NBER WORKING PAPER SERIES

THE EFFECT OF MEDICAL MARIJUANA LAWS ON THE HEALTH AND LABOR SUPPLY OF OLDER ADULTS: EVIDENCE FROM THE HEALTH AND RETIREMENT STUDY

Lauren Hersch Nicholas
Johanna Catherine Maclean

Working Paper 22688
http://www.nber.org/papers/w22688

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
September 2016, Revised March 2018

Previously circulated as "The Impact of Medical Marijuana Laws on the Labor Supply and Health of Older Adults: Evidence from the Health and Retirement Study." This work was supported by the National Institute on Aging (K01AG041763). We are grateful for support from Hopkins Population Center (NICHD R24HD042854) for use of restricted data sets in their cold room. Findings do not represent the views of the sponsor. We thank Stefanie Deluca, Brady Horn, Sean Lyons, Ian McCarthy, Dan Rees, Douglas Webber, and seminar participants at McMaster University, Cornell University, the 2016 Midwestern Health Economics Conference, the 2016 American Society of Health Economists Biennial Conference, and the 2016 Association for Public Policy and Management for helpful comments. We thank Kevin Zhang for excellent research assistance. All errors are our own. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

At least one co-author has disclosed a financial relationship of potential relevance for this research. Further information is available online at http://www.nber.org/papers/w22688.ack

The effect of medical marijuana laws on the health and labor supply of older adults: Evidence from the Health and Retirement Study
Lauren Hersch Nicholas and Johanna Catherine Maclean
NBER Working Paper No. 22688
September 2016, Revised March 2018
JEL No. I10,I18,J20

ABSTRACT

Older adults have the highest rates of many health conditions for which medical marijuana may be effective in moderating symptoms and are at elevated risk of reducing labor supply due to poor health. Surprisingly little is known about how this group responds to medical marijuana laws. We provide the first estimates of the effects of state medical marijuana laws on the health and labor supply of adults age 51 and older, focusing on those with medical conditions that may respond to medical marijuana. We use longitudinal data from the Health and Retirement Study to study these questions using differences-in-differences regression models. Three principle findings emerge from our analysis. First, we document that medical marijuana law passage leads to reductions in chronic pain and improvements in self-assessed health among older adults. Second, we show that passage of a state medical marijuana law leads to increases in older adult labor supply, with effects concentrated on the intensive margin. Third, effects are largest among older adults with a health condition that would qualify for legal medical marijuana use under current state laws. Findings highlight the role of health policy in supporting work among older adults.

Lauren Hersch Nicholas
Johns Hopkins School of Public Health
624 N Broadway, Room 450
Baltimore, MD 21205
USA
lauren.nicholas@jhu.edu

Johanna Catherine Maclean
Department of Economics
Temple University
Ritter Annex 869
Philadelphia, PA 19122
and NBER
catherine.maclean@temple.edu

1 Introduction

Legalization of marijuana, for medicinal or recreational use, is highly controversial in the United States (Anderson & Rees, 2014). On the one hand, critics argue that any legalization of marijuana will increase marijuana addiction, misuse of related substances, crime and violence, traffic accidents, and healthcare costs. Advocates, on the other hand, highlight the potential health benefits of medical marijuana, in particular in terms of managing symptom burden. Public support for legalization of medical marijuana has surged with well over three quarters of U.S. residents supporting some form of legalization of this product for medical purposes[1] and, as of 2017, 29 U.S states and the District of Columbia (DC) have passed laws legalizing medical use of marijuana ('MMLs'). Given this tension, policymakers must have a solid evidence base on both the potential costs and benefits of expanded access as they determine how best to regulate marijuana for medical use.

The available clinical trial evidence suggests that medical marijuana is effective in treating symptoms associated with several health conditions including chronic pain, nausea and vomiting, and sleep disorders (Hill, 2015; Goldenberg, Reid, IsHak, & Danovitch, 2017; McCormick et al., 2017). Older adults adults experience higher prevalence of many of the health conditions with symptoms that can be effectively treated with medical marijuana (Morgan, 2003; Unruh et al., 2008; Nahin, 2015) and are more likely to use prescription medications to treat symptom burden (National Center for Health Statistics, 2017). In 2015, 29 percent of the overall adult population reported lower back pain, 35 percent of adults age 45 years and older reported this condition (Barbour, 2017). In addition, while 22.7 percent of all adults suffer from arthritis, the prevalence of this condition is 29.3 percent among adults 45 to 64 years and 49.6 percent among adults 65 years and older (Barbour, 2017). Despite high rates of conditions that might respond to medical marijuana, older adults are understud-

[1]See, for example, https://www.washingtontimes.com/news/2017/apr/18/83-percent-americans-favor-legalizing-medical-weed/ (accessed December 15th, 2017).

ied in medical marijuana trials, raising questions of whether the available findings can be extrapolated to the older adult population. A recent National Academies of Science report emphasized the need for observational and experimental research to inform clinical decision-making related to medical marijuana use among understudied populations including older adults (McCormick et al., 2017).

Given typical age patterns of disease, the health benefits of MML passage may be concentrated among older adults if medical marijuana access leads to improved symptom control. If access to marijuana for medical purposes through passage of an MML reduces symptoms associated with work-impeding health conditions such as arthritis and chronic pain, this access could lead to enhanced participation in the labor market within the fastest growing segment of the population. Extending the work lives of older Americans can facilitate greater retirement savings and potentially delay Social Security benefit claiming.

To date, studies of MML health and labor effects have focused on youth and working age/pre-retirement age populations and, in particular, have not considered outcomes for those over age 65. However, understanding the effects for older adults is important given that poor health is frequently cited as a reason for older adult labor force exit (Dwyer & Mitchell, 1999; McGarry, 2004; Case & Deaton, 2005; Datta Gupta & Larsen, 2010; Garthwaite, 2012; Kaila-Kangas et al., 2014). Rapid growth in the size of the aging population, predicted to reach 20.9 percent of the population by 2050, suggests a particular need to understand the effects of MMLs for this demographic (Ortman, Velkoff, Hogan, et al., 2014).

In this paper, we help address this critical gap in the literature by testing the effect of medical marijuana laws on several health outcomes (chronic pain, work-limiting health conditions, self-assessed health, and depression), and measures of labor supply along both the extensive and intensive margins. We study the extent that our results are concentrated among patients with one or more health conditions that would typically qualify a patient for medical marijuana use, isolating individuals who plausibly use marijuana gained through

MMLs for primarily *medical* purposes or obtain an improved treatment regime after MML passage prompts additional visits to a healthcare provider in response to new treatment availability (Sabia, Swigert, & Young, 2017; Bradford & Bradford, 2016). We estimate differences-in-differences regression models using panel data from the 1992 - 2012 waves of the Health and Retirement Study (HRS) that control for a wide range of state-level characteristics that may predict our outcomes and the propensity of a state to pass an MML, and state-specific time trends. We are able to leverage within-person variation in MML exposure in addition to the within-state variation typically studied in this literature.

We have three principle findings in our study. (i) Our analysis of health outcomes suggests that passage of an MML leads to reductions in chronic pain and improved self-assessed health among older adults. For example, post-MML the probability of assessing one's health as very good or excellent increases by 3 percent. (ii) Passage of an MML leads to an increase in the probability of full-time employment by 3 percent and weekly hours worked (conditional on working) by 3 percent. Because we do not find evidence that passage of an MML changes the probability of any work, we interpret our findings to imply that passage of an MML allows currently working older adults to increase their participation in the labor market rather than motivating a return to paid employment for those older adults who have previously left the labor market due to health conditions. We hypothesize that the observed health improvements may drive the labor supply effects. (iii) Overall, we find that MML effects, both for health and labor supply, are concentrated among older adults likely to use marijuana for medical purposes based on their health histories, suggesting that any adverse health and labor supply reductions attributable to medical marijuana use in this population are more than offset by improved symptom management.

Our results have immediate implications for both state and federal policymakers considering the fate of medical marijuana law passage and enforcement. More generally, they contribute to a growing literature highlighting the role of health policy and access to medical care in older adult labor supply.

2 Background and related literature

2.1 Marijuana regulation in the U.S.

Marijuana is a controlled substance under U.S. federal law, thus its possession and distribution are illegal. The Controlled Substances Act of 1970 classifies marijuana as a Schedule I drug; the strictest regulation category used for 'Drugs with no currently accepted medical use and a high potential for abuse.' Schedule I drugs include ecstasy and heroin while cocaine is Schedule II and Valium is Schedule IV drug. Schedule I status severely limits researchers' capacity to utilize marijuana for clinical trials, resulting in a very small number of studies restricted to low potency tetrahydrocannabinol, which is markedly weaker than the medical marijuana available to patients through home cultivation or dispensaries (Williams, Olfson, Kim, Martins, & Kleber, 2016; Stith & Vigil, 2016). Existing clinical evidence is likely insufficient to inform medical marijuana policies and treatment decisions for many patients, especially older adults.

As of 2017, 29 states and DC have implemented an MML. To legally access marijuana, patients must receive a recommendation from a medical doctor indicating their need for this medication and provide evidence of legal residence within the state. State laws differ in terms of the conditions that qualify patients for medical marijuana. Common qualifying conditions are cachexia, cancer, digestive conditions, epilepsy, HIV/AIDS, glaucoma, muscle spasms, multiple sclerosis, and pain (Bradford & Bradford, 2017; Sabia et al., 2017). Table 1 Column 1 outlines the MML effective date for each state that has passed an MML through 2013 (Sabia & Nguyen, 2016); the last year of our study period.[2] The first state to pass an

[2]We list law changes that occurred after 2013 in table notes for completeness; we do not incorporate these laws changes in our analyses.

MML was California in 1996. This law removed criminal penalties for marijuana possession, cultivation, and use for a set of health conditions. Other early adopting states include Oregon (1998), Washington (1999), Alaska (1999), and Maine (1999). Florida and West Virginia are the most recent states to pass an MML (2017), after our study period.

2.2 Clinical evidence and medical marijuana use among older adults

Although clinical evidence is limited, randomized control trials have found that medical marijuana is an effective treatment for symptoms associated with pain, anxiety, depression, nausea, psychosis, sleep disorders, and spasticity (Hill, 2015; Whiting et al., 2015; Goldenberg et al., 2017; McCormick et al., 2017). Pain is the most common condition reported as the reason for medical marijuana use (Nunberg, Kilmer, Pacula, & Burgdorf, 2011; Reiman, Welty, & Solomon, 2017). Reiman et al. (2017) document that 63 percent of 2,897 medical marijuana patients reported using the drug to treat chronic pain symptoms. The vast majority of patients in their study reported that medical marijuana addressed chronic pain symptoms as well as prescription medications but without side effects, and use of medical marijuana reduced prescription opioid use. Enrolless in the New Mexico Medical Cannabis Program were more likely to cease using prescription opioids and reported less pain than non-enrollee controls (Vigil, Stith, Adams, & Reeve, 2017).

Although states do not release individual-level data, our analysis of available data suggests that 20 percent to 60 percent of all registered medical marijuana users in U.S. states reporting demographic information are over age 50.[3] Recent studies of medical users registering in their state (Anderson, Hansen, & Rees, 2013; Yi, 2015; Fairman, 2016; Kaskie, Ayyagari, Milavetz, Shane, & Arora, 2017) and convenience samples of medical marijuana patients (Nunberg et al., 2011; Ilgen et al., 2013) also suggest that older adults represent a

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

substantial share of medical marijuana patients.

Data from the National Survey of Drug Use and Health (NSDUH) collected by the federal government to monitor substance use indicate that 5.8 percent of adults ages 45 to 54, 6.1 percent of adults ages 55 to 64 years, and 1.3 percent of adults age 65 years and older reported any form of marijuana use in the past month in 2014, reflecting a 48 percent, 455 percent, and 333 percent increase since 2002 (Azofeifa, 2016). Rates of use in the past year are higher, but show similar increases, over the period 2002 to 2014: 2.9 percent to 9.0 percent among adults 50 to 64 years and 0.2 percent to 2.1 percent among adults 65 years and older (Stoner, 2016). Older adult medical marijuana use is increasingly noticed by marketers and popular press.[4]

2.3 Economic analyses of state medical marijuana laws

A growing economic literature explores the effect of MMLs on a range of outcomes. We provide a brief review of the studies most relevant to our work on older adults, who are currently understudied in the medical marijuana literature (McCormick et al., 2017). Using NSDUH, Wen, Hockenberry, and Cummings (2015) show that among adults 21 years and older passage of an MML leads to a 14 percent (15 percent) increase in prior month marijuana consumption (near daily use). The authors note that the estimated increases likely reflect some spillover effects from medical to recreational use (Wen et al., 2015). Choi (2014), also using NSDUH, finds a similar relationship between MMLs and marijuana use among those 21 years and older. Chu shows that passage of an MML leads to a 10 percent to 20 percent increase in arrests for marijuana-related possession and substance use disorder (SUD) admissions within the general population (Chu, 2014, 2015). Effects of MMLs on marijuana-

[4] https://mjbizmagazine.com/serving-the-senior-demographic/; https://skillednursingnews.com/2017/11/former-long-term-care-exec-bets-cannabis-demand-canada/; https://www.cbsnews.com/news/seniors-and-marijuana/; http://ualrpublicradio.org/post/marijuana-expo-brings-together-seniors-veterans-scientists-sons-arkansas; and http://www.cpr.org/news/story/more-aging-coloradans-are-turning-to-medical-marijuana-but-data-is-sparse.

related arrests among adults aged 45 years and above range from 1.1 percent to 11.9 percent and are often statistically indistinguishable from zero. Anderson and Rees (2014) show that passage of an MML increases the amount of marijuana plants eradicated under the Drug Enforcement Agency's Domestic Cannabis Eradication/Suppression Program.

There is also evidence that MML passage leads to changes in health outcomes. Sabia et al. (2017) find that passage of an MML leads to a 2 percent to 6 percent decline in the probability of obesity. The authors show that, following passage of an MML, days in poor physical and mental health decline while physical activity increases although the effects are sensitive to the inclusion of state trends. Findings for older adults are broadly comparable to the full sample, but are generally imprecise in models that include state trends. Anderson, Rees, and Sabia (2014) document that MML passage leads to a decline in completed suicides among men aged 20 to 29 and 30 to 39, but not other demographic groups. Abouk and Adams (2018) show that, post-MML, cardiovascular deaths increase by 2.3 percent among men and 1.2 percent among women. Effect sizes are even larger among older adults (defined as adults 65 years and older). Finally, Ullman (2016) shows that passage of an MML reduces work absences by 8.4 percent to 8.7 percent among workers 15 to 65 years of age in the Current Population Survey (CPS), although MML effects are somewhat sensitive to alternative specifications for workers ages 50 to 65.

Evidence suggests that patients are using marijuana medically to treat symptoms associated with a range of health conditions following passage of an MML. While currently available survey data does not, to the best of our knowledge, allow researchers to separately examine medical and recreational marijuana use, insight can be gleaned from medication use patterns. Two recent studies take this indirect approach. Bradford and Bradford (2016) analyze prescription drug use patterns among Medicare patients, documenting declines in filled prescriptions for therapeutic substitutes for a number of conditions including pain, anxiety, depression, nausea, psychosis, seizures, and sleep disorders among patients in states with legal access to medical marijuana. The magnitude of the prescription declines is non-trivial; 5.7 percent for pain medications, 5.0 percent for anxiety medications, 5.4 percent for nausea medications, and 4.5 percent for psychosis medications. In a follow up study, Bradford and Bradford (2017) document similar drops in use for therapeutic substitutes following passage of MML passage within the Medicaid population.

Three studies suggest that passage of an MML leads to a reduction in opioid use, opioids are used to treat chronic pain and thus are plausibly therapeutic substitutes for marijuana. Bachhuber, Saloner, Cunningham, and Barry (2014) use mortality data to show that passage of an MML reduces the opioid overdose rate by 24.8 percent. Similarly, Powell, Pacula, and Jacobson (2015) document that legal access to medical marijuana reduces admissions to SUD treatment for opioid use and overdose deaths attributable to opioids. Finally, Ozluk (2017) finds lower prescription opioid spending following MML passage. Collectively, these findings suggest that (i) some individuals, in particular older individuals, are using marijauna medically post-MML and (ii) passage of an MML leads to substitution towards medical marijuana and away from more conventional treatment options.

To the best of our knowledge, only one study explores the effect of MML implementation on labor market outcomes. Sabia and Nguyen (2016) leverage data from the CPS among adults ages 18 to 64. The authors document that passage of an MML decreases wages by 2.8 percent among males ages 20 to 29 years, but passage is largely unrelated to wages among other groups and unrelated to measures of considered labor supply (any work and conditional hours worked). The authors do not find evidence that passage of an MML affects these measures among individuals ages 50 to 64 years.

Our study makes several contributions that extend the medical marijuana literature. We focus on older adults, 51 years and above, the population that is most likely to suffer from the health conditions for which marijuana may be effective in treating symptoms. Because we have detailed health history information, we are able to isolate samples of older adults who suffer from the health conditions with symptoms treatable with marijuana. We can carefully consider a range of clinically relevant mechanisms including chronic pain and mental health problems. Finally, we are able to include person fixed effects as an alternative control for omitted variable bias. Our study of older adults fills a knowledge gap for policymakers, healthcare providers, and patients.

3 Mechanisms

3.1 Health

Medical marijuana offers a new treatment option for patients suffering from a number of health conditions. While marijuana cannot cure underlying conditions, medicinal use may reduce symptoms. As noted in the previous section, there is evidence that patients may substitute medical marijuana for other conventional treatments (Bachhuber et al., 2014; Powell et al., 2015; Bradford & Bradford, 2016, 2017; Ozluk, 2017). These substitution patterns are particularly relevant for older adults, as this population is much more likely to use prescription medications to treat symptoms associated with chronic health conditions than younger populations (National Center for Health Statistics, 2017). However, the extent to which such medication substitution affects patient health outcomes is *ex ante* ambiguous. A complicating factor in predicting the health effects of MML passage is that medication – be it marijuana or any other medication – effectiveness varies across patients (Porter, 2010).

Patient health and symptom burden should improve if medical marijuana is more effective than a patient's previous treatment program (which may include no treatment) and/or has a less aggressive side effect profile, and worsen if marijuana is a less effective treatment. If MML passage primarily leads to increases in recreational use (Wen et al., 2015), then we expect no improvement, and perhaps a decline, in health for the new recreational users.

Even if marijuana is more effective than a patient's previous treatment, 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. Patients who opt to use medical marijuana (which is generally obtained outside the conventional healthcare system) may lose access to valuable secondary treatments. Moreover, regular interactions with healthcare providers, who may be better able to assess changes in health than patients themselves, may also decline as patients withdraw from conventional healthcare. Finally, if patients co-use marijuana with other medications (Ozluk, 2017), drug interactions could harm health (U.S. National Library of Medicine, 2017).

3.2 Labor supply

Older adults may increase labor supply following medical marijuana access if the new treatment more effectively alleviates symptoms or provides similar efficacy with fewer side effects. Standard economic models of labor supply highlight the importance of health (Currie & Madrian, 1999). Moreover, there is substantial empirical evidence documenting that poor health prompts older adults to reduce labor supply (Dwyer & Mitchell, 1999; McGarry, 2004; Case & Deaton, 2005; Datta Gupta & Larsen, 2010; Garthwaite, 2012). Conventional prescription medications for many medical marijuana-qualifying health conditions often present patients with non-trivial side effects that can impede work. Anti-anxiety medications side effects include addiction, confusion, headaches, irritability, trouble concentrating, and worsening of depressive symptoms (Longo & Johnson, 2000; Stewart, Ricci, Chee, Morganstein, & Lipton, 2003). Patients using opioid pain relievers often suffer from cardiovascular problems, central nervous system complications, constipation, impaired judgment, itching, nausea or vomiting, and respiratory problems (Swegle & Logemann, 2006; Chau, Walker, Pai, & Cho, 2008).

However, marijuana is a drug that can have intoxicating effects on the user and that has serious side effects including addiction, amotivational syndrome, anxiety, depression, inattention, increased heart rate, lethargy, memory problems, and respiratory problems (Van Ours & Williams, 2011, 2012; Hill, 2015; Volkow et al., 2016). These attributes can harm health and impede labor supply, even among adults who use marijuana for medical purposes. If older adults increase recreational marijuana use in response to easier or access or perceived safety following MML passage, we expect labor supply to remain unchanged or decline. Labor supply could also decline if use of medical marijuana improves health and the increased value of leisure time decreases the desire to work and, for example, prompts older adults to enter retirement.

4 Data, variables, and methods

Given the ambiguous predicted implications of MMLs for older adult health and labor supply, we use quasi-experimental methods to evaluate the empirical question.

4.1 Health and Retirement Study

We draw data collected between 1992 through early 2013 from the Health and Retirement Study (HRS) 1992 to 2012 interview waves. We truncate the sample in 2012-2013 to avoid confounding from passage of state recreational marijuana laws that were passed post-2012. The HRS is a nationally representative panel survey of Americans over 50 and their spouses administered biennially since 1992. The survey is designed to track health and labor market outcomes among older adults, and is therefore well-suited to our study objectives. Through the 2012 wave, the HRS includes 247,233 interviews with 38,008 older persons. After excluding respondents based on residence outside the U.S., missing state, or proxy response, our analysis sample includes 183,032 respondent/year observations.

A limitation of the HRS, similar to all major surveys containing large samples of older adults and measures of health and labor supply of which we are aware, is that it does not collect information on marijuana use, either for medical or recreational purposes. Therefore, our results have a an intent-to-treat (ITT) interpretation and reflect the numerous secondary pathways through which MMLs can affect health and labor supply in addition to medical use. We discuss the plausibility of our effect sizes later in the manuscript.

4.2 State-level medical marijuana laws

Our source for MML effective dates is Sabia and Nguyen (2016). We match the MML effective dates to the HRS interview on month and year. We construct an indicator variable coded one if a state has an MML in place and zero otherwise. Table 1 Column 1 reports each state that has passed an MML by the end of our study period (2013) and the effective dates.

4.3 Outcome variables

We examine four health outcomes which have some clinical support for the use of medical marijuana as a treatment option, are measured in the HRS, and have a plausible link to labor supply. Specifically, (i) any chronic pain, (ii) depressive symptoms (measured by an abbreviated eight question version of the Center for Epidemiologic Studies - Depression Scale [CES-D] used in the HRS), (iii) health limiting the ability to work, and (iv) self-assessed health (we construct an indicator for reporting very good or excellent health).

These HRS survey items mirror questions that healthcare providers would use to diagnose and treat conditions such as pain and depression; conditions that are are subjective by nature (National Institutes of Health, 2011). For example, the National Institutes of Health advises that 'Pain is a very personal and subjective experience. There is no test that can measure and locate pain with precision' (U.S. National Library of Medicine, 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 (Benjamins, Hummer, Eberstein, & Nam, 2004; Nielsen, 2016). This measure is believed to capture aspects of mental and physical health (Apouey & Clark, 2015). The CES-D measures of depressive symptomatology have been validated in numerous settings (Radloff, 1977; Turvey, Wallace, & Herzog, 1999). These measures are frequently used in the economics and policy analysis literatures (Tian, Robinson, & Sturm, 2005; Kapteyn, Smith, & Van Soest, 2008; McInerney, Mellor, & Nicholas, 2013; Horn, Maclean, & Strain, 2017).

We examine three measures of labor supply: (i) any work in the past year (0/1), (ii) whether currently working full-time (0/1), working 35 or more hours per week for at least 36 weeks of the year), and (iii) usual hours worked per week among those who report any work. We take the logarithm of usual hours worked, thus coefficient estimates have the interpretation of an approximation of the percent change.

4.4 Control variables

We control for respondent age, race, Hispanic ethnicity, and education in all regressions.[5] We account for several time-varying state characteristics that may be correlated with both the passage of an MML and our outcomes to minimize bias due to omitted policy variables. To this end, we include an indicator for whether a state has decriminalized marijuana (Pacula,

[5]To preserve sample size we assign an indicator variable for observations with missing personal characteristics and assign that observation the mean (modal) value for continuous (binary) variables. Results are not appreciably different if we instead exclude observations with missing personal characteristics from the analysis sample or exclude the personal characteristic variables from the regression models.

Chriqui, & King, 2003), the beer tax per gallon from the Brewers' Almanac, the unemployment rate and average wage among adults 51 years and older from the Current Population Survey Outgoing Rotation Group (CPS-ORG). We also control for a set of labor market and social policies: effective minimum wage (i.e., the higher value of the state or federal wage), state Earned Income Tax (EITC) as a proportion of the Federal EITC, and maximum food stamp benefit for a family of four from the University of Kentucky Poverty Research Center. Finally, we control for the governor's (DC mayor's) political affiliation. We inflate all nominal values to 2012 terms using the Consumer Price Index.

4.5 Empirical model

We estimate the following differences-in-differences regression model:

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

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. X_{ist} is a vector of individual characteristics and τ_{st} is a vector of time-varying state characteristics. δ_s is a vector of state fixed effects which capture unobservable (to the econometrician) and fixed factors for each state, and γ_t is a vector of interview wave dummy variables which capture factors that affect the national as a whole. Ω_{st} is a vector of state-specific linear wave trends. These trends (linearly) capture unobservable, time-varying factors. ϵ_{ist} is the error term. We utilize linear probability models (LPMs) for binary outcomes and least squares for continuous outcomes. We cluster the standard errors around the state (Bertrand, Duflo, & Mullainathan, 2004). All results are unweighted. In a complimentary set of regressions, we replace state fixed effects with person fixed effects. Thus, we leverage within-person variation in exposure to MMLs and can, arguably, better mitigate bias from omitted, but time-invariant, respondent-level variables.

Although the HRS does not include information on medical marijuana use, the survey collects information about many of the underlying symptoms and health conditions that would qualify for medical marijuana within states that have passed an MML. We construct an indicator of whether a respondent appears to qualify for medical marijuana (the 'qualifying sample') if they report (i) current cancer treatment, (ii) current glaucoma, (iii) current arthritis, and / or (iv) severe pain in the current or any previous wave. 101,112 observations (or 55 percent of the full sample) meet this diagnosis. This is a conservative approach as it fails to identify those respondents with rare diagnoses such as multiple sclerosis, HIV/AIDS, and epilepsy, which are not measured in the HRS. We estimate all specifications of Equation 1 in the full sample and the qualifying sample. We expect that the relationships between MMLs and our outcome variables will be stronger in the qualifying sample than the full sample if MMLs increases access to medical marijuana among patients who benefit from its clinical use. To the best of our knowledge, the HRS is the only large scale survey of older adults that includes sufficient information to identify the population most likely to benefit from access to medical marijuana, and assess whether health and labor supply change in response to this access.

5 Results

5.1 Summary statistics

Table 2 reports summary statistics. In the full sample, 31 percent report experiencing pain, 29 percent report that health limits work ability, and 41 percent report their health as excellent or very good, and the mean number of depressive symptoms is 1.6 (out of a maximum of 8 symptoms). The qualifying sample, as expected, appears to have worse health than the full sample: 43 percent reports experiencing pain, 39 percent reports that health limits the ability to work, 32 percent reports very good or excellent health, and the mean number of depressive symptoms is 1.8. Turning to labor supply, in the full (qualifying) sample 39 percent (31 percent) reports working and 26 percent (19 percent) reports working full time, while the mean hours worked per week conditional on any work is 36.7 (34.8). 13 percent of the full sample and 15 percent of the qualifying sample reside in a state with an MML. The individual characteristics are comparable to an older sample and the state-level characteristics reflect the national as a whole.

5.2 Regression analysis of health outcomes

We first explore the effect of MML passage on older adult health. Results are reported in Table 3. Overall, we find that the health effects of MML passage are concentrated in pain and self-assessed health, we find no statistically significant evidence that MMLs are linked with either the probability of reporting that health limits the ability to work or depressive symptomology. We find that the health effects are more substantial in the qualifying sample than in the full sample. We interpret the more substantial (in terms of magnitude) effects in the qualifying sample to imply that marijuana obtained following an MML is used medically by a non-trivial share of respondents in this sample. More specifically, passage of an MML leads to a 0.2 percentage point (0.6 percent) reduction in chronic pain and a 1.4 percentage point (3.4 percent) increase in the probability of reporting very good or excellent self-assessed health; although the MML estimate in the pain regression is imprecise. Within the qualifying sample we find that passage of an MML leads to a statistically significant 2.2 percentage point (5.1 percent) reduction in reporting pain and a 2.5 percentage point (7.8 percent) increase in the probability of reporting very good or excellent health.

Based on age alone, the Azofeifa (2016) results suggest that 3.6 percent of our full sample and 3.3 percent of the qualifying sample had marijuana use in the past month. Our point estimates are consistent with a portion of these users receiving therapeutic benefit. For example, the pain results translate to one-sixth of all-cause marijuana users in the age group experiencing a reduction in pain based on the full sample and one-third based on the qualifying sample results.

5.3 Regression analysis of labor supply outcomes

Table 4 reports results on the effect of MML passage on older adult labor supply. We find no statistically significant evidence that MML passage leads to changes on the extensive margin of labor supply: the coefficient estimates, in both the full sample and the qualifying sample, in the any employment regressions are small in magnitude and imprecise. We interpret this finding to suggest that MML passage does not draw older workers into the labor market (or, perhaps more accurately, allow older workers to re-enter the labor market). We next consider the effect of MML passage on the intensive margin of labor supply: full time work propensity and conditional hours worked per week. We observe that passage of an MML leads to increases in labor supply along both of these measures. More specifically, passage of a MML leads to a 0.8 percentage point (3.1 percent) increase in the probability of fulltime work and a 3.3 percent increase in hours worked per week in the full sample.[6]

The magnitude of the MML effects are more substantial within the qualifying sample: passage of an MML leads to a 1.1 percentage point (5.8 percent) increase in the probability of working fulltime and a 6 percent increase in weekly hours worked (conditional on any work). The combination of our health and labor supply effects suggest that, on average, improved capacity to work dominates any work-impeding effects of marijuana use (recreational or medical). In particular, we hypothesize that reductions in symptoms associated with chronic health conditions (e.g., pain) and overall well-being, as measured by self-assessed health,

[6] In line with the null findings for any employment, including those respondents who do not report any work leads to a small positive, but imprecise, coefficient estimate. We interpret these null findings generated in the unconditional sample as further evidence that labor supply effects are driven by changes on the intensive margin. Moreover, because we do not observe MML effects on the extensive margin, we believe that our conditional hours worked findings are not likely driven by conditional-on-positive bias (Angrist & Pischke, 2009).

allow older adult workers to increase the amount of time they allocate to paid employment post-MML.

5.4 Person fixed effects

An advantage of the HRS is that the survey is longitudinal and thus we can include person fixed effects as an alternative control for omitted variables. Tables 5 (health outcomes) and 6 report these results. Findings are broadly robust to including person fixed effects; we continue to find improvements in pain, self-rated health, and hours worked in the qualifying sample. Although the beta coefficient estimates decline and standard error estimates increase in some specifications, the direction of the relationship is stable across this alternative, but more demanding, specification and 95 percent confidence intervals for estimates generated in the baseline and person fixed effect models generally overlap.

6 Robustness checks and Threats to Identification

6.1 Parallel trends

The principle assumption underlying DD models is that outcomes in the treatment (ever-MML) states and comparison states would have trended similarly had the treatment group not been treated (i.e., the 'parallel trends' assumption). This assumption, while necessary for DD models to recover causal effects, is inherently untestable as the treatment group was in fact treated and therefore the counterfactual is not observed. To verify that states had similar trends in health and labor supply outcomes prior to law passage, we use pre-period data to estimate regression models replacing the MML indicator with an interaction between the treatment group status and a linear time trend:

$$Y_{ist} = \beta_0 + \beta_1(Treat_s * Trend_{sr}) + \beta_2 Trend_{sr} + X_{ist}^{'}\beta_3 + \tau_{st}^{'}\beta_4 + \delta_s + \gamma_t + \mu_{ist} \qquad (2)$$

$Treat_s$ is an indicator variable for ever-MML and $Trend_{sr}$ is a linear time trend centered around the month and year of law passage (r). We randomly assign an MML passage date for control states and center the data around this 'false' effective date in a comparable manner. We do not include state-specific linear interview wave trends in Equation 2. Such trends may absorb differences in trends for MML versus non-MML states which could lead us to falsely conclude that these two groups of states moved in parallel pre-MML (Wolfers, 2006). We view a model without state trends as a more conservative test of parallel trends than a model with trends. However, results are not appreciably different than those reported when we do include state trends.

Results of the parallel trends tests are reported in Appendix Tables A1 (health) and A2 (labor supply). While we do observe that some of the estimated β_1 coefficients are statistically different from zero, we argue that the parallel trends test results do not invalidate the ability of our data to recover causal estimates. First, in the majority of regressions (12/16), the coefficient estimate of β_1 is not statistically different from zero. Second, in two of the four regressions in which the coefficient estimate of β_1 is statistically different from zero (probability of reporting pain and hours worked per week in the qualifying sample), the sign works *against* our ability to detect MML effects (Simon, Soni, & Cawley, 2016). For example, post-MML, the probability of reporting pain within the qualifying sample declines, but the coefficient estimate for β_1 in Equation 2 is positive, suggesting that chronic pain was increasing in treatment states relative to comparison states in the pre-MML period. Combining these two estimates suggests that we may understate the effect of MML passage on chronic pain and conditional hours worked in Equation 1, at least within the qualifying sample. While the estimates for β_1 in both of the depressive symptoms regressions are precisely estimated and positive in sign which may suggest that MML-passing states may have been experiencing worsening mental health conditions prior to the law passage, but we recovered no evidence that MML passage influenced this outcome in Equation 1. Thus, we interpret relationships between MML passage and depression among older adults with caution and encourage readers to do the same.

6.2 Event study

A concern with analyses of state policies is that they are not randomly assigned. Instead, state legislatures are prompted to implement policies based on population-level changes. In our context, MMLs may be passed due to changes in health conditions within the state. In this scenario, outcomes may induce changes in policies (MMLs) rather than policies inducing changes in outcomes. Such a phenomena would lead to policy endogeneity or reverse causality at the state-level. A standard approach to examine the presence of policy endogeneity is to estimate an event study (Autor, 2003; Lovenheim, 2009).

First, we center the data around the law effective date for each state that passed an MML during our study period. Next, we construct leads and lags around the effective date. Specifically, we include a series of two-year leads and lags in the regression from -10 and -9 years to + 7 and +8 years pre- and post-MML. We impose endpoint restrictions following Kline (2011): we assume that MML effects are not observable more than 10 years pre-passage and dissipate after 8 years. We code states that do not pass an MML by 2013 as zero for all lead and lag variables (Lovenheim, 2009). We exclude state-specific wave trends following Wolfers (2006) who argues that including time trends in models that allow for dynamics (as event studies do) complicates the interpretation of coefficient estimates. Statistically significant estimates of the leads suggest that policy endogeneity is present in our data. However, our ability to 'control' for such potential endogeneity can allow us to recover causal estimates of policy lags, which are the objects of primary interest in our study. Moreover, examination of the coefficient estimates on the lags allows study of the dynamics in MML effects while Equation 1 forces a constant treatment effect in the post-MML period.

Results generated in event studies are reported in Figures 1 and 3 for the full sample and 2 and 4 for the qualifying sample. 95 percent confidence intervals that account for within-state clustering (Bertrand et al., 2004) are reported with vertical lines. Overall, our event studies do suggest some policy endogeneity: health limits work was increasing in the full sample prior to MML adoption and hours worked were declining in the qualifying sample relative to baseline.

6.3 Endogeneity of the qualifying sample and migration

Passage of an MML may alter the number of HRS respondents reporting qualifying conditions, causing us to our analysis sample on an endogenous variable. This can lead to conditional-on-positive bias in regression coefficients, a common concern in policy analysis (Angrist & Pischke, 2009). However, the conditions that we use to construct the eligible sample are not likely 'cured' by the use of medical marijuana, instead use of this medication may allow better symptom management. Second, because patients must regularly consume marijuana to manage symptom burden they are not likely to 'forget' that they have a condition as they are regularly reminded of the condition through medication use. Nonetheless, we explore this possibility by regressing the probability of being in the qualifying sample on the MML variable and other controls in Equation 1. Results are reported in Appendix Table A3. We find no statistically significant evidence that MMLs affect the probability of being in the qualifying sample. The coefficient estimate, while imprecise, carries a negative sign and is small relative to the baseline proportion (-0.01 vs. 0.55).

A related concern is program induced migration (Moffitt, 1992). Older adults moving to MML states as a result of law passage could lead to bias in our coefficient estimates.

We regress the probability that an HRS respondent migrated across state lines between interviews on the MML indicator and other controls in Equation 1. Results are reported in Table A3 and suggest that passage of an MML reduces the likelihood that a respondent moves by 0.7 percentage points (30.4 percent relative to the baseline proportion of 0.023[7]) in the full sample; we do not observe statistically significant evidence of such migration patterns in the qualifying sample. Thus, some of our findings, at least within the full sample, may be driven by residents remaining in a state with an MML, when they might otherwise chose to move. However, the absolute value of the migration coefficient estimate is considerably smaller than the absolute value of the health and labor supply coefficient estimates, indicating that our results cannot be fully explained by MML-induced migration.

6.4 Effect of MMLs on individuals not in the qualifying sample

We next re-estimate Equation 1 using only those respondents who do not qualify for the access to medical marijuana through the health conditions outlined earlier in the manuscript. Appendix Tables A4 and A5 show no changes in health or labor supply for this group in response to MMLs, providing support for the hypothesis that results are largely driven by older adults utilizing marijuana medically post-MML.

6.5 Effects of specific MML provisions

Health policy scholars have noted that different types of MMLs may have differential impacts on both medical and recreational marijuana use (Anderson & Rees, 2014; Pacula, Powell, Heaton, & Sevigny, 2015; Wen et al., 2015). To explore such heterogeneous effects, we re-estimate Equation 1 for the following law provisions: (i) cultivation permitted (home or group), (ii) operating dispensaries, (iii) non-specific pain included as a qualifying health

[7] We note that the relative effect size is large, but we suspect that this large relative effect is driven by the fact that few older adults in our sample move across state lines.

condition, and (iv) patient registration required (effective dates are reported in Columns 2-5 of Table 1). These first three provisions may improve medical and recreational access with potential price and quality spillovers to the illegal market, while registration aims to deter program abuse by recreational users.

Cultivation, operating dispensaries, and chronic pain as a qualifying conditions appear to drive our health findings (Appendix Table A6). MMLs that require patients to register with the state to legally access medical marijuana are unrelated to our health outcomes. Cultivation and chronic pain as a qualifying health condition predict changes in labor supply (Appendix Table A7). MMLs that requires patients to register with the state *reduces* the probability of working, possibly because of workplace policies that preclude use of controlled substances while working. The manner in which states chose to regulate medical marijuana is important for older adult health and labor supply outcomes.

6.6 Alternative samples and controls for between-state heterogeneity

Appendix Tables A8 (health) and A9 (labor supply) demonstrate robustness of our results to alternative samples and regression specifications. First, we exclude adults older than 75, who are unlikely to change their labor supply. Second, we exclude California to ensure that our results are not driven by a single large, early-adopting state. In our main analyses we control for between-state heterogeneity through the use of time-varying state characteristics (e.g., wages), state fixed effects, and state-specific linear wave trends. While this is a standard specification within the MML literature (Anderson et al., 2013; Sabia & Nguyen, 2016) the state trends may throw away useful variation in MML effects and some of the included time-varying state-level controls may in fact be outcomes of MMLs (Sabia & Nguyen, 2016) which could lead to over-controlling bias (Angrist & Pischke, 2009). We estimate regressions models that (i) exclude state-specific linear waves trends and (ii) time-varying state-level variables. Overall, our results are broadly robust to these alternative samples and approaches to addressing between-state heterogeneity though some checks lose statistical significance.

6.7 Heterogeneity in MML effects by sex

There are established sex differences in terms of health (e.g., women are more likely to experience mental health problems than men (Substance Abuse and Mental Health Services Administration, 2014) and labor supply (i.e., men are more likely to work than women, particularly in an older sample such as we analyze in the HRS, see for example Banerjee and Blau (2016). To explore such heterogeneity, we have estimated separate regressions for men and women.[8] Results are reported in Appendix Tables A10 (health) and A11 (labor supply). We find interesting heterogeneity in health effects across gender. Post-MML, both reported pain and depressive symptoms decline among men, but not women, in passing states. However, women, but not men, experience improvements in self-assessed health post-MML. In terms of labor supply, the sex-stratified regressions suggest that although the labor supply effects are stronger for men than for women (i.e., larger relative effect sizes and greater precision), both groups appear to increase labor supply post-MML.

6.8 Additional robustness checks

We conduct several robustness checks that we report in the text for brevity, but that are available on request. Our identification strategy assumes that the changes in health and labor supply outcomes observed after states pass MMLs are driven by the laws themselves, and not an unobserved third factor that follows the same rollout pattern across states as the laws we study. 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

[8]We chose to rely on the pooled sample in our main analyses to preserve sample size.

DC, and estimate the effect of these false laws. Across 100 simulations, our mean point estimates are small and statistically indistinguishable from zero in all regressions. We have lagged the MMLs one year to allow for a time delay and outcomes; for example it make take some time for older adults to learn about medical marijuana, receive a recommendation, initiate marijuana use, and then experience improvements in symptom burden and increase participation in the labor market. Results generated in models that include such a lag are comparable to our main results. We have used alternative coding schemes for MMLs (i.e., Pacula et al. (2015) and Wen et al. (2015)). Results are broadly comparable to those that we report in the manuscript.

Finally, we examined the effect of MML passage on a measure of arguably non-medical marijuana use among older adults: admissions to substance use disorder treatment (SUD) with marijuana listed as the primary substance of abuse in the Treatment Episode Data Set (TEDS). We constructed the rate among adults 55 years and older; age information provided in the TEDS precluded closer alignment with our HRS analysis sample in terms of age (i.e., 51 years and older). More specifically, we estimated a version of Equation 1 using the count of state-level admissions to SUD treatment over the period 1992 to 2012. We found no evidence that this measure of marijuana use was altered by an MML passage. We found similar results using any indicator of marijuana use as the dependent variable. While clearly not definitive, this null finding is suggestive, in combination with information from marijuana patients reported earlier in the manuscript, that older adults who use marijuana post-MML are using the product for medical purposes.

7 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 state medical marijuana laws (MMLs) on older adult health and labor supply outcomes. Thus, we examine an understudied yet important sub-group. First, we document that reported chronic pain declines and overall assessments of one's health improve post-MML among older adults. More specifically, post-MML the probability of reporting pain declines by 0.6 percent (statistically insignificant)and the probability of reporting one's health as very good or excellent increases by 3.4 percent. These findings suggest that access to medical marijuana through MMLs allows, at least some, older adults to better manage symptoms associated with chronic health conditions. Second, we find that MML passage allows older adults who are currently working to increase their labor supply, but we do not find evidence that MMLs allows older adults to re-enter the labor market. In particular, we find that passage of an MML increases the probability of working full time and the number of hours worked per week (among working adults) both increase by 3 percent. Finally, health and labor supply effects are even larger among older adults who are likely to use marijuana for medical purposes based on their health histories; for example pain declines by a statistically significant 2.2 percentage points among the 55 percent of our sample with one or more health conditions that would qualify for medical marijuana use.

A key concern with marijuana regulation is that expanded access will promote recreational, and not medical, use of the product. While our study cannot fully address this important question, our estimates can bring some evidence to bear for the older adult population. The fact that we identify improvements in health outcomes that plausibly capture symptom burden (i.e., reported pain and overall health assessments) and increases in labor supply concentrated among those with medical marijuana qualifying conditions suggests that, even if some older adults do use marijuana obtained following passage of an MML recreationally, on average passage of an MML and the ensuing changes in health and labor supply confers important benefits to some older adults.

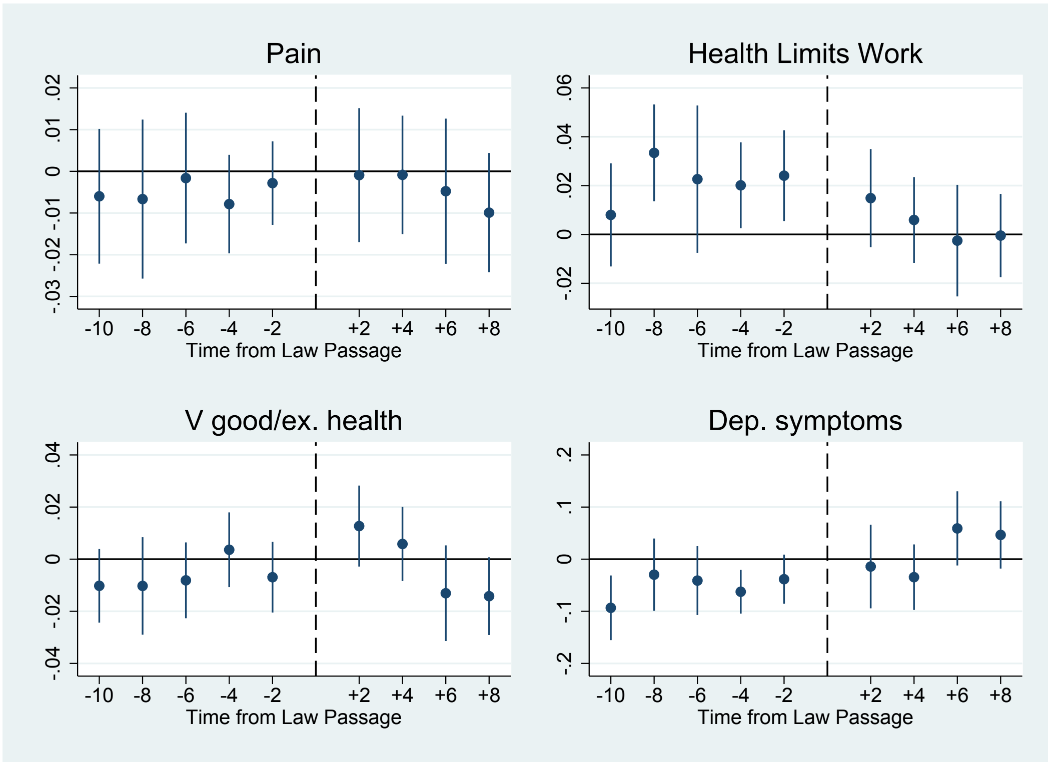
We can compare our findings with a previous study that examines the labor market effects of MML passage. Sabia and Nguyen (2016) finds no change in employment propensity following passage of an MML, which is comparable to our null findings for any employment. However, while we document that older adults increase labor supply along the intensive margin (defined as full time work and conditional hours worked) post-MML, Sabia and Nguyen (2016) find no statistically significant evidence that conditional hours worked increase. We hypothesize that our focus on an older sample of workers than Sabia and Nguyen (2016) may explain this divergence in findings: we examine workers who are 50 years and older while Sabia and Nguyen (2016) examine workers through age 64. Analysis of the Annual Social and Economic Supplement to the Current Population Survey 1992-2012 indicates that 48 percent of adults 50 years and older and 24 percent of adults ages 65 to 75 years report being in the labor force. Thus, a non-trivial share of older workers are in the labor force and may increase their labor supply following passage of an MML. Moreover, as noted earlier in the manuscript, older workers are the types of workers who are most likely to experience many of the the health conditions whose symptoms may be effectively treated by medical marijuana, suggesting that these workers are precisely the workers one would expect to observe positive labor supply effects. Finally, our confidence intervals overlap with Sabia and Nguyen's confidence intervals; hence we cannot rule out that the two studies produce comparable estimates. Collectively, these two studies shed important light on the full effects of MML passage on the labor market; Sabia and Nguyen document effects within working populations while we examine older adults specifically.

Our findings also contribute to a larger literature highlighting the role of health policies and access to medical treatments for older workers' labor supply. Pain medications may be particularly important for older workers. In addition to our results around medical marijuana access, Garthwaite (2012) found a 3.9 percentage point (10 percent) decline in labor supply among adults with joint conditions following the sudden withdrawal of Vioxx, a popular anti-inflammatory medication previously used to treat joint pain.

Our study has limitations. (i) 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. (ii) Our identification strategy only uses variation in MMLs for those states that implemented such laws during our study period. (iii) As is the case in all other economics studies examining MML effects of which we are aware, we lack data on medical marijuana use in the HRS and our results have an ITT interpretation. However, our effects are comparable, or smaller than, other ITT effects reported in the literature. For instance, Bradford and Bradford (2016) show a that, post-MML, Medicare prescriptions decline 5.7 percent for pain medications, 5.0 percent for anxiety medications, 5.4 percent for nausea medications, and 4.5 percent for psychosis medications, and Bachhuber et al. (2014) show a 24.8 percent decline in opioid-related overdoses post-MML. Moreover, while the average treatment effect (ATT) is clearly important clinically, ITT is relevant for policy purposes due to the complex pathways that MMLs can lead to changes in health and labor supply. Moreover, as noted earlier in the manuscript, MMLs are the lever available to policy makers. (iv) We lack data on all health conditions for which medical marijuana may be an effective treatment for alleviating painful symptoms (e.g., anxiety, nausea).

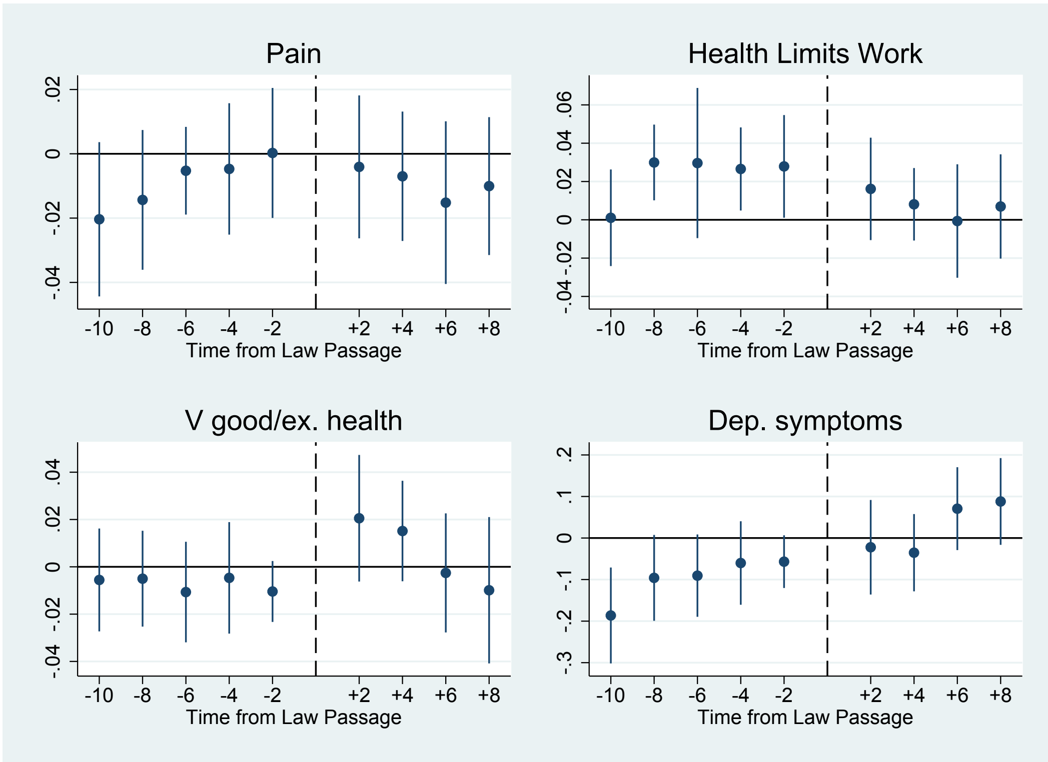
The policy debate surrounding legalization of marijuana, for medical or recreational purposes, is fierce. In particular, with the Trump Administration's proposal to renew Federal enforcement of marijuana possession laws in states with MMLs by allowing the Rohrabacher-Farr Amendment to expire raises new concerns among medical marijuana advocates and at the same time offers hope for critics who would like to curtail all marijuana access through regulation. Policymakers must carefully weigh the costs and the benefits of such legalization. We provide evidence that there may be benefits in terms of the health and labor supply of older adults, a population that, based on clinical anecdotal evidence, has elevated need for medications that can reduce painful symptoms associated with a range of health conditions and is plausibly using marijuana medically. Taken in combination with findings that MMLs may reduce body weight (Sabia et al., 2017), improve physical well-being (Sabia et al., 2017), 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.

Figure 1: Effect of state medical marijuana laws on older adult health outcomes using an event study: HRS 1992-2012 (full sample)



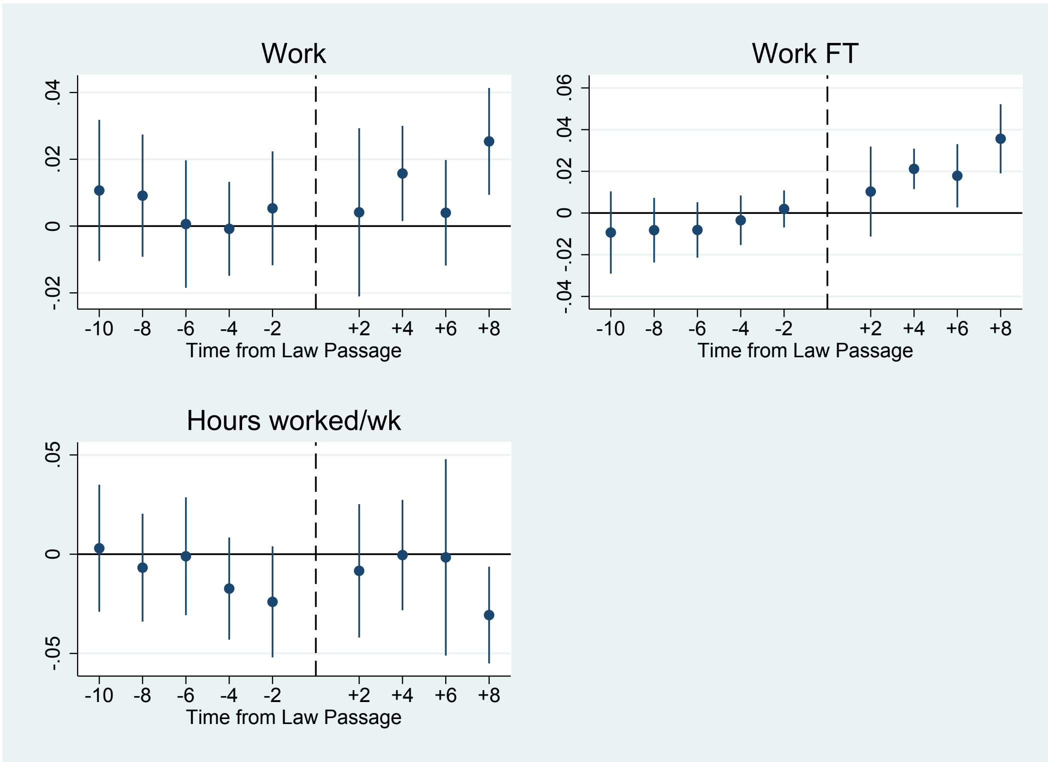
Notes: Sample includes HRS respondents 51 years and older. All models estimated with a linear probability model (binary outcome) or least squares (continuous outcome), and control for individual and state characteristics, state fixed effects and interview wave fixed effects. The omitted period is the year of MML passage. 95 percent confidence intervals that account for within-state clustering are reported with vertical lines.

Figure 2: Effect of state medical marijuana laws on older adult health outcomes using an event study: HRS 1992-2012 (qualifying sample)



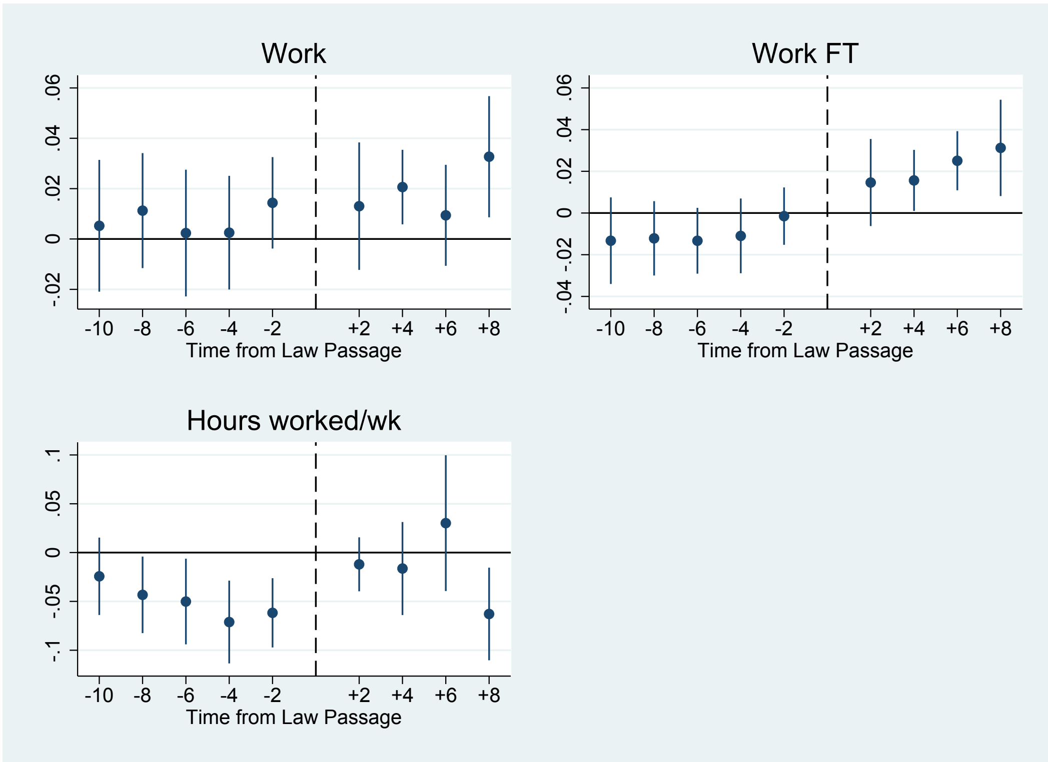
Notes: Sample includes HRS respondents 51 years and older who report 1 or more condition that would qualify for legal medical marijuana use. All models estimated with a linear probability model (binary outcome) or least squares (continuous outcome), and control for individual and state characteristics, state fixed effects and interview wave fixed effects. The omitted period is the year of MML passage. 95 percent confidence intervals that account for within-state clustering are reported with vertical lines.

Figure 3: Effect of state medical marijuana laws on older adult labor supply outcomes using an event study: HRS 1992-2012 (full sample)



Notes: Sample includes HRS respondents 51 years and older. 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. The omitted period is the year of MML passage. 95 percent confidence intervals that account for within-state clustering are reported with vertical lines.

Figure 4: Effect of state medical marijuana laws on older adult labor supply outcomes using an event study: HRS 1992-2012 (qualifying sample)



Notes: Sample includes HRS respondents 51 years and older who report 1 or more condition that would qualify for legal medical marijuana use. 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. The omitted period is the year of MML passage. 95 percent confidence intervals that account for within-state clustering are reported with vertical lines.

Table 1: State medical marijuana laws 1996-2013

State	Any MML	MML Provisions			
		Cultivation	Dispensary	Non-specific pain	Registry
Column	(1)	(2)	(3)	(4)	(5)
Alaska	3/1999	n/a	n/a	3/1999	3/1999
Arizona	4/2011	4/2011	12/2012	4/2011	4/2011
California	11/1996	11/1996	11/1996	11/1996	n/a
Colorado	6/2001	6/2001	7/2005	6/2001	6/2001
Connecticut	5/2012	n/a	8/2014	n/a	5/2012
DC	7/2010	n/a	7/2013	n/a	7/2010
Delaware	7/2011	n/a	n/a	7/2011	7/2011
Hawaii	12/2000	n/a	n/a	12/2000	12/2000
Maine	12/1999	n/a	4/2011	n/a	12/2009
Massachusetts	1/2013	n/a	n/a	n/a	1/2013
Michigan	12/2008	12/2008	12/2009	12/2008	n/a
Montana	11/2004	11/2004	4/2009	11/2004	n/a
Nevada	10/2001	10/2001	n/a	10/2001	10/2001
New Hampshire	7/2013	n/a	n/a	7/2013	7/2013
New Jersey	10/2010	n/a	12/2012	10/2010	10/2010
New Mexico	7/2007	n/a	6/2009	n/a	7/2007
Oregon	12/1998	12/1998	11/2009	12/1998	1/2007
Rhode Island	1/2006	1/2006	4/2013	1/2006	1/2006
Vermont	7/2004	n/a	6/2013	7/2007	7/2004
Washington	11/1998	7/2011	4/2009	11/1998	n/a

Notes: Data source is Sabia and Nguyen (2016). We note that the following states passed MMLs after 2013: Arkansas (2016), Florida (2017), Illinois (2014), Maryland (2014), Minnesota (2014), New York (2014), North Dakota (2016), Ohio (2016), Pennsylvania (2016), and West Virgina (2017).

Table 2: Summary statistics: HRS 1992-2012

Sample:	1	2
Health outcomes		
Pain	0.31	0.43
Health limits work	0.29	0.39
Very good/excellent health	0.41	0.32
Depressive symptoms	1.55	1.81
Labor supply outcomes		
Work	0.39	0.31
Work FT	0.26	0.19
Hours worked/wk (conditional on working)	36.70	34.75
MML		
Any	0.13	0.15
Individual characteristics		
Age	66.50	67.99
Less than high school	0.29	0.30
High school	0.31	0.32
Some college	0.40	0.38
White	0.80	0.80
African American	0.15	0.16
Other race	0.05	0.04
Hispanic	0.09	0.09
State characteristics		
Marijuana decriminalized	0.32	0.32
Beer tax ($ per gallon)	0.26	0.27
Unemployment rate among adults 51+	0.042	0.042
Hourly wage among adults 51+ ($)	18.10	18.08
Minimum wage ($)	5.77	6.00
State EITC as a proportion of the federal EITC	0.12	0.13
Maximum monthly food stamp benefit, family of 4 ($)	487.96	506.20
Democrat governor	0.46	0.46
N	183,032	101,112

Notes: Sample includes HRS respondents 51 years and older. Sample 1 = full sample. Sample 2 = qualifying sample; which includes respondents who report 1 or more condition that would qualify for legal medical marijuana use.

Table 3: Effect of MML passage on older adult health outcomes: HRS 1992-2012

Outcome:	Pain		Health lim. work		V. good/ex. health		Dep. symptoms	
Sample:	1	2	1	2	1	2	1	2
Proportion/mean	0.31	0.43	0.29	0.39	0.41	0.32	1.55	1.81
Any MML	-0.002	-0.022**	-0.004	-0.008	0.014**	0.025**	-0.006	-0.023
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.04)
N	182,376	100,767	157,704	91,688	182,406	100,793	182,412	100,803

Notes: Sample includes HRS respondents 51 years and older. Sample 1 = full sample. Sample 2 = qualifying sample; which includes respondents who report 1 or more condition that would qualify for legal medical marijuana use. All models estimated with an LPM (binary outcome) or LS (continuous outcome), and control for individual characteristics, state characteristics, state fixed effects, interview wave fixed effects, and state-specific linear time trends. Standard errors clustered around the state and reported in parentheses. * significant at 10 percent, ** significant at 5 percent, *** significant at 1 percent.

Table 4: Effect of MML passage on older adult labor supply outcomes: HRS 1992-2012

Outcome:	Work		Work FT		Hours worked/wk	
Sample:	1	2	1	2	1	2
Proportion/mean	0.39	0.31	0.26	0.19	36.7	34.8
Any MML	-0.003	-0.001	0.008*	0.011**	0.033*	0.060***
	(0.01)	(0.01)	(0.00)	(0.00)	(0.02)	(0.02)
N	182,078	100,673	182,078	100,673	69,705	30,790

Notes: Sample includes HRS respondents 51 years and older. Sample 1 = full sample. Sample 2 = qualifying sample; which includes respondents who report 1 or more condition that would qualify for legal medical marijuana use. Hours worked per week are conditional on any work and are log transformed. All models estimated with an LPM (binary outcome) or LS (continuous outcome), and control for individual characteristics, state characteristics, state fixed effects, interview wave fixed effects, and state-specific linear time trends. Standard errors clustered around the state and reported in parentheses. * significant at 10 percent, ** significant at 5 percent, *** significant at 1 percent.

Table 5: Effect of MML passage on older adult health outcomes using person fixed effects: HRS 1992-2012

Outcome:	Pain		Health lim. work		V. good/ex. health		Dep. symptoms	
Proportion/mean	0.31	0.43	0.29	0.39	0.41	0.32	1.55	1.81
Any MML	-0.006	-0.02*	-0.014	-0.012	0.016***	0.022*	-0.016	0.005
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)
N	182,471	108,808	157,798	99,204	182,504	108,834	182,510	108,845

Notes: Sample includes HRS respondents 51 years and older. Sample 1 = full sample. Sample 2 = qualifying sample; which includes respondents who report 1 or more condition that would qualify for legal medical marijuana use. All models estimated with an LPM (binary outcome) or LS (continuous outcome), and control for person fixed effects, interview wave fixed effects, and state-specific linear time trends. Standard errors clustered around the state and reported in parentheses. * significant at 10 percent, ** significant at 5 percent, *** significant at 1 percent.

Table 6: Effect of MML passage on older adult health outcomes using person fixed effects: HRS 1992-2012

Outcome:	Work		Work FT		Hours worked/wk	
Sample:	1	2	1	2	1	2
Proportion/mean:	0.39	0.31	0.26	0.19	36.7	34.8
Any MML	-0.003	-0.001	0.004	0.005	0.024	0.057**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
N	182,174	108,706	182,174	108,706	69,747	34,186

Notes: Sample includes HRS respondents 51 years and older. Sample 1 = full sample. Sample 2 = qualifying sample; which includes respondents who report 1 or more condition that would qualify for legal medical marijuana use. Hours worked per week are conditional on any work and are log transformed. All models estimated with an LPM (binary outcome) or LS (continuous outcome), and control for person fixed effects, interview wave fixed effects, and state-specific linear time trends. Standard errors clustered around the state and reported in parentheses. * significant at 10 percent, ** significant at 5 percent, *** significant at 1 percent.

References

Abouk, R., & Adams, S. (2018). Examining the Relationship between Medical Marijuana Laws and Cardiovascular Deaths in the US. *International Journal of Drug Policy*, *53*(1–7).

Anderson, D. M., Hansen, B., & Rees, D. I. (2013). Medical marijuana laws, traffic fatalities, and alcohol consumption. *Journal of Law and Economics*, *56*(2), 333–369.

Anderson, D. M., & Rees, D. I. (2014). The legalization of recreational marijuana: How likely is the worst-case scenario? *Journal of Policy Analysis and Management*, *33*(1), 221–232.

Anderson, D. M., Rees, D. I., & Sabia, J. J. (2014). Medical marijuana laws and suicides by gender and age. *American Journal of Public Health*, *104*(12), 2369–2376.

Angrist, J. D., & Pischke, J.-S. (2009). *Mostly harmless econometrics: An empiricist's companion*. Princeton University Press.

Apouey, B., & Clark, A. E. (2015). Winning big but feeling no better? The effect of lottery prizes on physical and mental health. *Health Economics*, *24*(5), 516-538.

Autor, D. H. (2003). Outsourcing at will: The contribution of unjust dismissal doctrine to the growth of employment outsourcing. *Journal of Labor Economics*, *21*(1), 1–42.

Azofeifa, A. (2016). National estimates of marijuana use and related indicatorsnational survey on drug use and health, united states, 2002–2014. *MMWR. Surveillance Summaries*, *65*.

Bachhuber, M. A., Saloner, B., Cunningham, C. O., & Barry, C. L. (2014). Medical cannabis laws and opioid analgesic overdose mortality in the united states, 1999-2010. *JAMA Internal Medicine*, *174*(10), 1668–1673.

Banerjee, S., & Blau, D. (2016). Employment trends by age in the united states why are older workers different? *Journal of Human Resources*, *51*(1), 163–199.

Barbour, K. E. (2017). Vital signs: prevalence of doctor-diagnosed arthritis and arthritis-attributable activity limitationunited states, 2013–2015. *MMWR. Morbidity and Mortality Weekly Report*, *66*.

Benjamins, M. R., Hummer, R. A., Eberstein, I. W., & Nam, C. B. (2004). Self-reported health and adult mortality risk: An analysis of cause-specific mortality. *Social Science & Medicine*, *59*(6), 1297-1306.

Bertrand, M., Duflo, E., & Mullainathan, S. (2004). How much should we trust differences-in-differences estimates? *Quarterly Journal of Economics*, *119*(1).

Bradford, A. C., & Bradford, W. D. (2016). Medical marijuana laws reduce prescription medication use in medicare part d. *Health Affairs*, *35*(7), 1230-1236.

Bradford, A. C., & Bradford, W. D. (2017). Medical marijuana laws may be associated with a decline in the number of prescriptions for medicaid enrollees. *Health Affairs*.

Case, A., & Deaton, A. S. (2005). Broken down by work and sex: How our health declines. In *Analyses in the economics of aging* (pp. 185–212). University of Chicago Press.

Chau, D. L., Walker, V., Pai, L., & Cho, L. M. (2008). Opiates and elderly: Use and side effects. *Clinical Interventions in Aging*, *3*(2), 273.

Choi, A. (2014). *The impact of medical marijuana laws on marijuana use and other risky health behaviors.* American Society of Health Economists.

Chu, Y.-W. L. (2014). The effects of medical marijuana laws on illegal marijuana use. *Journal of Health Economics*, *38*, 43–61.

Chu, Y.-W. L. (2015). Do medical marijuana laws increase hard-drug use? *The Journal of Law and Economics*, *58*(2), 481–517.

Currie, J., & Madrian, B. C. (1999). Health, health insurance and the labor market. *Handbook of Labor Economics*, *3*, 3309–3416.

Datta Gupta, N., & Larsen, M. (2010). The impact of health on individual retirement plans: Self-reported versus diagnostic measures. *Health Economics*, *19*(7), 792–813.

Dwyer, D. S., & Mitchell, O. S. (1999). Health problems as determinants of retirement: Are self-rated measures endogenous? *Journal of Health Economics*, *18*(2), 173–193.

Fairman, B. J. (2016). Trends in registered medical marijuana participation across 13 usstates and district of columbia. *Drug and Alcohol Dependence*, *159*, 7279.

Garthwaite, C. L. (2012, July). The economic benefits of pharmaceutical innovations: The case of cox-2 inhibitors. *American Economic Journal: Applied Economics*, *4*(3), 116-137.

Goldenberg, M., Reid, M. W., IsHak, W. W., & Danovitch, I. (2017). The impact of cannabis and cannabinoids for medical conditions on health-related quality of life: A systematic review and meta-analysis. *Drug & Alcohol Dependence*, *174*, 80–90.

Hill, K. P. (2015). Medical marijuana for treatment of chronic pain and other medical and psychiatric problems: a clinical review. *Journal of the American Medical Association*, *313*(24), 2474–2483.

Horn, B. P., Maclean, J. C., & Strain, M. R. (2017). Do minimum wage increases influence worker health? *Economic Inquiry*, *In Press*.

Ilgen, M. A., Bohnert, K., Kleinberg, F., Jannausch, M., Bohnert, A. S., Walton, M., … Blow, F. C. (2013). Characteristics of adults seeking medical marijuana certification. *Drug and Alcohol Dependence*, *132*, 654659.

Kaila-Kangas, L., Haukka, E., Miranda, H., Kivekäs, T., Ahola, K., Luukkonen, R., … Leino-Arjas, P. (2014). Common mental and musculoskeletal disorders as predictors of disability retirement among finns. *Journal of Affective Disorders*, *165*, 38–44.

Kapteyn, A., Smith, J. P., & Van Soest, A. (2008). Dynamics of work disability and pain. *Journal of Health Economics*, *27*(2), 496–509.

Kaskie, B., Ayyagari, P., Milavetz, G., Shane, D., & Arora, K. (2017). The increasing use of cannabis among older americans: A public health crisis or viable policy alternative? *The Gerontologist*, gnw166.

Kline, P. (2011). The impact of juvenile curfew laws on arrests of youth and adults. *American Law and Economics Review*, *14*(1), 44–67.

Longo, L. P., & Johnson, B. (2000). Addiction: Part i. benzodiazepines-side effects, abuse risk and alternatives. *American Family Physician*, *61*(7), 2121–2128.

Lovenheim, M. F. (2009). The effect of teachers unions on education production: Evidence from union election certifications in three midwestern states. *Journal of Labor Economics*, *27*(4), 525–587.

McCormick, M., et al. (2017). *The health effects of cannabis and cannabinoids* (Tech. Rep.). National Academies of Sciences, Engineering, and Medicine.

McGarry, K. (2004). Health and retirement do changes in health affect retirement expectations? *Journal of Human Resources*, *39*(3), 624–648.

McInerney, M., Mellor, J. M., & Nicholas, L. H. (2013). Recession depression: Mental health effects of the 2008 stock market crash. *Journal of Health Economics*, *32*(6), 1090-1104.

Moffitt, R. (1992). Incentive effects of the us welfare system: A review. *Journal of Economic Literature*, *30*(1), 1–61.

Morgan, K. (2003). Daytime activity and risk factors for late-life insomnia. *Journal of Sleep Research*, *12*(3), 231–238.

Nahin, R. L. (2015). Estimates of pain prevalence and severity in adults: United states, 2012. *The Journal of Pain*, *16*(8), 769–780.

National Center for Health Statistics. (2017). *Health, united states, 2016: with chartbook on long-term trends in health* (Tech. Rep.). National Center for Health Statistics.

National Institutes of Health. (2011). Chronic pain: Symptoms, diagnosis, & treatment. *NIH Medline Plus: The Magazine*, *6*(1), 5-6.

Nielsen, T. H. (2016). The relationship between self-rated health and hospital records. *Health Economics*, *25*(4), 497–512.

Nunberg, H., Kilmer, B., Pacula, R. L., & Burgdorf, J. R. (2011). An analysis of applicants presenting to a medical marijuana specialty practice in california. *Journal of Drug Policy Analysis*, *4*(1). (Article 1)

Ortman, J. M., Velkoff, V. A., Hogan, H., et al. (2014). *An aging nation: The older population in the united states* (Tech. Rep.). United States Census Bureau.

Ozluk, P. (2017). *The effects of medical marijuana laws on utilization of prescribed opioids and other prescription drugs.*

Pacula, R. L., Chriqui, J. F., & King, J. (2003). *Marijuana decriminalization: What does it mean in the united states?* [NBER Working Paper Series].

Pacula, R. L., Powell, D., Heaton, P., & Sevigny, E. L. (2015). Assessing the effects of medical marijuana laws on marijuana use: The devil is in the details. *Journal of Policy Analysis and Management*, *34*(1), 7–31.

Porter, M. E. (2010). What is value in health care? *New England Journal of Medicine*, *363*(26), 2477–2481.

Powell, D., Pacula, R. L., & Jacobson, M. (2015). *Do medical marijuana laws reduce addictions and deaths related to pain killers?* (National Buruea of Economic Research Working Paper Series 21345)

Radloff, L. S. (1977). The ces-d scale. *Applied Psychological Measurement*, *1*(3), 385-401.

Reiman, A., Welty, M., & Solomon, P. (2017). Cannabis as a substitute for opioid-based pain medication: Patient self-report. *Cannabis and Cannabinoid Research*, *2*(1), 160–166.

Sabia, J. J., & Nguyen, T. T. (2016). *The effect of medical marijuana laws on labor market outcomes* (IZA Discussion Paper No. 9831). IZA.

Sabia, J. J., Swigert, J., & Young, T. (2017). The effect of medical marijuana laws on body weight. *Health Economics*, *26*, 6-34.

Sansone, R. A., & Sansone, L. A. (2008). Pain, pain, go away: Antidepressants and pain management. *Psychiatry*, *5*(12), 1619.

Simon, K., Soni, A., & Cawley, J. (2016). *The impact of health insurance on preventive care* *and health behaviors: Evidence from the 2014 aca medicaid expansions* (Tech. Rep. No. 22265). National Bureau of Economic Research.

Stewart, W. F., Ricci, J. A., Chee, E., Morganstein, D., & Lipton, R. (2003). Lost productive time and cost due to common pain conditions in the us workforce. *Journal of the American Medical Association*, *290*(18), 2443–2454.

Stith, S. S., & Vigil, J. M. (2016). Federal barriers to cannabis research. *Science*, *352*(6290), 1182.

Stoner, S. (2016). *Marijuana use by older adults* (Tech. Rep.). Alcohol & Drug Abuse Institute, University of Washington.

Substance Abuse and Mental Health Services Administration. (2014). *Results from the 2013 national survey on drug use and health: Summary of national findings* (NSDUH Series No. H-48). Substance Abuse and Mental Health Services Administration.

Swegle, J. M., & Logemann, C. (2006). Management of common opioid-induced adverse effects. *American Family Physician*, *74*(8), 1347-1354.

Tian, H., Robinson, R. L., & Sturm, R. (2005). Labor market, financial, insurance and disability outcomes among near elderly americans with depression and pain. *Journal of Mental Health Policy and Economics*, *8*(4), 219.

Turvey, C. L., Wallace, R. B., & Herzog, R. (1999). A revised ces-d measure of depressive symptoms and a dsm-based measure of major depressive episodes in the elderly. *International Psychogeriatrics*, *11*(2), 139–148.

Ullman, D. (2016). The effect of medical marijuana on sickness absence. *Health Economics*, *In Press*.

Unruh, M. L., Redline, S., An, M.-W., Buysse, D. J., Nieto, F. J., Yeh, J.-L., & Newman, A. B. (2008). Subjective and objective sleep quality and aging in the sleep heart health study. *Journal of the American Geriatrics Society*, *56*(7), 1218–1227.

U.S. National Library of Medicine. (2011). *Chronic pain: Symptoms, diagnosis, & treatment*

(6 No. 1). 5-6: National Library of Medicine.

U.S. National Library of Medicine. (2017). *Medline plus: Cannabidiol* (Tech. Rep.). U.S. National Library of Medicine.

Van Ours, J. C., & Williams, J. (2011). Cannabis use and mental health problems. *Journal of Applied Econometrics*, *26*(7), 1137–1156.

Van Ours, J. C., & Williams, J. (2012). The effects of cannabis use on physical and mental health. *Journal of Health Economics*, *31*(4), 564–577.

Vigil, J. M., Stith, S. S., Adams, I. M., & Reeve, A. P. (2017). *Associations between medical cannabis and prescription opioid use in chronic pain patients: A preliminary cohort study* (Vol. 12; Tech. Rep. No. 11).

Volkow, N. D., Swanson, J. M., Evins, A. E., DeLisi, L. E., Meier, M. H., Gonzalez, R., ... Baler, R. (2016). Effects of cannabis use on human behavior, including cognition, motivation, and psychosis: A review. *JAMA Psychiatry*, *73*(3), 292–297.

Wen, H., Hockenberry, J. M., & Cummings, J. R. (2015). The effect of medical marijuana laws on adolescent and adult use of marijuana, alcohol, and other substances. *Journal of Health Economics*, *42*, 64–80.

Whiting, P. F., Wolff, R. F., Deshpande, S., Di Nisio, M., Duffy, S., Hernandez, A. V., ... others (2015). Cannabinoids for medical use: a systematic review and meta-analysis. *Journal of the American Medical Association*, *313*(24), 2456–2473.

Williams, A. R., Olfson, M., Kim, J. H., Martins, S. S., & Kleber, H. D. (2016). Older, less regulated medical marijuana programs have much greater enrollment rates than newer medicalized programs. *Health Affairs*, *35*(3), 480-488.

Wolfers, J. (2006). Did unilateral divorce laws raise divorce rates? a reconciliation and new results. *American Economic Review*, *96*(5), 1802-1820.

Yi, E. (2015). Medical marijuana use among older adults: A systematic review. *Gerontologist*, *55*, 672–672.

Appendix Materials

Table A1: Parallel trends testing for older adult health outcomes: HRS 1992-2012

Outcome:	Pain		Health lim. work		V. good/ex. health		Dep. symptoms	
Sample:	1	2	1	2	1	2	1	2
Prop./mean:	0.31	0.43	0.29	0.39	0.41	0.32	1.55	1.81
MML*time	0.0001	0.0002*	0.0001	0.0001	0	0	0.0004*	0.0010**
trend	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0002)	(0.0003)
Time	-0.0027**	-0.0005	-0.0047**	-0.0042**	-0.0001	-0.0016*	0.0067*	0.0220**
trend	(0.0007)	(0.0010)	(0.0009)	(0.0010)	(0.0006)	(0.0009)	(0.0028)	(0.0025)
N	117,134	59,195	98,465	54,483	117,127	59,195	117,127	59,197

Notes: Sample includes HRS respondents 51 years and older. Sample 1 = full sample. Sample 2 = qualifying sample; which includes respondents who report 1 or more condition that would qualify for legal medical marijuana use. Only pre-MML data are included in the sample and states that do not pass an MML by 2010 are randomly assigned a false MML implementation date. The time trend variable takes a value of -1 one year prior to law implementation, -2 two years prior to law implementation, and so forth. All models estimated with an LPM (binary outcome) or LS (continuous outcome), and control for individual characteristics, state characteristics, state fixed effects, and interview wave fixed effects. Standard errors clustered around the state and reported in parentheses. Only pre-MML data is included in the analysis. * significant at 10 percent, ** significant at 5 percent, *** significant at 1 percent.

Table A2: Parallel trends testing for older adult labor supply outcomes: HRS 1992-2012

Outcome:	Work		Work FT		Hours worked/wk	
Sample:	1	2	1	2	1	2
Proportion/mean:	0.39	0.31	0.26	0.19	36.7	34.8
MML*time	-0.0001	0	0	0	0	-0.0003*
trend	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Time	0.0069**	0.0035**	0.0083**	0.0060**	0.0060**	0.0126**
trend	(0.0006)	(0.0011)	(0.0006)	(0.0009)	(0.0009)	(0.0020)
N	116,969	59,133	116,969	59,133	59,133	18,907

Notes: Sample includes HRS respondents 51 years and older. Sample 1 = full sample. Sample 2 = qualifying sample; which includes respondents who report 1 or more condition that would qualify for legal medical marijuana use. Only pre-MML data are included in the sample and states that do not pass an MML by 2010 are randomly assigned a false MML implementation date. The time trend variable takes a value of -1 one year prior to law implementation, -2 two years prior to law implementation, and so forth. Hours worked per week are conditional on any work and are log transformed. All models estimated with an LPM (binary outcome) or LS (continuous outcome), and control for individual characteristics, state characteristics, state fixed effects, and interview wave fixed effects. Standard errors clustered around the state and reported in parentheses. Only pre-MML data is included in the analysis. * significant at 10 percent, ** significant at 5 percent, *** significant at 1 percent.

Table A3: Effect of MML passage on the probability of being in the qualifying sample and across-state migration among older adults: HRS 1992-2012

Outcome:	Qualifying sample	Move across state lines	
Sample:	1	1	2
Proportion:	0.55	0.023	0.023
Any MML	-0.006	-0.007*	-0.007
	(0.007)	(0.004)	(0.004)
N	182,518	148,764	89,117

Notes: Sample includes HRS respondents 51 years and older. Sample 1 = full sample. Sample 2 = qualifying sample; which includes respondents who report 1 or more condition that would qualify for legal medical marijuana use. All models estimated with an LPM and control for individual characteristics, state characteristics, state fixed effects, interview wave fixed effects, and state-specific linear time trends. Standard errors clustered around the state and reported in parentheses. * significant at 10 percent, ** significant at 5 percent, *** significant at 1 percent.

Table A4: Effect of MML passage on older adult health outcomes among those not in the qualifying sample: HRS 1992-2012

Outcome:	Pain	Health lim. work	V. good/ex. health	Dep. symptoms
Proportion/mean:	0.15	0.13	0.53	1.22
Any MML	0.003	-0.009	-0.001	-0.012
	(0.01)	(0.01)	(0.01)	(0.03)
N	73,615	58,545	73,619	73,614

Notes: Sample includes HRS respondents 51 years and older who do not report 1 or more condition that would qualify for legal medical marijuana use. All models estimated with an LPM (binary outcome) or LS (continuous outcome), and control for individual characteristics, state characteristics, state fixed effects, interview wave fixed effects, and state-specific linear time trends. Standard errors clustered around the state and reported in parentheses. * significant at 10 percent, ** significant at 5 percent, *** significant at 1 percent.

Table A5: Older adult labor supply outcomes among those not in the qualifying sample: HRS 1992-2012

Outcome:	Work	Work FT	Hours worked/wk
Proportion/mean:	0.49	0.36	38.5
Any MML	-0.001	0.006	-0.01
	(0.008)	(0.01)	(0.02)
N	73,418	73,418	35,533

Notes: Sample includes HRS respondents 51 years and older who do not report 1 or more condition that would qualify for legal medical marijuana use. Hours worked per week are conditional on any work and are log transformed. All models estimated with an LPM (binary outcome) or LS (continuous outcome), and control for individual characteristics, state characteristics, state fixed effects, and interview wave fixed effects. Standard errors clustered around the state and reported in parentheses. * significant at 10 percent, ** significant at 5 percent, *** significant at 1 percent.

Table A6: Effect of specific MML law provision passage on older adult health outcomes: HRS 1992-2012

Outcome:	Pain		Health lim. work		V. good/ex. health		Dep. symptoms	
Sample:	1	2	1	2	1	2	1	2
Proportion/mean:	0.31	0.43	0.29	0.39	0.41	0.32	1.55	1.81
Cultivation	-0.003	-0.027***	-0.008	-0.016	0.015**	0.026**	-0.001	-0.021
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)
Operating	-0.011***	-0.035***	0.012	0.009	0.014	0.026**	0.025	0.03
dispensary	(0.00)	(0.00)	(0.01)	(0.02)	(0.01)	(0.01)	(0.04)	(0.04)
Pain as qualifying	0	-0.019*	-0.003	-0.01	0.013*	0.025**	0.003	-0.019
condition	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.04)
Patient	-0.001	-0.002	0.008	0.007	0.007	0.017	-0.011	-0.065
registration	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.05)	(0.08)
N	182,376	108,761	157,704	99,159	182,406	108,787	182,412	108,798

Notes: Sample includes HRS respondents 51 years and older. Sample 1 = full sample. Sample 2 = qualifying sample; which includes respondents who report 1 or more condition that would qualify for legal medical marijuana use. All models estimated with an LPM (binary outcome) or LS (continuous outcome), and control for individual characteristics, state characteristics, state fixed effects, interview wave fixed effects, and state-specific linear time trends. Standard errors clustered around the state and reported in parentheses. * significant at 10 percent, ** significant at 5 percent, *** significant at 1 percent.

Table A7: Effect of specific MML law provision passage on older adult labor supply outcomes: HRS 1992-2012

Outcome:	Work		Work FT		Hours worked/wk	
Sample:	1	2	1	2	1	2
Proportion/mean:	0.39	0.31	0.26	0.19	36.7	34.8
Cultivation	0.004	0.010***	0.010**	0.01	0.041**	0.072***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.02)	(0.02)
Operating	-0.002	0	0.004	0.001	0.031	0.042
dispensary	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)
Pain as qualifying	-0.003	-0.001	0.007	0.009	0.033*	0.070***
condition	(0.01)	(0.01)	(0.00)	(0.01)	(0.02)	(0.02)
Patient	-0.027**	-0.031**	-0.01	0.002	0.011	0.062*
registration	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.04)
N	182,078	108,660	182,078	108,660	69,705	34,172

Notes: Sample includes HRS respondents 51 years and older. Sample 1 = full sample. Sample 2 = qualifying sample; which includes respondents who report 1 or more condition that would qualify for legal medical marijuana use. Hours worked per week are conditional on any work and are log transformed. All models estimated with an LPM (binary outcome) or LS (continuous outcome), and control for individual fixed effects, interview wave fixed effects, and state-specific linear time trends. Standard errors clustered around the state and reported in parentheses. * significant at 10 percent, ** significant at 5 percent, *** significant at 1 percent.

Table A8: Effect of MML passage on older adult health outcomes, various robustness checks: HRS 1992-2012

Outcome:	Pain		Health limits work		V good/ex. health		Dep. symptoms	
Exclude > 75 yrs								
Proportion/mean:	0.31	0.45	0.26	0.37	0.44	0.33	1.51	1.81
Any MML	0.003	-0.007	-0.009	-0.019	0.014	0.031**	-0.02	-0.04
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.04)
N	143,003	82,577	131,686	78,379	143,034	82,598	143,030	82,607
Drop CA								
Proportion/mean:	0.31	0.43	0.29	0.39	0.41	0.32	1.54	1.80
Any MML	-0.001	-0.009	-0.012	-0.015	0.01	0.015	-0.032	-0.065
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)	(0.05)
N	165,197	99,229	142,904	90,599	165,219	99,249	165,229	99,261
Drop state trends								
Proportion/mean:	0.31	0.43	0.29	0.39	0.41	0.32	1.55	1.81
Any MML	-0.002	-0.007	-0.012	-0.013	0.002	0.013	0.018	0.025
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)
N	182,376	108,761	157,704	99,159	182,406	108,787	182,412	108,798
Drop time-varying X's								
Proportion/mean:	0.31	0.43	0.29	0.39	0.41	0.32	1.55	1.81
Any MML	-0.001	-0.005	-0.014**	-0.014	0.003	0.01	0.02	0.033
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)
N	182,376	108,761	157,704	99,159	182,406	108,787	182,412	108,798

Notes: Sample 1 = full sample. Sample 2 = qualifying sample. All models estimated with an LPM (binary outcome) or LS (continuous outcome), and control for individual characteristics, state characteristics, state fixed effects, interview wave fixed effects, and state-specific linear time trends; unless noted otherwise. Standard errors clustered around the state and reported in parentheses. * significant at 10 percent, ** significant at 5 percent, *** significant at 1 percent.

Table A9: Effect of MML passage on older adult labor supply outcomes, various robustness checks: HRS 1992-2012

Outcome:	Work		Work FT		Hours worked/wk	
Sample:	1	2	1	2	1	2
Drop > 75 yrs						
Proportion/mean:	0.48	0.39	0.33	0.25	3.5	3.4
Any MML	0.004	0.003	0.016***	0.018***	0.027	0.067***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
N	142,724	82,472	142,724	82,472	67,105	32,503
Drop CA						
Proportion/mean:	0.39	0.31	0.26	0.19	3.5	3.4
Any MML	0	-0.004	0.007	0.007	0.036	0.074**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)
N	164,961	99,140	164,961	99,140	63,035	31,299
Drop state trends						
Proportion/mean:	0.39	0.31	0.26	0.19	36.7	34.8
Any MML	0.012	0.012	0.022***	0.023***	0.005	0.03
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
N	182,456	108,862	182,456	108,862	69,871	34,229
Drop time-varying X's						
Proportion/mean:	0.39	0.31	0.26	0.19	36.7	34.8
Any MML	0.011	0.01	0.021***	0.022***	0.008	0.035*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
N	182,456	108,862	182,456	108,862	69,871	34,229

Notes: Sample includes HRS respondents 51 years and older. Sample 1 = full sample. Sample 2 = qualifying sample; which includes respondents who report 1 or more condition that would qualify for legal medical marijuana use. Hours worked per week are conditional on any work and are log transformed. All models estimated with an LPM (binary outcome) or LS (continuous outcome), and control for individual characteristics, state characteristics, state fixed effects, interview wave fixed effects, and state-specific linear time trends; unless noted otherwise. Standard errors clustered around the state and reported in parentheses. * significant at 10 percent, ** significant at 5 percent, *** significant at 1 percent.

Table A10: Effect of MML passage on older adult health outcomes by sex: HRS 1992-2012

Outcome:	Pain		Health lim. work		V. good/ex. health		Dep. symptoms	
Sample:	1	2	1	2	1	2	1	2
Men								
Proportion/mean:	0.26	0.40	0.27	0.34	0.42	0.33	1.32	1.55
Any MML	-0.009	-0.045**	-0.008	-0.007	0.007	0.032	-0.083***	-0.071
	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)	(0.03)	(0.05)
N	75,369	36,933	66,791	34,103	75,388	36,947	75,374	36,938
Women								
Proportion/mean:	0.34	0.46	0.30	0.40	0.41	0.32	1.70	1.96
Any MML	0.003	-0.008	-0.001	-0.01	0.018**	0.021**	0.052	0.001
	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.03)	(0.06)
N	107,007	63,834	90,913	57,585	107,018	63,846	107,038	63,865

Notes: Sample includes HRS respondents 51 years and older. Sample 1 = full sample. Sample 2 = qualifying sample; which includes respondents who report 1 or more condition that would qualify for legal medical marijuana use. All models estimated with a linear probability model and control for individual and state characteristics, state fixed effects, interview wave fixed effects, and state-specific linear time trends. Standard errors are clustered at the state level and are reported in parentheses. significant at 10 percent, ** significant at 5 percent, *** significant at 1 percent.

Table A11: Effect of state medical marijuana laws on older adult labor supply outcomes by sex: HRS 1992-2012

Outcome:	Work		Work FT		Hours wk/week	
Sample:	1	2	1	2	1	2
Men						
Proportion/mean:	0.45	0.36	0.32	0.23	39.41	36.94
Any MML	-0.009	-0.013	-0.002	0.004	0.024	0.038
	(0.01)	(0.02)	(0.01)	(0.01)	(0.03)	(0.05)
	75,278	36,901	75,278	36,901	33,323	12,864
Women						
Proportion/mean:	0.35	0.29	0.21	0.17	34.22	33.18
Any MML	0	0.006	0.008*	0.005	0.021	0.066**
	(0.01)	(0.01)	(0.00)	(0.01)	(0.02)	(0.03)
N	106,896	63,812	106,896	63,812	36,424	17,938

Notes: Sample includes HRS respondents 51 years and older. Sample 1 = full sample. Sample 2 = qualifying sample; which includes respondents who report 1 or more condition that would qualify for legal medical marijuana use. Hours worked per week are conditional on any work and are log transformed. All models estimated with a linear probability model and control for individual and state characteristics, state fixed effects, interview wave fixed effects, and state-specific linear time trends. Standard errors are clustered at the state level and are reported in parentheses. significant at 10 percent, ** significant at 5 percent, *** significant at 1 percent.