

AJPH LETTERS AND RESPONSES

POPULATION-LEVEL ANALYSES CANNOT TELL US ANYTHING ABOUT INDIVIDUAL-LEVEL MARIJUANA-OPIOID SUBSTITUTION

Livingston et al.¹ studied the state-level correlation between opioid overdose deaths and recreational marijuana legislation. In the article's introduction, the authors claim that the study will contribute to the literature on "whether cannabis is substituted for opioids in pain management," and the reader is given the premise that "with this substitution, an immediate reduction in opioid-related poisonings would be expected." Therefore, those who read the study's findings—that recreational marijuana legislation was followed by 0.7 fewer opioid overdose deaths statewide per month—are led to believe that the study constitutes evidence that pain-afflicted individuals in Colorado are substituting marijuana for opioids.

This conclusion is an example of the well-known "ecological fallacy"—the often-incorrect assumption that population-level trends will be replicated on the individual level. In fact, despite the negative correlation that Livingston et al.¹ found at the population

level, the correlation between marijuana use and opioid use among the underlying individuals could be negative, negligible, or even positive. That is, the findings by Livingston et al. do not provide compelling evidence of an individual-level substitution effect between marijuana and opioid use.

The ecological fallacy is explained thoroughly elsewhere,²⁻⁴ but the lesson of the ecological fallacy is conveyed nicely in the title of an *AJPH* letter⁵ regarding a similar study: "State-Level Relationships Cannot Tell Us Anything About Individuals." As applied to the article by Livingston et al., we can infer that state-level data surrounding marijuana legislation and opioid death rates cannot tell us anything about individuals' substitution behaviors.

Studies about marijuana legalization are likely to attract substantial attention from the media, the general public, and activists, many of whom will not appreciate methodological nuances. Therefore, it is important that authors clearly lead their readers away from drawing overly expansive conclusions from research findings. Unfortunately, Livingston et al.¹ do the opposite. *AJPH*

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CONTRIBUTORS

Both authors conceptualized the letter. T. L. Caputi wrote the draft of the letter, and K. A. Sabet provided constructive edits.

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LIVINGSTON ET AL. RESPOND

We appreciate the opportunity to respond to Caputi and Sabet's letter to the editor concerning our recent article. In our article, we briefly discussed the substitution of cannabis for opioids as one possible mechanism by which cannabis legalization may affect opioid-related deaths, because a growing body of literature supports the hypothesis of substitution.¹⁻³ We agree with Caputi and Sabet that our study was not designed or intended to examine individual-level drug substitution patterns—our objective was evaluating the effects of a natural experiment in state-level policy.

Ecological fallacy in the context of interrupted time-series designs deserves further comment. Some have a simplistic dismissive reaction to aggregate data and assume that any inference made from these data runs afoul of the ecological fallacy, which is not the case. Bias resulting from ecological fallacy, a form of cross-level confounding, is a function of both the use of aggregate-level data and the study design. For an interrupted time-series design

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