ADDICTION

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Letters to the Editor

MEDICAL MARIJUANA LAWS, SUBSTANCE USE TREATMENT ADMISSIONS AND THE ECOLOGICAL FALLACY

Sir: Meinhofer *et al.* [1] analyzes administrative data from state medical marijuana laws and substance use treatment admissions in an ecological study design to show that medical marijuana laws are associated with state-level increases in marijuana, alcohol and cocaine treatment admissions among pregnant women. While these findings are provocative, the utility of ecological analyses in assessing the effects of medical marijuana use is severely limited and this study's results could reflect bias, rather than an individual-level effect.

Ecological studies are susceptible to a bias commonly referred to as the 'ecological fallacy'—the (often implied) assumption that correlations occurring at the population-level parallel correlations at the individual level [2]. This assumption is sometimes true, but not always; indeed, correlations that exist when analysing population-level data may not exist or may even be reversed when analysing individual-level data. Researchers must use individual-level data to reliably discern the individual-level effect of medical marijuana use, an individual-level exposure.

Concern over the ecological fallacy in studies correlating medical marijuana laws with population-level have been expressed several times in the research literature [3–7], and this study invokes the same concern. As an ecological study using state-level data, Meinhofer *et al.* [1] should not be used as evidence that an individual's medical marijuana use is correlated with an increased likelihood that the individual enters substance use treatment.

Why, then, are ecological studies still regularly published? First, not all ecological analyses are inappropriate. For example, when an exposure universally affects the population of interest (e.g. almost all cigarette smokers are affected by cigarette tax increases), an ecological study may reliably capture increases in individual risk. This is generally not the case for medical marijuana; only approximately 2.5% of adults in medical marijuana states actually use medical marijuana, and the rest are unlikely to experience significant health benefits or consequences from medical marijuana legalization [8]. The present study's focus on marijuana treatment admissions may strengthen the reliability of its results, as marijuana users are probably disproportionately affected by marijuana-related laws; however, the exposure is probably still far from universal.

Further, some argue that ecological studies act as preliminary evidence to provoke further individual-level investigation. However, marijuana researchers should be cognizant that (a) lay people may not be equipped to discern preliminary evidence from conclusive results in peer-reviewed studies and (b) advocates on both sides of the medical marijuana debate often disseminate study headlines that support their viewpoint (regardless of study rigour and usually omitting any limitations). Consequently, marijuana researchers should take care to clearly communicate the limitations of their work or, failing that, choose not to publish such preliminary results.

In this case, researchers, policymakers and the public should be well informed that the population-level correlation observed between medical marijuana laws and substance use treatment admission may reflect bias and the ecological fallacy, rather than the effects of medical marijuana use.

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MEDICAL MARIJUNA LAWS: RESPONSE TO CAPUTI

In his response to our study [1], Caputi [2] expressed concern that our findings might be susceptible to the ecological fallacy—the assumption that population-level correlations parallel individual-level correlations. He correctly argued that: 'researchers must use individual-level data to reliably discern the individual-level effect of medical marijuana use (MMU), an individual-level exposure'. This, however, was not the association that our study aimed nor claimed to discern. What our study aimed to discern was the association between medical marijuana laws (MMLs), a state-level exposure, and state-level marijuana treatment admissions by pregnant women. MMU and MMLs are not equivalent exposures, and MMLs are not an individual-level exposure. As such, Caputi's argument is misdirected.

As a state-level exposure, MMLs may generate spillovers not only affecting MMU, but also illicit marijuana use (IMU) and other substance use among non-patients. The economics literature describes that spillovers may occur through networks or general equilibrium effects [3]. Examples of MML-induced spillovers include illegal drug market responses affecting marijuana potency or prices; changes in health-care provider practices; changes in beliefs about the punishment risk, safety and stigma of IMU; and greater availability of diverted marijuana initially intended for MMU. Marijuana treatment admissions, our primary outcome and one that is necessarily preceded by marijuana use, may be affected by MML-induced changes in MMU or IMU. Additionally, it may be affected by changes in the probability of entering substance use disorder (SUD) treatment, even in the absence of changes in MMU or IMU. This might occur through greater marijuana use surveillance by providers or law enforcement.

Despite MMLs being a state-level exposure, we certainly agree with Caputi that individual-level data would be preferable, as it would allow to control for potential individual-level confounders. Unfortunately, the National Survey of Drug Use and Health used in previous MML studies analyzing individual-level marijuana measures (e.g. use, use disorder, treatment) for the general population is not large enough for the pregnant women subpopulation. Instead we relied on the Treatment Episode Data Set, which captures a large number of pregnant women entering SUD treatment. However, as all individuals in our data can be affected by MMLs, an individual-level analysis of marijuana treatment admissions relative to other treatment admissions would be problematic. We addressed this issue by aggregating admissions at the state-level and dividing them by state-level population estimates, a more appropriate denominator.

We mitigated potential bias with a difference-in-differences design exploiting the staggered implementation of MMLs and showed that results were robust to numerous controls. Perhaps most importantly, we did not report our results in isolation but reconciled them with the broader marijuana literature to strengthen their interpretation and credibility. We cited numerous studies using individual-level data and documenting a positive association between MMLs and marijuana measures among adults; greater marijuana use by pregnant women nation-wide; changes in beliefs regarding the safety of marijuana use during pregnancy; potential therapeutic benefits of marijuana use for pregnant women experiencing nausea; dispensaries recommending marijuana use for pregnancy-related nausea; and that 18% of pregnant woman with marijuana use disorder enter treatment [4].

Given nation-wide growth in marijuana use by pregnant women, changes in public perceptions about marijuana safety, recent findings that individual-level marijuana use by pregnant women increased after legalization in Washington [5] and findings from our study linking MMLs to increases in state-level marijuana treatment admissions by pregnant women, more research is needed to understand the effects of MMLs on pregnant women and their offspring.

Declaration of interests

None.

Keywords Marijuana use, medical marijuana laws.

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