999). These measures are frequently used in the health economics literature (Tian, Robinson, & Sturm, 2005; Kapteyn, Smith, & Van Soest, 2008; Atlas & Skinner, 2009; Apouey & Clark, 2015; Maclean, 2013; McInerney, Mellor, & Nicholas, 2013; Maclean, Webber, French, & Ettner, 2015).

3.4 Control variables

We include individual- and state-level control variables in our regression models. We control for respondent age, race (African American and other race, with white race as the omitted group), Hispanic ethnicity, and education (less than high school, at least some college education, with high school graduates as the omitted group). To account for time-varying between-state differences that may be correlated with both the passage of an MML and our outcome variables we include an indicator for whether a state has decriminalized marijuana (Pacula, Chriqui, & King, 2003),[16] the beer tax per gallon in dollars from the Brewers' Almanac, the seasonally adjusted annual unemployment rate from the Bureau of Labor Statistics Local Area Unemployment Database, and hourly wages for prime age adults (23 to 54 years) from the Current Population Survey Outgoing Rotation Group. We inflate all nominal values to 2012 terms using the Consumer Price Index - Urban Consumers.

3.5 Empirical model

We estimate the relationship between state MMLs, and older adult labor supply and health outcomes with the following differences-in-differences regression model:

$$Y_{ist} = \alpha_0 + \alpha_1 M_{st} + X_{ist}^{'}\alpha_2 + \tau_{st}^{'}\alpha_3 + S_s + \gamma_t + \omega_{st} + \epsilon_{ist} \quad (1)$$

Y_{ist} is a labor supply or health outcome for older adult i in state s in year t. M_{st} is an indicator for an MML in state s in year t. We estimate separate models with each of our MML variables. X_{ist} is a vector of individual characteristics that may influence our outcomes while τ_{st} is a vector of time-varying state policy and employment characteristics. S_s is a vector of state fixed effects which capture time invariant state-level characteristics that influence older adult chronic pain and labor supply outcomes and MML passage. γ_t is a vector of interview wave dummy variables capturing common time trends for all respondents interviewed in a given wave. We include state-specific linear wave trends, ω_{st}, to allow for

[16]We thank Rosalie Pacula for sharing updated decriminalization data with us.

different linear trends in the outcome variables across states.[17] ϵ_{ist} is the error term.

We utilize linear probability models (LPMs) for binary outcomes and least squares (LS) for continuous outcomes. Although there are limitations of the LPM (e.g., out of sample predictions), this model does avoid the incidental parameter problem in fixed effects regression models (Greene, 2004; Ullman, 2016). We cluster the standard errors around the state to account for clustering of similar older adults within a state (Bertrand, Duflo, & Mullainathan, 2004).[18] All results are unweighted (Solon, Haider, & Wooldridge, 2015). We estimate models separately for men and women given differences in labor supply (Blau & Kahn, 2007) and health outcomes (Nahin, 2015; Vigil, 2011; Macintyre, Hunt, & Sweeting, 1996; Horn, Maclean, & Strain, 2015; Maclean, Webber, & French, 2015) between these two groups. More specifically, men are more likely to participate in the labor market than women, while women are more likely to experience pain, worse self-assessed health, and worse mental health than men.

Although the HRS does not include information about whether respondents use medical marijuana, the survey does include questions about whether respondents have many of the underlying health conditions that would qualify them for legal access to medical marijuana within states that have passed an MML (Sabia et al., 2015; Bradford & Bradford, 2016a). We construct an indicator of whether a respondent appears to qualify for medical marijuana if they report 1) current cancer treatment, 2) current glaucoma, 3) current arthritis, or 4) lifetime severe pain.[19] We refer to respondents who meet one or more of these conditions as the 'qualifying' sample. While this definition likely captures many potential medical marijuana users, it fails to identify those respondents with diagnoses such as multiple sclerosis, HIV, and epilepsy, which are not measured in the HRS, and patients who develop one one of conditions and initiate successful treatment between waves. We estimate all specifications of Equation 1 in the full population and the qualifying sample. We expect that the relationships between MMLs and our outcome variables should be stronger[20] in the qualifying sample than the full sample of respondents.[21]

[17] Specifically, we interact each state fixed effect with a separate linear wave trend; the wave trend takes on the values of 1 for 1992, 2 for 1994, and so forth.

[18] Although the HRS is a nationally representative survey, we have 51 clusters in our analysis data set. Thus, we have sufficient clusters to consistently estimate our standard errors (Cameron & Miller, 2015).

[19] Specifically, if the respondent reported severe pain in any previous round of the HRS.

[20] Or at least not weaker, as Bradford and Bradford (2016a) note that patients induced to use medical marijuana through MMLs may be more marginal patients and thus their health conditions may be less severe.

[21] A concern with our qualifying sample is that passage of and MML may alter the number of HRS respondents reporting qualifying conditions and thus lead to concerns that we are stratifying our sample

4 Results

4.1 Summary statistics

Table 2 reports summary statistics for men and women in both the full and qualifying samples. Men are more likely to work than women in our sample; in the full sample 45% and 32% of men report any work and full time work while 35% of women report any work and 21% of women work full time. Among working respondents, men work 39.41 hours per week and women work 34.22 hours per week. Among men and women, labor supply is lower in the qualifying sample than in the full sample. For example, only 36% (23%) of men and 29% (17%) of women in the qualifying sample report any work (working full time).

Among men, 26%, 15%, and 27% of the full sample reports any pain, pain that limits activities, and that health limits the ability to work. In the male qualifying sample, the respective shares are: 40%, 25%, and 39%. As predicted, the prevalance rates of our pain measures are higher in the older adult female sample. In the full (qualifying) older women sample, 34% (46%) report any pain, 23% (32%) report pain that limits activities, and 30% (40%) reports that health limits the ability to work.

14% of men and 13% of women reside in a state with any MML in our sample. These shares are somewhat higher in the qualifying sample: 15% of men and women. 14% and 13% of men and women in the full sample reside in a state with access to medical marijuana through either home cultivation or a dispensary. Access through home cultivation is somewhat more common than access through a dispensary in both the full male and female samples (13% vs. 11%).

4.2 Regression analysis of older adult labor supply outcomes

We first consider whether the passage of an MML translates into changes in labor supply outcomes among older adults. Results are reported in Table 3, results based on the male sample are in the top panel and results based on the female sample are in the bottom panel (all tables henceforth follow this format). We find little evidence that passage of an MML impacts employment propensity among either older adult men or older adult women (i.e., coefficient estimates are small in magnitude and statistically indistinguishable from zero in the any employment regressions).

on an endogenous variable. In unreported analysis we regressed the probability of being in the qualifying sample on the MMLs and other controls. We find no evidence that MMLs impact the probability of being in the qualifying sample.

However, we find evidence that passage of an MML leads to increases in labor supply among both older adult men and older adult women on the intensive margin (full time work propensity and hours worked per week). Passage of an MML leads to a 1.4 percentage point (6.7%) increase in the probability of older women working full time in the full sample and a 1.6 percentage point (9.4%) increase in this probability in the qualifying sample. We find comparable estimates in regressions that include an indicator for an MML that allows legal acccess to medical marijuana through home cultivation or dispensaries (although coefficient estimates are smaller in magnitude and somewhat less precise, particularly in the qualifying sample where the estimate is statistically indsitinguishable from zero). In regressions in which the outcome variable is the logarithm of usual hours worked per week (conditional on any work), our findings are comparable to those generated in the full time employment regressions. Among both older men and older women, we find that passage of an MML leads to increases in usual hours worked. Among older men, we find that passage of an MML leads to a 4.2% and 4.9% increase in the number of hours worked per week in the full sample and the qualifying sample. The coefficient estimates are similar, although smaller in magnitude and less precise, in regressions that include an indicator for passage of an MML that allow for legal access to medical marijuana. Findings are broadly comparable among older women, altough we find that the effects of legal access through home cultivation or dispensaries are larger in magnitude and more precisely estimated. For example, passage of an MML that allows for legal access leads to a 3.9% (5.1%) increase in hours worked per week in the full (qualityfing) sample.

4.3 Regression analysis of older adult health outcomes

We next consider whether the labor supply effects that we observe following MML passage may be explained by improvements in health conditions that are potentially treatable with medical marijuana. Regression results for pain and work-limiting disabilities are reported in Table 4, and results for overall health and depressive symptomatology are reported in Table 5. Among older men, we find that passage of an MML leads to a decrease in any pain in the qualifying sample: passage of any MML leads to a 4.2 percentage point (10.5%) decrease in reported pain in the full sample and a 3.9 percentage point (9.8%) in the qualifying sample (coefficients in the full sample carry a negative sign, suggesting a similar relationship, but are not statistically different from zero). We find no evidence that passage of an MML impacts the probability of reporting that pain limits activity (indeed coefficient estimates, although imprecise in all regressions, carry a positive sign in the full sample and a negative sign in the

qualifying sample). Surprisingly, among women we find evidence that passage of an MML that provides legal access to the product *increases* the probability of reporting pain in the full sample by 1.3 percentage points (3.8%).

Among men, we find that passage of an MML improves overall health and reduces depressive symptomatology. Passage of an MML that provides legal access leads to a 2.1 percentage point (5.0%) increase in the probability of reporting very good or excellent health (our proxy for overall health status) in the full sample. Effect sizes are similar for the any MML indicator and in the qualifying sample, although the coefficient estimates are not always statistically different from zero. We find that passage of an MML reduces depressive symptoms by 6% and the probability of meeting the diagnostic criteria for depression by 7.2% in the full sample. Effects are similar in sign and magnitude in the qualifying sample and for passage of MMLs that allow for legal access, but are less precise.

Our analysis of the effect of MML passage on older adult women's health produces a mixed set of results. First, in terms of overall health status, we find that passage of an MML leads to increases in the probability of reporting one's health as very good or excellent: passage of a law leads to a 2.1 percentage point (5.1%) increase in the probability of reporting this health status (the coefficient in the regression that includes an indicator of an MML that allows for legal access to medical marijauna produces a nearly identical estimate in the full sample). Coeffecient estimates in the qualifying sample suggest that passage of any MML (an MML that allows for legal access) leads to a 1.5 percentage point or a 4.9% (1.4 percentage point or 4.4%) increase in the probability of reporting this health status in the qualifying sample. However, coefficient estimates in the qualifying sample are not statistically different from zero. Depressive symptoms *worsen* among older women following passage of MMLs. For example, following passage of any MML (an MML that allows legal access) depressive symptoms among women increase by 0.076 symptoms or 4.5% (0.073 symptoms or 4.3%).

The finding that passage of an MML appears to worsen depressive symptomatology is not inconsistent with the potential pathways through which medical marijuana may impact health outcomes (or symptoms associated with underlying health conditions) outlined in our conceptual framework. While we cannot test this pathway in our data, women moving from conventional treatment of pain, which often entails the use of both opioid pain relievers and anti-depressants, to medical marijuana, could see increased depression after discontinuing anti-depressants. While we observe no improvement in pain outcomes (Table 4) among women following passage of an MML (indeed we observe some evidence that pain may increase), it is possible that pain symptoms are broadly unaltered as women substitute from

conventional pain medications to medical marijuana to less burdensome side effects of opioids or other medications. The loss of access to anti-depressants that doctors often co-prescribe with pain relieving medications worsens the depressive symptomatology we measure here. Women are more likely to receive treatment for mental health conditions than men (Hinton, Zweifach, Tang, Unützer, & Oishi, 2006; Pattyn, Verhaeghe, & Bracke, 2015), making them the group where we would expect to see results if substitution of medical marijuana is differentially effective from previous treatment. Though we cannot test these hypotheses in our data, Bradford and Bradford (2016a) document the largest reductions in prescriptions for pain and mental health medications within the Medicare population following passage of an MML.

There are several possible explanations for the relatively strong labor supply response among women despite the mixed health effects. We examine several different measures of health, but we do not have any information on how these measures 'sum up' to produce an individual's health. While speculative, this hypothesis is consistent with our finding that women's self-assessed health, which we view as a proxy for overall health status and/or the stock of health (Grossman, 2000; Apouey & Clark, 2015), does in fact improve following passage of an MML. Second, apart from medication effectiveness, marijuana may have fewer side effects. Thus, even if health symptoms are unchanged, a reduction in side effects may permit work. Third, our regression models estimate average treatment effects and it may be that different sub-populations of women experience different health effects from expanded access to medical marijuana through MMLs. The labor supply effects we observe may be driven by those women for whom health improves. Fourth, women may experience health gains in conditions that we cannot measure which facilitate increased labor supply. Finally, women − particularly women in an older cohort such as that captured in the HRS − provide a substantial amount of caregiving, particularly to their spouses. The health improvements we observe for men may lessen womens' caregiving responsibilities and allow these women to increase labor supply.

5 Robustness checks

5.1 Event study

A threat to our identification strategy is that MMLs are endogenously determined within states' political economies (Besley & Case, 2000). For example, states may decide to implement an MML to address rates of pain among older adults within their populations.

If true, estimates generated in Equation 1 will be biased due to reverse causality ('policy endogeneity'). To address this concern we next estimate an event study.

Our event study model controls for pre-law trends in our outcome variable. Specifically, we construct a variable that measures the difference between the HRS survey year and the law change year for each state that ever passed an MML before or during our study period (i.e., by the end of 2013). This value takes on negative values in the pre-law period, 0 in the law change year, and positive values in the years after the following the law change. States that did not pass an MML by 2013 are coded as 0 for this variable. We refer to this variable as the 'year relative to MML'. We interact the year relative to MML with the MML indicator variable. We re-estimate Equation 1 including the year relative to MML and the interaction term as additional covariates. The event study regression model is as follows:

$$Y_{ist} = \beta_0 + \beta_1 M_{st} + \beta_2 (rel\_year)_{st} + \beta_3 M_{st} * (rel\_year)_{st} + X_{ist}^{'} \beta_4 + \tau_{st}^{'} \beta_5 + S_s + T_t + \mu_{ist} \quad (2)$$

In this specification, β_1 captures any discrete change in our outcomes in the law change year and $(rel\_year)_{st}$ accounts for the pre-law trends that may differ between the treated and untreated states. A statistically significant β_2 coefficient would suggest policy endogeneity. However, if policy endogeneity is present, including this variable in the regression model should account for such endogeneity and allow us to estimate the causal effect of MMLs on our outcomes. Finally, β_3 can inform us about differences in trends in outcome variables in the post-law period for the treated and untreated states. We do not include state-specific linear time trends in the event study as these trends may absorb true dynamics and thus lead to inaccurate conclusions about law effects (Wolfers, 2006).

Tables 6, 7, and 8 present event study results for labor supply, pain and work-limiting disability, and self-assessed health and depressive symptomatology outcomes. In general our event studies suggest that some evidence of policy endogeneity (i.e., β_2 is statistically different from zero in some regressions). However, such policy endogeneity cannot fully explain our findings as the key estimates (β_1) are not appreciably different from those generated in our core DD models. Moreover, the magnitudes of the difference in trends between the treatment and comparison groups in the pre-law period are relatively small. For example, among men (Table 6) the effect of any MML, captured by β_1, on our labor supply outcomes is broadly comparable to the main results reported in Table 3. More specifically, we find that passage of an MML leads to a 2.4% and 4.5% increase in hours worked per week in the full sample and the qualifying sample respectively. Examination of the pre-law trends (β_2) provides no

evidence in pre-intervention trends: all coefficient estimates are very small in magnitude and statistically indistinguishable from zero. Estimates of β_3 imply, although not revealed in our main DD models, that any employment and full time employment propensities in the treated states are trending upward (relative to comparison states) in the post-law period. This trend suggests that, over time, older men residing in states that pass MMLs experience increases in their employment propensities relative to comparable men residing in states that do not pass an MML. For example, in the any employment regression, the β_3 estimate is 0.0002 which implies that in each year following the MML passage, the probability of any employment in the treatment group (states passing an MML) increases by 0.02 percentage points (0.4%) in the full sample.

Findings are broadly similar among older women, although we do find more evidence of policy endogeneity in this sample, although as in the older male sample the magnitudes of the estimated coefficients are relatively small. For women, passage of an MML leads to increased labor supply in the post period. However, the event study analysis provides less conclusive evidence that passage of an MML leads to an increase in hours worked than our main DD model: the coefficient estimate on β_1 is smaller in magnitude and statistically indistinguishable from zero. Moreover, the coefficient estimate on β_3 carries a negative sign, suggesting that usual hours worked per week among older adult women in treated states are declining (relative to comparison states) in the post-law period.

Policy endogeneity also does not drive the main DD results for pain and work disability outcomes (Table 7). While we observe some evidence of statistically different pre-law trends between states that do and do not adopt an MML (the coefficient estimates on β_2 are often statistically different from zero and the sign suggests that adopting states experienced worsening health among older adults prior to law passage), the event study (β_1) coefficients are broadly comparable in terms of direction, magnitude, and statistical significance to those generated in the basic DD models. However, we find stronger evidence that the probability of reporting pain and work-limiting disabilities increases among older women in the year of MML adoption: the coefficient estimates on β_1 are more likely to be statistically different from zero in the event study relative to the main DD regression. In general, our event study models for overall health status and depressive symptoms (reported in Table 8) suggest that the main DD results hold, although there is some evidence of differences in pre-law trends between states that chose to adopt and chose not to adopt an MML. Examination of the post-law trends shows that the improvements in overall health experienced in adopting states may decline over time, but that as time passes the trend in older adult women's depressive

symptoms declines in adopting states relative to never adopting states.

5.2 Alternative MML coding schemes

In our main analysis we use MML effective dates reported by Pacula et al. (2015). However, Anderson et al. (2015) and Wen et al. (2015) propose alternative coding schemes for MML variables. We next re-estimate our any MML specification using these alternative coding schemes. Results, reported in Tables 9 (labor supply outcomes), 10 (chronic pain and work limiting disability outcomes), and 11 (overall health and depressive symptomology), are broadly robust to those generated in the main specification. However, we do note that the magnitude of estimated effects and their statistical significance vary across coding schemes to some extent.

5.3 Additional robustness checks

Our identification strategy assumes that the changes in chronic pain and labor supply outcomes observed after states pass MMLs are driven by the laws themselves, and not an unobserved third factor that may correlate with law passage and our outcomes of interest. If present, such a third factor may lead to the changes in outcome variables we report here. We test this hypothesis by conducting a Monte Carlo simulation in which we randomly assign with replacement actual state legislative histories to our 50 states and DC, and estimate the effect of these false laws on pain and labor market outcomes. Across 100 simulations, our point estimates are small and statistically indistinguishable from zero for all outcomes and all laws (Tables 12 and 13). Coefficients on individual laws and outcomes are also generally small in magnitude and statistically indistinguishable from zero. We are unable to replicate our main findings using these 'false laws,' which further supports the validity of our research design.

One additional concern with our analysis this far is that older adults may migrate to states that have passed an MML to access the new medical treatment (i.e., a form of program induced migration). Such migration patterns may lead us to overstate MML effects. We explore this possibility by regressing an indicator of whether a respondent had moved since the last wave on the MML status from the previous wave. We find no evidence of a relationship between MMLs and cross-state moves in either the full or qualifying sample. Our results are broadly robust to a number of alternative specifications including use of respondent fixed effects (these models rely on within respondent, rather than within state,

variation in MMLs for identification; these models may also control for between person heterogeneity in the reporting of our self-reported health variables), restricting our analysis population to adults under 75 (i.e., those older adults most likely to participate in the labor market), allowing for a one year lag between the passage of an MML and our outcome variables to allow for learning about the new medication by both patients and providers, and excluding California from the analysis sample (this state was the first state to pass an MML and represents a disproportionately large share of our observations, thus we wish to ensure that California does not drive our findings). All results not reported here are available on request from the corresponding author.

6 Discussion

In this study we provide new information to the current policy debate surrounding legalization of marijuana for medical purposes through state regulations. Specifically, we explore the effects of medical marijuana laws (MMLs) on older adult labor supply and health outcomes. Because marijuana has been shown to improve symptoms related to health conditions such as chronic pain and mental health (Hill, 2015; Whiting et al., 2015), it is possible that MMLs, by allowing legal use of an effective treatment that can improve health (or rather reduce the symptoms associated with underlying health conditions) and, in turn, facilitate continued participation in the labor market among older adults. Our findings, suggest that the passage of an MML leads to improvements in labor supply and with health improvements being a plausible pathway.

To the best of our knowledge, there are no previous studies that explore the impact of MMLs on labor supply among older adults. However, Garthwaite (2012) explores the effect of the removal of Vioxx, a medication designed to reduce chronic pain associated with joint pain, from the U.S. market on the labor supply of older adults. We argue that this study is a reasonable comparator as chronic pain is highly prevalent among older adults. This study finds that the removal of Vioxx lead to a 54% reduction in the probability of any work among the affected population (those suffering from joint pain).[22] In our labor suply findings, we find that, at most, passage of an MML leads to a 9.4% increase in the probability of employment and a 4.6% to 4.9% increase in hours worked per week.[23] Thus, relative to the findings of Garthwaite (2012), our findings are more modest in size, but appear to be

[22]Garthwaite does not examine the intensive margin of labor supply in his study.

[23]The extensive margin effects in our study are driven by women only.

reasonable, particularly as we our regression models have an intent-to-treat interpreation. Moreover, our analyses of state medical marijuana programs that require users to register and provide age information suggest that anywhere from 20% to 60% of users are older adults, providing additional (albeit suggestive) evidence that our findings are reasonable given the current medical marijauana use prevalence in our study population.

While novel in many ways, our study is not without limitations. First, the HRS does not include information on marijuana use, for either medical or recreational purposes, and therefore we are unable to document the effect of MMLs on medical marijuana use. Instead, our findings have an intent-to-treat interpretation, and suggest that the effects for those older adults who are induced to use medical marijuana due to an MML are even larger than the estimates presented here, which average across users and non-users. Thus, our estimates likely represent a lower bound on the true treatment on the treated effect. Second, our sample is potentially vulnerable to survivor bias, that is we only observe the sample of older adults who are cognitively and physically able to complete their own interviews and may not generalize to the full older adult population. Third, our identification strategy uses variation in MMLs for those states that implemented such laws during our study period (1992 to 2013). The extent to which findings from these states will generalize to other states, or to a Federal policy permitting access to marijuana for medicinal purposes, is not clear. Fourth, we lack data on many of the conditions for which medical marijuana may be effective in treating and for which states list as qualifying conditions (e.g., anxiety, multiple sclerosis).

The policy debate surrounding legalization of marijuana, for medical or recreational purposes, is fierce. Policy makers must carefully weigh both the costs and the benefits of such legalization. In terms of medical marijuana, many previous economic studies have examined the potential costs to legalization (e.g., addiction, traffic accidents, healthcare use) among young and working age adults. We provide evidence that there may be benefits in terms of pain reduction and labor supply of older adults, a population that, based on anecdotal evidence, is indeed using marijuana medically to address health needs. Taken in combination with findings that MMLs may reduce body weight (Sabia et al., 2015), improve physical well-being (Sabia et al., 2015), reduce suicide rates among some sub-populations (Anderson et al., 2014), lower opioid-related overdoses (Bachhuber et al., 2014; Powell et al., 2015), and reduce alcohol-related traffic accidents (Anderson et al., 2013), our findings suggest that there are potentially important social benefits to MMLs that must be considered in policy decisions regarding regulation of medical marijuana.

Table 1: State medical marijuana laws 1996-2013

State	Any MML	Home cultivation	Operating dispensary	Legal access
Alaska	03/1999	03/1999	NA	03/1999
Arizona	11/2010	11/2010	12/2012	11/2010
California	11/1996	11/1996	11/1996	11/1996
Colorado	12/2000	12/2000	2005	12/2000
Connecticut	10/2012	NA	NA	NA
DC	07/2010	NA	04/2013	04/2013
Delaware	05/2011	NA	NA	NA
Hawaii	06/2000	06/2000	NA	06/2000
Maine	12/1999	12/1999	2011	12/1999
Massachusetts	01/2013	01/2013	NA	01/2013
Michigan	12/2008	12/2008	2009	12/2008
Montana	11/2004	11/2004	2009	11/2004
Nevada	10/2001	10/2001	12/2009	10/2001
New Hampshire	07/2013	NA	NA	NA
New Jersey	06/2010	06/2010	12/2012	06/2010
New Mexico	07/2007	07/2007	07/2009	07/2007
Oregon	12/1998	12/1998	07/2009	12/1998
Rhode Island	01/2006	01/2006	04/2013	01/2006
Vermont	07/2004	07/2004	06/2013	07/2004
Washington	12/1998	06/2007	2009	06/2007
N	20	16	14	17

Notes: Sources: Pacula et al. (2015).

Table 2: Summary Statistics: HRS 1992-2012

	Men		Women	
Sample:	Full	Qualifying	Full	Qualifying
Labor supply outcomes				
Any work	0.45	0.36	0.35	0.29
Work full time	0.32	0.23	0.21	0.17
Hours (conditional)	39.41	36.94	34.22	33.18
Health outcomes				
Any pain	0.26	0.40	0.34	0.46
Pain limits activity	0.15	0.25	0.23	0.32
Health limits work	0.27	0.39	0.30	0.40
Very good/excellent health	0.42	0.33	0.41	0.32
Depressive symptoms	1.32	1.55	1.70	1.96
Depression	0.18	0.22	0.26	0.30
Medical marijuana laws				
Any MML	0.14	0.15	0.13	0.15
MM access	0.14	0.15	0.13	0.15
Home cultivation	0.13	0.15	0.13	0.14
Dispensary	0.11	0.12	0.11	0.12
Demographics				
Age	66.39	68.33	66.58	67.79
Less than high school	0.28	0.31	0.29	0.30
High school graduate	0.27	0.28	0.34	0.34
Some college	0.45	0.41	0.37	0.36
White	0.82	0.83	0.79	0.79
African American	0.13	0.13	0.17	0.17
Other race	0.05	0.04	0.04	0.04
Hispanic	0.09	0.08	0.09	0.09
State characteristics				
Marijuana decriminalized	0.32	0.32	0.32	0.32
Beer tax (dollars per gallon)	0.26	0.26	0.27	0.27
Unemployment rate	7.50	7.51	7.43	7.47
Hourly wage	12.48	12.96	12.51	12.99
N	75,628	37,040	107,404	64,072

Notes: Sample includes HRS respondents 51 years and older between 1992 and 2012. Qualifying sample includes respondents that report current cancer treatment, current glaucoma, current arthritis, and lifetime severe pain.

Table 3: Effect of state medical marijuana laws on older adult labor supply outcomes: HRS 1992-2012

Outcome:	Employed		Employed full time		Hours (logged)	
Sample:	Full	Qualifying	Full	Qualifying	Full	Qualifying
Men						
Proportion/mean	0.45	0.36	0.32	0.23	39.41	36.94
Any MML	-0.008	-0.012	0.004	0.005	0.042**	0.049*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)
Access	0	-0.007	-0.002	0.006	0.002	0.015
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
N	75360	36932	75360	36932	33368	12878
Women						
Mean/proportion	0.35	0.29	0.21	0.17	34.22	33.18
Any MML	-0.002	0.002	0.014***	0.016**	0.031	0.046*
	(0.008)	(0.016)	(0.005)	(0.007)	(0.022)	(0.024)
Access	-0.008	-0.004	0.009*	0.008	0.039*	0.051**
	(0.01)	(0.02)	(0.005)	(0.009)	(0.02)	(0.022)
N	107,096	63,928	107,096	63,928	36,503	17,961

Notes: All models estimated with a linear probability model (binary outcome) or least squares (continuous outcome), and control for individual and state characteristics, state fixed effects, state-specific linear time trends, and interview wave fixed effects. Qualifying sample includes respondents that report current cancer treatment, current glaucoma, current arthritis, and lifetime severe pain. Standard errors are clustered at the state level and are reported in parentheses. significant at 10%, ** significant at 5%, *** significant at 1%.

Table 4: Effect of state medical marijuana laws on older adult pain and work-limiting disability outcomes: HRS 1992-2012

Outcome:	Any pain		Pain limits activity		Health limits work	
Sample:	Full	Qualifying	Full	Qualifying	Full	Qualifying
Men						
Proportion	0.26	0.40	0.15	0.25	0.27	0.34
Any MML	-0.01	-0.042**	0.005	-0.005	-0.011	-0.011
	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
Access	-0.008	-0.039***	0.00	-0.01	-0.020**	-0.021*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	75,502	36,982	75,502	36,982	66,909	34,148
Women						
Proportion	0.34	0.46	0.23	0.32	0.30	0.40
Any MML	0.008	-0.003	0.003	-0.009	0.004	0.002
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
Access	0.013**	0.003	0.005	-0.006	0.001	-0.003
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
N	107,253	63,973	107,253	63,973	91,128	57,716

Notes: All models estimated with a linear probability model and control for individual and state characteristics, state fixed effects, state-specific linear time trends, and interview wave fixed effects. Qualifying sample includes respondents that report current cancer treatment, current glaucoma, current arthritis, and lifetime severe pain. Standard errors are clustered at the state level and are reported in parentheses. significant at 10%, ** significant at 5%, *** significant at 1%.

Table 5: Effect of state medical marijuana laws on older adult self-assessed health and depressive symptomatology outcomes: HRS 1992-2012

Outcome	Very good health		Depressive symptoms		Depression	
Sample:	Full	Qualifying	Full	Qualifying	Full	Qualifying
Men						
Proportion/mean	0.42	0.33	1.32	1.55	0.18	0.22
Any MML	0.015	0.036**	-0.079*	-0.076	-0.013*	-0.018
	(0.01)	(0.02)	(0.04)	(0.06)	(0.01)	(0.02)
Access	0.021**	0.032	-0.076	-0.08	-0.012	-0.019
	(0.01)	(0.02)	(0.05)	(0.07)	(0.01)	(0.02)
N	75,521	36,996	75,507	36,987	75,507	36,987
Women						
Proportion/mean	0.41	0.32	1.70	1.96	0.26	0.30
Any MML	0.021***	0.015	0.076***	0.069	0.012*	0.01
	(0.01)	(0.01)	(0.02)	(0.04)	(0.01)	(0.01)
Access	0.021***	0.014	0.073***	0.067	0.013*	0.015
	(0.01)	(0.01)	(0.02)	(0.04)	(0.01)	(0.01)
N	107,262	63,983	107,284	64,004	107,284	64,004

Notes: All models estimated with a linear probability model (binary outcome) or least squares (continuous outcome), and control for individual and state characteristics, state fixed effects, state-specific linear time trends, and interview wave fixed effects. Qualifying sample includes respondents that report current cancer treatment, current glaucoma, current arthritis, and lifetime severe pain. Standard errors are clustered at the state level and are reported in parentheses. significant at 10%, ** significant at 5%, *** significant at 1%.

Table 6: Effect of state medical marijuana laws on older adult labor supply outcomes using an event study framework: HRS 1992-2012

Outcome:	Employed		Employed full time		Hours (logged)	
Sample:	Full	Qualifying	Full	Qualifying	Full	Qualifying
Men						
Proportion/mean	0.45	0.36	0.32	0.23	39.41	36.94
Any MML	-0.0029	0.0016	0.0065	0.0105	0.0243*	0.0454*
	(0.0136)	(0.0163)	(0.0118)	(0.0139)	(0.0139)	(0.0230)
Rel. yr.	0	0	0	0	-0.0001	-0.0002
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Rel. yr.*post	0.0002*	0.0002	0.0002*	0.0002*	-0.0002	-0.0002
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)
Access	0.0058	0.0119	0.0028	0.0123	-0.0058	0.0075
	(0.0148)	(0.0155)	(0.0105)	(0.0141)	(0.0169)	(0.0171)
Rel. yr.	-0.0001	-0.0001	0	-0.0001	-0.0001	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Rel yr.*post	0.0002**	0.0003*	0.0002**	0.0002*	0	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)
N	75,360	36,932	75,360	36,932	33,368	12,878
Women						
Mean/proportion	0.35	0.29	0.21	0.17	34.22	33.18
Any MML	0.0017	0.0036	0.0159**	0.0201*	0.0087	0.0402
	(0.0071)	(0.0123)	(0.0052)	(0.0095)	(0.0195)	(0.0246)
Rel. yr.	0.0000	0.0000	0.0001*	0.0001	0.0002	0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Rel. yr.*post	0.0002**	0.0002	0.0001	0.0000	-0.0001	-0.0003*
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)
MM Access	0.0001	-0.0063	0.0128*	0.008	0.0141	0.0381
	(0.0069)	(0.0139)	(0.0055)	(0.0103)	(0.0204)	(0.0242)
Rel. yr.	0.0000	0.0000	0.0001	0.0001*	0.0002	0.0002
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Rel. yr.*post	0.0003**	0.0002**	0.0001*	0.0000	-0.0002	-0.0005*
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)
N	107,096	63,928	107,096	63,928	36,503	17,961

Notes: All models estimated with a linear probability model (binary outcome) or least squares (continuous outcome), and control for individual and state characteristics, state fixed effects, and interview wave fixed effects. Qualifying sample includes respondents that report current cancer treatment, current glaucoma, current arthritis, and lifetime severe pain. 'Rel. yr.' = relative year. 'Post' = post law period. Standard errors are clustered at the state level and are reported in parentheses. significant at 10%, ** significant at 5%, *** significant at 1%.

Table 7: Effect of state medical marijuana laws on older adult pain and work-limiting disability outcomes using an event study framework: HRS 1992-2012

Outcome:	Any pain		Pain limits activity		Health limits work	
Sample:	Full	Qualifying	Full	Qualifying	Full	Qualifying
Men						
Proportion	0.26	0.40	0.15	0.25	0.27	0.34
Any MML	-0.0043	-0.0356*	0.0017	-0.01	-0.0212*	-0.0278*
	(0.0100)	(0.0201)	(0.0060)	(0.0124)	(0.0098)	(0.0135)
Rel. yr.	0.0000	0.0001	-0.0001*	0.0001	-0.0001	0.0000
	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0001)
Rel. yr.*post	0.0001	0.0001	0.0000	0.0000	0.0001*	0.0002
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Access	-0.0033	-0.0332*	0.0007	-0.0111	-0.0264**	-0.0382**
	(0.0089)	(0.0146)	(0.0064)	(0.0119)	(0.0084)	(0.0123)
Rel. yr.	0.0000	0.0002*	0.0000	0.0001	-0.0001	0.0000
	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0001)
Rel. yr.*post	0.0000	0.0000	0.0000	-0.0001	0.0001**	0.0002*
	(0.0001)	(0.0002)	(0.0000)	(0.0001)	(0.0000)	(0.0001)
N	75,502	36,982	75,502	36,982	66,909	34,148
Women						
Proportion	0.34	0.46	0.23	0.32	0.30	0.40
Any MML	0.0146*	0.0133	0.0105	0.0040	0.0048	0.0051
	(0.0071)	(0.0092)	(0.0064)	(0.0100)	(0.0119)	(0.0163)
Rel. yr.	0.000	0.0001	0.000	0.0001	0.0001	0.0001
	(0.0000)	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0001)
Rel. yr.*post	-0.0002**	-0.0002**	-0.0002*	-0.0002	-0.0004**	-0.0005**
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)
Access	0.0178*	0.0194*	0.0127*	0.0103	0.0011	0.0001
	(0.0071)	(0.0115)	(0.0056)	(0.0114)	(0.0112)	(0.0170)
Rel. yr.	0	0.0001	0.0000	0.0001	0.0001	0.0001
	(0.0000)	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0001)
Rel. yr.*post	-0.0003**	-0.0003**	-0.0002**	-0.0002*	-0.0004**	-0.0004*
	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)
N	107,253	63,973	107,253	63,973	91,128	57,716

Notes: All models estimated with a linear probability model and control for individual and state characteristics, state fixed effects, and interview wave fixed effects. Qualifying sample includes respondents that report current cancer treatment, current glaucoma, current arthritis, and lifetime severe pain. 'Rel. yr.' = relative year. 'Post' = post law period. Standard errors are clustered at the state level and are reported in parentheses. significant at 10%, ** significant at 5%, *** significant at 1%.

Table 8: Effect of state medical marijuana laws on older adult depressive symptomatology outcomes using an event study framework: HRS 1992-2012

Outcome:	Very good health		Depressive symptoms		Depression	
Sample:	Full	Qualifying	Full	Qualifying	Full	Qualifying
Men						
Proportion/mean	0.42	0.33	1.32	1.55	0.18	0.22
Any MML	0.0212	0.0511**	-0.0666*	-0.1324**	-0.004	-0.0194
	(0.0126)	(0.0179)	(0.0352)	(0.0427)	(0.0069)	(0.0123)
Rel. yr.	0.0000	-0.0002	0.0006*	0.0013**	0.0002*	0.0002**
	(0.0001)	(0.0001)	(0.0002)	(0.0004)	(0.0001)	(0.0001)
Rel. yr.*post	-0.0003**	-0.0002*	0.0003	0.0004	0	0.0001
	(0.0001)	(0.0001)	(0.0003)	(0.0003)	(0.0001)	(0.0001)
Access	0.0237*	0.0452*	-0.0601	-0.1329**	-0.0018	-0.0178
	(0.0115)	(0.0197)	(0.0372)	(0.0401)	(0.0069)	(0.0118)
Rel. yr.	0.000	-0.0002	0.0006*	0.0013**	0.0002*	0.0003**
	(0.0001)	(0.0001)	(0.0002)	(0.0004)	(0.0001)	(0.0001)
Rel. yr.*post	-0.0002**	-0.0001	0.0002	0.0002	0.0000	0.0000
	(0.0001)	(0.0001)	(0.0003)	(0.0004)	(0.0001)	(0.0001)
N	75,521	36,996	75,507	36,987	75,507	36,987
Women						
Proportion/mean	0.41	0.32	1.70	1.96	0.26	0.30
Any MML	0.0133*	0.012	0.0583**	0.0518	0.0100*	0.0086
	(0.0071)	(0.0116)	(0.0208)	(0.0424)	(0.0051)	(0.0082)
Rel. yr.	0.0001	0.0000	0.0000	0.0007*	0	0.0001*
	(0.0000)	(0.0001)	(0.0002)	(0.0003)	(0.0000)	(0.0001)
Rel. yr.*post	-0.0002**	-0.0002*	-0.0003	-0.0006	-0.0001	-0.0001
	(0.0001)	(0.0001)	(0.0004)	(0.0005)	(0.0001)	(0.0001)
Access	0.0101	0.0074	0.0691**	0.0614	0.0140*	0.0155*
	(0.0071)	(0.0125)	(0.0228)	(0.0424)	(0.0059)	(0.0087)
Rel. yr.	0.0000	0.0000	0.0001	0.0007*	0.0000	0.0001
	(0.0000)	(0.0001)	(0.0002)	(0.0003)	(0.0000)	(0.0001)
Rel. yr.*post	-0.0001*	-0.0002*	-0.0006*	-0.0007*	-0.0001*	-0.0001
	(0.0001)	(0.0001)	(0.0002)	(0.0004)	(0.0001)	(0.0001)
N	107,262	63,983	107,284	64,004	107,284	64,004

Notes: All models estimated with a linear probability model (binary outcome) or least squares (continuous outcome), and control for individual and state characteristics, state fixed effects, and interview wave fixed effects. Qualifying sample includes respondents that report current cancer treatment, current glaucoma, current arthritis, and lifetime severe pain. 'Rel. yr.' = relative year. 'Post' = post law period. Standard errors are clustered at the state level and are reported in parentheses. significant at 10%, ** significant at 5%, *** significant at 1%.

Table 9: Effect of state medical marijuana laws on older adult labor supply outcomes using alternative law coding schemes: HRS 1992-2012

Outcome:	Employed		Employed full time		Hours(logged)	
Sample:	Full	Qualifying	Full	Qualifying	Full	Qualifying
Men						
Proportion/mean	0.45	0.36	0.32	0.23	39.41	36.94
Anderson et al	-0.011	-0.013	-0.002	0.002	0.037**	0.067**
	(0.008)	(0.011)	(0.009)	(0.011)	(0.017)	(0.032)
Wen et al	-0.012	-0.014	-0.001	0.003	0.041**	0.071**
	(0.008)	(0.011)	(0.009)	(0.011)	(0.017)	(0.032)
N	75,360	36,932	75,360	36,932	33,368	12,878
Women						
Mean/proportion	0.35	0.29	0.21	0.17	34.22	33.18
Anderson et al	0.001	0.001	0.014***	0.014*	0.028	0.047*
	(0.009)	(0.017)	(0.005)	(0.007)	(0.022)	(0.024)
Wen et al	0.001	0.003	0.014***	0.014**	0.027	0.043*
	(0.009)	(0.016)	(0.004)	(0.007)	(0.021)	(0.024)
N	107,096	63,928	107,096	63,928	36,503	17,961

Notes: All models estimated with a linear probability model (binary outcome) or least squares (continuous outcome), and control for individual and state characteristics, state fixed effects, state-specific linear time trends, and interview wave fixed effects. Qualifying sample includes respondents that report current cancer treatment, current glaucoma, current arthritis, and lifetime severe pain. Standard errors are clustered at the state level and are reported in parentheses. significant at 10%, ** significant at 5%, *** significant at 1%.

Table 10: Effect of state medical marijuana laws on older adult pain and work-limiting disability outcomes using alternative law coding schemes: HRS 1992-2012

Outcome:	Any pain		Pain limits activity		Health limits work	
Sample:	Full	Qualifying	Full	Qualifying	Full	Qualifying
Men						
Proportion	0.26	0.40	0.15	0.25	0.27	0.34
Anderson et al	-0.005	-0.036*	0.007	-0.002	-0.005	-0.007
	(0.011)	(0.021)	(0.007)	(0.012)	(0.009)	(0.012)
Wen et al	-0.006	-0.036*	0.006	-0.002	-0.005	-0.004
	(0.011)	(0.021)	(0.006)	(0.012)	(0.009)	(0.012)
N	75,502	36,982	75,502	36,982	66,909	34,148
Women						
Proportion	0.34	0.46	0.23	0.32	0.30	0.40
Anderson et al	0.005	-0.007	0	-0.013	0.002	-0.006
	(0.008)	(0.012)	(0.009)	(0.012)	(0.015)	(0.020)
Wen et al	0.004	-0.009	-0.002	-0.015	0.001	-0.007
	(0.008)	(0.012)	(0.009)	(0.012)	(0.015)	(0.020)
N	107,253	63,973	107,253	63,973	91,128	57,716

Notes: All models estimated with a linear probability model and control for individual and state characteristics, state fixed effects, state-specific linear time trends, and interview wave fixed effects. Qualifying sample includes respondents that report current cancer treatment, current glaucoma, current arthritis, and lifetime severe pain. Standard errors are clustered at the state level and are reported in parentheses. significant at 10%, ** significant at 5%, *** significant at 1%.

Table 11: Effect of state medical marijuana laws on older adult welling outcomes using alternative law coding schemes: HRS 1992-2012

Outcome:	Very good health		Depressive symptoms		Depression	
Sample:	Full	Qualifying	Full	Qualifying	Full	Qualifying
Men						
Proportion/mean	0.41	0.32	1.70	1.96	0.26	0.30
Anderson et al	0.006	0.024	-0.078**	-0.062	-0.016*	-0.017
	(0.015)	(0.022)	(0.035)	(0.052)	(0.008)	(0.014)
Wen et al	0.007	0.026	-0.086**	-0.072	-0.016*	-0.016
	(0.015)	(0.021)	(0.035)	(0.052)	(0.008)	(0.013)
N	75,521	36,996	75,507	36,987	75,507	36,987
Women						
Anderson et al	0.017**	0.015	0.068**	0.035	0.013*	0.006
	(0.008)	(0.009)	(0.034)	(0.059)	(0.007)	(0.013)
Wen et al	0.018**	0.016*	0.061*	0.016	0.01	0.001
	(0.007)	(0.009)	(0.035)	(0.061)	(0.008)	(0.015)
N	107,262	63,983	107,284	64,004	107,284	64,004

Notes: All models estimated with a linear probability model (binary outcome) or least squares (continuous outcome), and control for individual and state characteristics, state fixed effects, state-specific linear time trends, and interview wave fixed effects. Qualifying sample includes respondents that report current cancer treatment, current glaucoma, current arthritis, and lifetime severe pain. Standard errors are clustered at the state level and are reported in parentheses. significant at 10%, ** significant at 5%, *** significant at 1%.

Table 12: Average effects of placebo state medical marijuana laws among older men: HRS 1992-2012

MML:	Any Law		Legal Access	
Sample:	Full	Qualifying	Full	Qualifying
Employed	0.0049	0.0056	0.0065	0.0086
	(0.013)	(0.013)	(0.014)	(0.015)
Employed full time	0.0093	0.0077	0.0099	0.0094
	(0.012)	(0.015)	(0.014)	(0.016)
Hours (logged)	0.0143	0.0094	0.0122	0.0104
	(0.020)	(0.034)	(0.020)	(0.035)
Any pain	0.0021	0.0044	0.0039	0.0049
	(0.009)	(0.014)	(0.010)	(0.016)
Pain limits activity	0.0006	0.0025	0.0021	0.0034
	(0.009)	(0.014)	(0.010)	(0.016)
Health limits work	-0.0063	-0.0063	-0.0034	-0.0026
	(0.017)	(0.023)	(0.018)	(0.025)
Very good health	0.0042	0.0028	0.0022	0.0012
	(0.012)	(0.017)	(0.013)	(0.019)
Depressive symptoms	0.0788	0.0534	0.0781	0.045
	(0.043)	(0.063)	(0.051)	(0.066)
Depression	0.0027	0.0023	0.0027	0.0007
	(0.010)	(0.015)	(0.011)	(0.016)

Notes: Means and standard deviations from 100 replications of a Monte Carlo simulation randomly assigning state medical marijuana legislative histories. All models estimated with a linear probability model (binary outcome) or least squares (continuous outcome), and control for individual and state characteristics, state fixed effects, state-specific linear time trends, and interview wave fixed effects. Qualifying sample includes respondents that report current cancer treatment, current glaucoma, current arthritis, and lifetime severe pain. significant at 10%, ** significant at 5%, *** significant at 1%.

Table 13: Average effects of placebo state medical marijuana laws among older women: HRS 1992-2012

MML:	Any Law		Legal Access	
Sample:	Full	Qualifying	Full	Qualifying
Employed	0.0024	0.0023	0.0019	0.0024
	(0.010)	(0.011)	(0.011)	(0.012)
Employed full time	0.004	0.0043	0.0036	0.0043
	(0.010)	(0.009)	(0.011)	(0.009)
Hours (logged)	0.0059	0.0089	0.0066	0.0091
	(0.021)	(0.027)	(0.026)	(0.033)
Any pain	-0.0008	0.0002	0.0014	0.0017
	(0.011)	(0.013)	(0.011)	(0.014)
Pain limits activity	-0.003	-0.0019	-0.0014	-0.0019
	(0.010)	(0.013)	(0.009)	(0.012)
Health limits work	-0.0061	-0.0045	-0.0037	-0.0028
	(0.016)	(0.023)	(0.017)	(0.024)
Very good health	0.0053	0.0037	0.0049	0.0051
	(0.009)	(0.011)	(0.010)	(0.012)
Depressive symptoms	0.0505	0.0466	0.0379	0.0271
	(0.044)	(0.051)	(0.047)	(0.052)
Depression	0.0019	0.0043	-0.0013	-0.0003
	(0.010)	(0.012)	(0.011)	(0.013)

Notes: Means and standard deviations from 100 replications of a Monte Carlo simulation randomly assigning state medical marijuana legislative histories. All models estimated with a linear probability model (binary outcome) or least squares (continuous outcome), and control for individual and state characteristics, state fixed effects, state-specific linear time trends, and interview wave fixed effects. Qualifying sample includes respondents that report current cancer treatment, current glaucoma, current arthritis, and lifetime severe pain. significant at 10%, ** significant at 5%, *** significant at 1%.

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