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IZA DP No. 10489

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ABSTRACT

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

We study the effect of state medical marijuana laws on labor supply among older adults; the demographic group with the highest rates of many health conditions for which marijuana may be an effective treatment. We use the Health and Retirement Study to study this question and estimate differences-in-differences regression models. We find that passage of a state medical marijuana law leads to increases in labor supply among older adults. These effects should be considered as policymakers determine how best to regulate access to medical marijuana.

JEL Classification: I10, I18, J20

Keywords: older adults, labor supply, medical marijuana, regulation, medication

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1 Introduction

Legalization of marijuana, for medicinal or recreational use, is highly controversial in the United States and globally. 28 U.S states and the District of Columbia (DC) have passed laws legalizing use of marijuana for medical purposes ('MMLs'). Critics argue that any legalization of marijuana will increase marijuana addiction, misuse of related substances, crime, traffic accidents, and healthcare costs. Advocates on the other hand highlight the potential health benefits, in terms of reducing painful symptoms related to a range of health conditions, of expanded access to medical marijuana. Given this tension, policymakers must have a solid evidence base on the potential costs and benefits of legalization as they determine how best to regulate medical marijuana.

Medical marijuana offers a new treatment option for patients suffering from a number of health conditions. Although clinical evidence is limited,[1] 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; Joy, Watson, & Benson, 1999; Lynch & Campbell, 2011). Moreover, observational studies suggest that individuals use medical marijuana to treat symptoms associated with health conditions (Nunberg, Kilmer, Pacula, & Burgdorf, 2011; Troutt & DiDonato, 2015). The most commonly cited health conditions among patients seeking medical marijuana include pain, mental health problems, nausea, and sleep disorders. The majority of medical marijuana patients report using the product as a substitute for prescription medications and that medical marijuana is more effective than their previous treatment (Nunberg et al., 2011; Troutt & DiDonato, 2015).

We study the effect of MML passage on older adult labor supply. We consider both the extensive and intensive margin. Older adults are important to study as they are more likely to suffer from many of the chronic conditions whose symptoms may be effectively treated with medical marijuana than younger adults (Gordon et al., 2002; Morgan, 2003; Leske et al., 2008; Unruh et al., 2008; Nahin, 2015). Moreover, older adults are likely to stop working as a result of poor health (Dwyer & Mitchell, 1999; McGarry, 2004; Case & Deaton, 2005; Datta Gupta & Larsen, 2010). To this end, we draw data from the Health and Retirement Study between 1992 and 2012. We estimate differences-in-differences regressions and consider the effect of MMLs that offer patients access to medical marijuana through home cultivation or dispensaries. Our findings suggest that MML implementation leads to

[1]The limited clinical research is likely due to marijuana's classification as a Schedule I drug, this classification sharply limits researchers access to such drugs for research purposes.

increases in labor supply among older adults.

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. Indeed, the Controlled Substances Act of 1970 classifies marijuana as a Schedule I drug. Schedule I is the strictest drug classification in the U.S. and is reserved for 'Drugs with no currently accepted medical use and a high potential for abuse.' Moreover, 'Schedule I drugs are the most dangerous of all the drug schedules with potentially severe psychological or physical dependence.' Schedule I drugs include ecstasy, heroin, and lysergic acid diethylamide (LSD). For comparison, cocaine is a Schedule II drug, Valium is a Schedule IV drug, and Robitussin cough syrup is a Schedule V drug.

Schedule I status severely limits researchers' capacity to utilize marijuana for clinical trials. This barrier has lead to a small set of U.S.-based marijuana clinical trails (Williams, Olfson, Kim, Martins, & Kleber, 2016; Stith & Vigil, 2016). In addition, clinical trials are only permitted to test low potency tetrahydrocannabinol (THC)[2] marijuana, which is markedly weaker than the medical marijuana available to patients through home cultivation or dispensaries, raising questions regarding the extent to which clinical trial findings generalize to actual patients' experiences (Stith & Vigil, 2016).

As of 2017, 28 states and DC have implemented MMLs. 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 specific conditions that qualify patients for medical use of marijuana, the most common qualifying conditions are cachexia, cancer, epilepsy, HIV/AIDS, muscle spasms, multiple sclerosis, and pain (Bradford & Bradford, 2016a; Sabia, Swigert, & Young, 2015).

Table 1 outlines the MML effective date for each state that has passed an MML allowing patients legal access via home cultivation or an operating dispensary through December 2013. These state law changes provide identification in our empirical models (discussed later). The first state to offer legal access to medical marijuana was California in 1996. Early MMLs tended to be implemented through voter initiatives which provided legal protection for users, but generally offered few details on how patients would access the product. More

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

recent MMLs tend to be implemented through legislative acts and offer protection for legal access to marijuana (Williams et al., 2016). We focus only on the laws that provide access to medical marijuana through home cultivation or operating dispensaries, interested readers can see Pacula, Powell, Heaton, and Sevigny (2015) for more details on state MMLs.

2.2 Medical marijuana use among older adults

Although states do not release individual-level data, our analysis of available data suggests that 20% to 60% of all registered medical marijuana users in U.S. states reporting demographic information are over age 50, or are 'older adults.'[3] Recent studies of registered users in seven states (Fairman, 2016), and convenience samples of medical marijuana patients (Nunberg et al., 2011; Reinarman, Nunberg, Lanthier, & Heddleston, 2011; Ilgen et al., 2013) provide comparable evidence that older adults represent a substantial share of medical marijuana patients.[4] 6.1% of older Americans aged 55-64 reported any form of marijuana use in the past month in 2014, since 2002 rates of use have increased 455% among this group and 333% among those 65 and above (Azofeifa, 2016). These statistics suggest that older adults are using medical marijuana, perhaps to a greater exetent that younger adults, to treat symptoms related to health conditions.

2.3 Economic analyses of state medical marijuana laws

A series of economic studies has explored the effect of expanded access to medical marijuana through MMLs on recreational use of marijuana (Anderson, Hansen, & Rees, 2015; Pacula et al., 2015; Wen, Hockenberry, & Cummings, 2015; Chu, 2014; Choi, 2014) and the use of other substances (Chu, 2013; Anderson, Hansen, & Rees, 2013; Choi, Dave, & Sabia, 2016), and the effect of these laws on health outcomes (Anderson, Rees, & Sabia, 2014; Sabia & Nguyen, 2016). Broadly, the economic literature suggests that passage of an MML increases recreational use among adult populations, but the effect of MML passage among youth populations is unclear. Moreover, passage of an MML effects the use of some related substances among adults: alcohol, heroin, and tobacco use declines following passage of an MML, while cocaine use is not affected.

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

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

Among youth and working age populations, economists find that BMI declines, self-assessed health improves, and mental health problems decline following passage of MMLs, at least among some patient populations. While a full consensus has not yet been reached, studies that consider specific attributes of state MMLs suggest that laws which provide a mechanism, such as home cultivation or dispensaries, through which patients can legally access the product are associated with more substantial changes in marijuana use and associated outcomes (e.g., Pacula et al. (2015)).

Germane our study, evidence suggests that patients are in fact using medical marijuana to treat symptoms associated with a range of health conditions following passage of an MML, particularly laws that provide legal access. In a recent study, Bradford and Bradford (2016b) analyze prescribing patterns among Medicare (Medicare is the public insurance program for older adults in the U.S.) patients (a population similar to our analysis sample of older adults). The authors document declines in prescriptions for therapeutic substitutes after passage of an MML that allows legal access for a number of conditions including pain, anxiety, depression, nausea, psychosis, seizures, and sleep disorders. The magnitude of the prescription declines is non-trivial. For example, 5.7% for pain medications, 5.0% for anxiety medications, 5.4% for nausea medications, and 4.5% for psychosis medications. In a follow up study, Bradford and Bradford (2016a) document similar substitution patterns following passage of an MML offering legal access within the Medicaid population (Medicaid is a public health insurance program for lower income adults in the U.S.). Relatedly, Bachhuber, Saloner, Cunningham, and Barry (2014) show that the passage of an MML leads to a substantial decline (24.8%) in the number of opioid-related overdose deaths, suggesting that passage of an MML allows patients to address pain symptoms through less harmful treatment options (i.e., medical marijuana vs. perscription opioid pain relievers). Powell, Pacula, and Jacobson (2015) document a similiar relationship but the authors higlight the importance of MMLs that offer legal access. Collectively, these findings suggest that passage of an MML leads to substitution towards medical marijuana and away from more conventional treatment options.

Few studies explore the effect of MML implementation on labor market outcomes. The existing studies focus on the working age population and offer mixed evidence. Sabia and Nguyen (2016) document that passage of an MML may decrease wages and Ullman (2016) shows that passage of such a law reduces work absences. Our contribution to this small literature is that we focus on older adults, a population at elevated risk for (i) experiencing health conditions whose symptoms are potentially treatable by medical marijuana and (ii) reducing labor supply in response to poor health.

2.4 Conceptual framework

Access to medical marijuana can potentially influence labor supply in several ways. The key channel through which we expect access to effect labor supply is patient health, in particular by influencing symptoms associated with health conditions. Patients may substitute medical marijuana for other treatments. However, the extent to which such medication substitution affects patient health outcomes is *ex ante* ambiguous. If medical marijuana is more effective than a patient's previous treatment program (which may include no treatment), then we expect patient health to improve. However, medical marijuana need not be more effective than other treatment options to increase labor supply. Medical marijuana may be equally effective but offer patients a less burdensome side effect profile. Conventional prescription medications for many medical marijuana-qualifying health conditions often present patients with non-trivial side effects. For 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) while patients using opioid pain relievers often suffer from cardiovascular problems, central nervous system problems, constipation, impaired judgment, itching, nausea or vomiting, and respiratory problems (Szarvas, Harmon, & Murphy, 2003; Swegle & Logemann, 2006; Chau, Walker, Pai, & Cho, 2008).

Alternatively, patients may experience worse health if marijuana is less effective than their previous treatment in terms of relieving symptoms. Moreover, 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, e.g., through dispensaries) may lose access to valuable secondary treatments. Moreover, regular interactions with healthcare providers, who may be better able to address changes in health than patients themselves, may also decline as patients withdraw from conventional healthcare.

If medical marijuana is less effective than other treatment options, substitution away from more effective treatment may lead to worsening patient health. Moreover, medical

marijuana has known side effects: difficultly with thinking and problem solving, hallucinations, increased heart rate, memory problems, paranoia, and respiratory problems among others (Hill, 2015). The intoxicating effects of marijuana itself and side effects (Hill, 2015) may reduce labor supply. Additionally, if use of medical marijuana improves health, the increased value of leisure time may decrease the desire to work, particularly among patients approaching standard retirement ages.

The implication of expanded access to medical marijuana for labor supply is therefore an empirical question and likely varies across patients. We attempt to estimate the net effects of these numerous, and potentially offsetting, mechanisms among older adults.

3 Data, variables, and methods

3.1 Health and Retirement Study

We draw data from the Health and Retirement Study (HRS) between the 1992 and 2012 interview waves (our study period extends through early 2013 when the last of the 2012 wave interviews are collected). 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 labor market and health outcomes among older adults. 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 of older adults 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.

3.2 State-level medical marijuana laws

We use legal data collected by Pacula et al. (2015) to assess states' medical marijuana law environment.[5] We construct an indicator variable for an MML that allows patients legal access to medical marijuana through either (i) home cultivation or (ii) an operating dispensary (regardless of whether the dispensary is legally protected by the state). We treat states with operating dispensaries, but do not not have a law providing protection for

[5]We thank Rosalie Pacula for sharing an updated version of this coding scheme from the RAND Drug Policy Database with us.

dispensaries, as providing patients with *de facto* legal access through dispensaries. On the other hand, we treat states that provide legal protection for dispensaries, but do not have any operating dispensaries, as not offering legal access through dispensaries. We chose to focus on MMLs that offer legal access as such laws are more likely to allow patients to obtain the medication. We match MMLs to the HRS based on the month and year of law passage.[6]

3.3 Outcome variables

We examine three labor supply measures: (i) any work in the past year, (ii) whether currently working full-time (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.

To study mechanisms through which MMLs may effect labor supply, we examine health outcomes available in the HRS for which there is some evidence that medical marijuana is an effective treatment and that have a plausible link to labor supply. Specifically, we consider measures of (i) chronic pain (any), (ii) health limiting the ability to work, (iii) self-assessed health ('SAH', excellent or very good health), and (iv) depressive symptoms (a count of the number of depressive symptoms as measured by an abbreviated eight question version of the Center for Epidemiologic Studies - Depression Scale [CES-D] used in the HRS).

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 (NIH, 2011). Self-assessed health has been shown to predict, even after conditioning on observable characteristics, more objective measures of health status such as mortality and healthcare utilization (Miilunpalo, Vuori, Oja, Pasanen, & Urponen, 1997; Benjamins, Hummer, Eberstein, & Nam, 2004; Nielsen, 2016). This measure is believed to capture aspects of 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 literature (Tian, Robinson, & Sturm, 2005; Kapteyn, Smith, & Van Soest, 2008; Atlas & Skinner, 2009; Apouey & Clark, 2015; Maclean, 2013; McInerney, Mellor, & Nicholas, 2013; Maclean, Webber, French, & Ettner, 2015; Horn, Maclean, & Strain, 2016).

[6]For some states, see Table 1, we lack an effective month for operating dispensaries. In such cases we assume January is the effective month.

3.4 Control variables

We control for respondent age, race, Hispanic ethnicity, and education in all regressions. We also include several state-level variables to account for time-varying between-state differences that may be correlated with both the passage of an MML and our outcomes, and hence minimize bias due to omitted variables. To this end, we include an indicator for whether a state has decriminalized marijuana (Pacula, Chriqui, & King, 2003), the beer tax per gallon from the Brewers' Almanac, the unemployment rate among adults 50 years and older from the Current Population Survey Outgoing Rotation Group (CPS), and hourly wages among adults 50 years and older from the CPS. We also control for a set of labor market and social policies: effective minimum 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 political affiliation (Democrat or not). We inflate all nominal values to 2012 terms using the Consumer Price Index - Urban Consumers.

3.5 Empirical model

We estimate the following regression model:

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

Y_{ist} is a labor supply outcome for older adult i in state s in year t. M_{st} is an indicator for an MML that offers legal access 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 and γ_t is a vector of interview wave dummy variables. 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 (Solon, Haider, & Wooldridge, 2015). We estimate models separately for men and women. We also report results generated in regressions that control for state-specific linear interview wave trends.

4 Results

4.1 Summary statistics

Table 2 reports summary statistics. Men are more likely to work than women in our sample: 45% and 32% of men report any work and full time work while 35% of women report any work and 21% of women work full time. Among working respondents, men work 39 hours per week and women work 34 hours per week. 14% and 13% of men and women in the full sample reside in a state with access to medical marijuana through either home cultivation or a dispensary, home cultivation is somewhat more prevalent than dispensaries: 13% vs. 11%.

4.2 Regression analysis of labor supply outcomes

Labor supply results are reported in Table 3. We find no statistically significant evidence that passage of an MML leads to an increase in labor supply among older men. Although coefficient estimates are generally positive, suggesting that labor supply increases following passage of an MML, none are statistically distinguishable from zero. Among women we observe that passage of MMLs allowing legal access do translate into increases in labor supply. More specifically, we find that passage of an MML allowing legal access leads to a 1.4 percentage point (4%) increase in the probability of any work and a 2.6 percentage point (12%) increase in the probability of full time work, the coefficient in the conditional hours worked regression is positive but imprecise.

We obtain qualitatively similar results when we control for state-specific linear interview wave trends in our regression models (Table 4). Although coefficient estimates in the male sample are all positive, suggesting that labor supply increases following passage of an MML, none are statistically distinguishable from zero. Among women, the coefficient on any work becomes imprecise, but we find that both the probability of full time work and hours worked per week (among working women) increases following passage of an MML.

4.3 Event study

A threat to our identification strategy is that MMLs are endogenously determined within states' political economies (Besley & Case, 2000). States may decide to implement an MML to address declining labor supply among older adults within their populations. If true, our estimates will be biased due to reverse causality. To address this concern we estimate an event study.

Ideally, we would like to estimate a fully non-parametric event study (Goodman-Bacon, 2016). However, the HRS is nationally representative sample and thus many of our state-interview wave cells are, not surprisingly, small. Thus, we estimate a parametric event study, which we note as a limitation. Our event study controls for pre-law trends in our outcome variable. Specifically, we construct a variable that measures the difference between the HRS interview year and the law change year for each state that ever passed an MML before or during our study period (i.e., by the end of 2013). This value takes on negative values in the pre-law period, 0 in the law change year, and positive values in the years after the following the law change. States that did not pass an MML by 2013 are coded as 0 for this variable. We refer to this variable as the 'relative year'. We interact the relative year with the MML indicator variable. We re-estimate Equation 1 including the year relative to MML and the interaction term as additional covariates.[7] The event study regression model is:

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

In this specification, β_1 captures any discrete change in our outcomes in the law change year and $(rel\_year)_{st}$ accounts for the pre-law trends that may differ between the treated and untreated states. A statistically significant β_2 coefficient would suggest policy endogeneity. If policy endogeneity is present, including this variable in the regression model should account for such endogeneity and allow us to estimate the causal effect of MMLs on our outcomes. Finally, β_3 can inform us about differences in trends in outcome variables in the post-law period for the treated and untreated states.

Table 5 presents event study results for labor supply outcomes. Overall, our event study provides some evidence of policy endogeneity in the older men sample: the estimate on β_2 as statistically different from zero in the any work regression and the coefficient carries a negative sign, suggesting that work propensities may have been declining in states that would eventually pass an MML. However, policy endogeneity does not drive our central findings. As in the basic DD regressions, β_1 estimates are not statistically different from zero (although the coefficient estimates in the any work and full time work are positive while the coefficient estimate in the conditional hours worked regression is negative). Estimates of β_3 imply, although not revealed in our main DD models, that any work and full time work propensities in the treated states are trending upward (relative to comparison states) in the

[7] We do not include state-specific linear interview wave trends as inclusion of such variables may muddle the interpretation of regression coefficients (Wolfers, 2006).

post-law period. This trend suggests that, over time, older men residing in states that pass an MML experience increases in their work propensities relative to comparable men residing in states that do not pass an MML. For example, in the any work regression, the β_3 estimate is 0.0002 which implies that in each year following the MML passage, the probability of any work in the treatment group (states passing an MML) increases by 0.02 percentage points (0.4%) in the full sample.

Findings generated in the event study are broadly similar among older women. However, we do not observe any evidence of policy endogeneity: all estimates of β_2 are statistically indistinguishable from zero. The estimates on β_1 suggest an immediate increase in the probability of full time work at the time of the MML passage (the coefficient in the any work regression is also positive, but is imprecise). For women, passage of an MML leads to increased probability of both any work and full time work in the post period, more specifically, in each year post-law women in treated states are 0.03 percentage points (0.09%) more likely to work and 0.01 percentage points (0.05%) more likely to work full time. Our findings suggest that in the post-law period, conditional hours worked per week is declining among older women.

4.4 Regression analysis of health outcomes

We explore whether the labor supply effects that we observe following MML passage may be explained by improvements in health conditions whose symptoms are potentially treatable with medical marijuana. Results are reported in Table 6. Among men, we find that passage of an MML that allows legal access leads to a 2.4 percentage point (9%) decrease in the probability that health limits work, but we observe no other statistically significant evidence that passage of an MML impacts the health conditions we study. Among women, we find that passage of an MML that allows legal access is not associated with any statistically significant changes in chronic pain or self-assessed health, but we do find that passage of such a law leads to a 0.047 unit (3%) *increase* in reported depressive symptoms.

Including state-specific linear interview wave time trends produces similar results for health limiting work and depressive symptoms (Table 7). However, we find some evidence that following passage of an MML, women report more pain, and both men and women are more likely to report their health as excellent or very good.

The finding that passage of an MML appears to worsen pain and depressive symptomatology among women is not inconsistent with the potential pathways through which medical marijuana may impact health outcomes (or symptoms associated with underlying health

conditions). For instance, women moving from conventional treatment of pain, which often entails the use of both opioid pain relievers and anti-depressants, to medical marijuana, could experience increased pain and depressive symptomatology after discontinuing anti-depressants. Women are more likely to receive treatment for mental health conditions than men (Hinton, Zweifach, Tang, Unützer, & Oishi, 2006; Pattyn, Verhaeghe, & Bracke, 2015), making them the group where we would expect to see results if substitution of medical marijuana is differentially effective from previous treatment. The discontinuation of anti-depressants may also lead to worsening pain symptoms among women.

There are several possible explanations for the labor supply response among women despite the mixed health effects. We examine only a sub-set of potentially relevant health measures due to data availability. Women may experience health gains in conditions that we cannot measure which facilitate increased labor supply. Second, we do not know how the measures of health we study 'sum up' to capture overall health, which may improve even if some health measures decline with passage of an MML. Some scholars view self-assessed health as capturing an overall measure of health (Simon, Soni, & Cawley, 2016). This interpretation of self-assessed health might suggest that health overall improves for both men and women. Third, marijuana may have fewer side effects which may permit work. Fourth, our regression models estimate average treatment effects and it may be that different sub-populations of women experience different health effects from expanded access to medical marijuana through MMLs. The labor supply effects we observe may be driven by those women for whom symptoms improve (or for whom medication side effects decline). Finally, older women provide a substantial amount of caregiving, particularly to their spouses. Reductions in symptoms among men may lessen womens' caregiving responsibilities and allow these women to increase labor supply.

4.5 Robustness checks

We conduct several robustness checks (available on request). Our identification strategy assumes that the changes in labor supply outcomes observed after states pass MMLs are driven by the laws themselves, and not an unobserved third factor. We test this hypothesis by conducting a Monte Carlo simulation in which we randomly assign with replacement actual state legislative histories to our 50 states and DC, and estimate the effect of these false laws. Across 100 simulations, our mean point estimates are small and statistically indistinguishable from zero in all regressions. Older adults may migrate to states that have passed an MML to access the new medical treatment. Such migration patterns may lead us

to overstate MML effects. We explore this possibility by regressing an indicator of whether a respondent had moved since the last wave on the MML status from the previous wave. We find no evidence of a relationship between MMLs and cross-state moves. We have estimated a number of alternative specifications including use of respondent fixed effects, restricting our analysis population to adults under 75 (i.e., respondents most likely to work), allowing for a year lag between the passage of an MML and our outcomes, and excluding California (this state was the first state to pass an MML and represents a disproportionately large share of the sample). Results generated in these alternative specifications are qualitatively the same as our main results.

5 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 labor supply. We find that passage of a state MML that allows patients to legally access the product leads to increases in labor supply among older adults, although effects for older men are not concurrent with MML passage and instead emerge over time. Moreover, the labor supply effects we identify are on both the extensive and intensive margin. One exception to this pattern of results is that we find some evidence that older women residing in treated states may reduce the number of hours they work per week in the post-MML period.

While novel in many ways, our study has limitations. First, 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. Second, our identification strategy only uses variation in MMLs for those states that implemented such laws during our study period. Third, like 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.

The policy debate surrounding legalization of marijuana, for medical or recreational purposes, is fierce. Policy makers must carefully weigh the costs and the benefits of such legalization. In terms of medical marijuana, many previous economic studies have examined the potential costs to legalization among youth and working age adults. We provide evidence that there may be benefits in terms of labor supply and health of older adults, a population that, based on anecdotal evidence, is indeed using marijuana medically to address health

needs. Taken in combination with findings that MMLs may reduce body weight (Sabia et al., 2015), improve physical well-being (Sabia et al., 2015), reduce suicide rates among some sub-populations (Anderson et al., 2014), lower opioid-related overdoses (Bachhuber et al., 2014; Powell et al., 2015), and reduce alcohol-related traffic accidents (Anderson et al., 2013), our findings suggest that there are potentially important social benefits to MMLs that must be considered in policy decisions regarding regulation of medical marijuana.

Table 1: State medical marijuana laws 1996-2013

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

Notes: Sources: Pacula et al. (2015). We lack an effective month for operating dispensaries in some states, in this case we code the dispensary as open January 1.

Table 2: Summary Statistics: HRS 1992-2012

Sample:	Men	Women
Labor supply outcomes		
Any work	0.45	0.35
Work full time	0.32	0.21
Hours worked per week (conditional on working)	39.41	34.22
Health outcomes		
Any pain	0.26	0.34
Health limits work	0.27	0.30
Excellent or very good health	0.42	0.41
Depressive symptoms	1.32	1.70
State medical marijuana laws		
Legal access	0.14	0.13
Home cultivation	0.13	0.13
Operating dispensary	0.11	0.11
Respondent characteristics		
Age	66.39	66.58
White	0.82	0.79
African American	0.13	0.17
Other race	0.05	0.04
Hispanic	0.09	0.09
Less than high school	0.45	0.37
High school	0.27	0.34
Some college	0.28	0.29
State characteristics		
Marijuana decriminalized	0.32	0.32
Beer tax per gallon (dollars)	0.26	0.27
Unemployment rate among adults 50+	0.04	0.04
Hourly wage among adults 50+	18.07	18.12
Effective minimum wage	5.77	5.77
State EITC/Federal EITC	0.13	0.11
Max food stamp benefit	487.72	488.13
Democrat Governor	0.46	0.46
N	75,628	107,404

Notes: Sample includes HRS respondents 51 years and older between 1992 and 2012.

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

Outcome:	Any work	Work full time	Hours (conditional)
Men			
Proportion/mean	0.45	0.32	39.41
Legal access	0.014	0.014	-0.014
	(0.012)	(0.010)	(0.013)
N	75,227	75,227	33,297
Women			
Proportion/mean	0.35	0.21	34.22
Legal access	0.014*	0.026***	0.013
	(0.007)	(0.005)	(0.020)
N	106,851	106,851	36,408

Notes: All models estimated with a linear probability model (binary outcome) or least squares (continuous outcome), and control for individual and state characteristics, state fixed effects, and interview wave fixed effects. Hours are logged in regressions but not in summary statistics. Standard errors are clustered at the state level and are reported in parentheses. %*; %**; and %, *** = Statistically significant at the 10%; 5%; and 1% level.

Table 4: Effect of state medical marijuana laws on older adult labor supply outcomes including state-specific linear interview wave trends: HRS 1992-2012

Outcome:	Any work	Work full time	Hours (conditional)
Men			
Proportion/mean	0.45	0.32	39.41
Legal access	0.004	0.000	0.001
	(0.010)	(0.008)	(0.021)
N	75,227	75,227	33,297
Women			
Proportion/mean	0.35	0.21	34.22
Legal access	-0.007	0.010*	0.046*
	(0.010)	(0.005)	(0.024)
N	106,851	106,851	36,408

Notes: All models estimated with a linear probability model (binary outcome) or least squares (continuous outcome), and control for individual and state characteristics, state fixed effects, interview wave fixed effects, and state-specific linear interview wave trends. Hours are logged in regressions but not in summary statistics. Standard errors are clustered at the state level and are reported in parentheses. %*; %**; and %, *** = Statistically significant at the 10%; 5%; and 1% level.

Table 5: Effect of state medical marijuana laws on older adult labor supply outcomes using an event study: HRS 1992-2012

Outcome:	Any work	Work full time	Hours (conditional)
Men			
Proportion/mean	0.45	0.32	39.41
Legal access	0.0089	0.0051	-0.006
	(0.0118)	(0.0097)	(0.0145)
Relative year	-0.0001*	0.0000	-0.0001
	(0.0001)	(0.0001)	(0.0001)
Relative year * post-law period	0.0002**	0.0002**	0.0000
	(0.0001)	(0.0001)	(0.0001)
N	75,227	75,227	33,297
Women			
Proportion/mean	0.35	0.21	34.22
Legal access	0.0032	0.0153*	0.0216
	(0.0080)	(0.0057)	(0.0212)
Relative year	-0.0001	0.0001	0.0000
	(0.0001)	(0.0001)	(0.0001)
Relative year * post-law period	0.0003**	0.0001*	-0.0002*
	(0.0001)	(0.0001)	(0.0001)
N	106,851	106,851	36,408

Notes: All models estimated with a linear probability model (binary outcome) or least squares (continuous outcome), and control for individual and state characteristics, state fixed effects, and interview wave fixed effects. Hours are logged in regressions but not in summary statistics. Standard errors are clustered at the state level and are reported in parentheses. %*; %**; and %, *** = Statistically significant at the 10%; 5%; and 1% level.

Table 6: Effect of state medical marijuana laws on older adult health outcomes: HRS 1992-2012

Outcome:	Any pain	Health limits work	SAH	Depressive symptoms
Men				
Proportion/mean	0.26	0.27	0.41	1.32
Legal access	0.000	-0.024***	0.010	-0.013
	(0.01)	(0.01)	(0.01)	(0.03)
N	75,369	66,791	75,388	75,374
Women				
Proportion/mean	0.34	0.30	0.42	1.70
Legal access	0.004	-0.007	0.006	0.047**
	(0.01)	(0.01)	(0.01)	(0.02)
N	107,007	90,913	107,018	107,038

Notes: All models estimated with a linear probability model (binary outcome) or least squares (continuous outcome), and control for individual and state characteristics, state fixed effects, and interview wave fixed effects. SAH=self-assessed excellent or very good health. Standard errors are clustered at the state level and are reported in parentheses. %*; %**; and %, *** = Statistically significant at the 10%; 5%; and 1% level.

Table 7: Effect of state medical marijuana laws on older adult health outcomes including state-specific linear interview wave trends: HRS 1992-2012

Outcome:	Any pain	Health limits work	SAH	Depressive symptoms
Men				
Proportion/mean	0.26	0.27	0.41	1.32
Legal access	-0.010	-0.024***	0.021**	-0.077
	(0.01)	(0.01)	(0.01)	(0.05)
N	75,369	66,791	75,388	75,374
Women				
Proportion/mean	0.34	0.30	0.42	1.70
Legal access	0.012*	0.000	0.021***	0.063***
	(0.01)	(0.01)	(0.01)	(0.02)
N	107,007	90,913	107,018	107,038

Notes: All models estimated with a linear probability model (binary outcome) or least squares (continuous outcome), and control for individual and state characteristics, state fixed effects, interview wave fixed effects, and state-specific linear interview wave trends. SAH=self-assessed excellent or very good health. Standard errors are clustered at the state level and are reported in parentheses. %*; %**; and %, *** = Statistically significant at the 10%; 5%; and 1% level.

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