

Heroin overdose death rates climbed after 2010.<sup>1</sup> We specified random-effects meta-analysis comparisons of 2 intervals and found that, from 2006 to 2010, risk of dependence was 23.7% (95% CI, 16.8%-30.6%) vs 41.7% (95% CI, 35.3%-48.0%) from 2011 to 2016. We then explored 2002 to 2010 and derived an estimate of 20.1% (95% CI, 15.5%-24.7%). We compared the estimate of 20.3% (95% CI, 14.6%-25.9%) in 2002 to 2009 with 39.9% (95% CI, 31.4%-48.5%) from 2010 to 2016.

**Discussion** | When observed within approximately 1 to 12 months after heroin onset, an estimated 23% to 38% of new heroin users have become dependent on heroin. Rank-order correlation and post hoc exploratory analyses prompt a hypothesis of recently increased odds of becoming dependent on heroin.

Seeking estimates for comparison, we found 3 published studies on how often heroin dependence was found among people who have used heroin at least once in their lifetime. The National Comorbidity Survey (1990-1992) estimate was 23% dependence rate (with a standard error [SE] of 5%); National Epidemiologic Survey on Alcohol and Related Conditions (2001-2002) estimate (SE) was 28% (4%); and National Epidemiologic Survey on Alcohol and Related Conditions-III (2012-2013) estimate (SE) was 25% (2%).<sup>4,6</sup> These 3 values yield a random-effects meta-analysis summary of 26%, with a 95% CI of 22% to 29%, which clearly overlaps this study's overall finding of 23% to 38% of all participants becoming heroin dependent soon after first heroin use.

**Limitations.** In comparing this article with other surveys, differences in methods deserve consideration (eg, recall errors; cumulative odds of competing heroin dependence-associated risks, such as fatal overdose or incarceration; and left-truncation processes).<sup>5,6</sup> In addition, estimates for 2002 through 2005 are from random-effects meta-analysis models and should be considered as post hoc exploratory data analyses completed after visual inspection of the year-specific estimates. Finally, all conclusions are subject to reevaluation when 2017 to 2018 NSDUH data files are released.

**Conclusions** | Irrespective of whether US heroin users now experience increased odds of becoming heroin-dependent, general principles indicate that primary prevention and early outreach initiatives are needed to control the spread of the nation's current heroin epidemic. We now lack evidence-based interventions for new heroin users before dependence develops and before medication-assisted treatment is indicated. Neglect of new users might foster incrementally greater challenges and costs in the expansions of heroin dependence treatment service responses to the current public health emergency.

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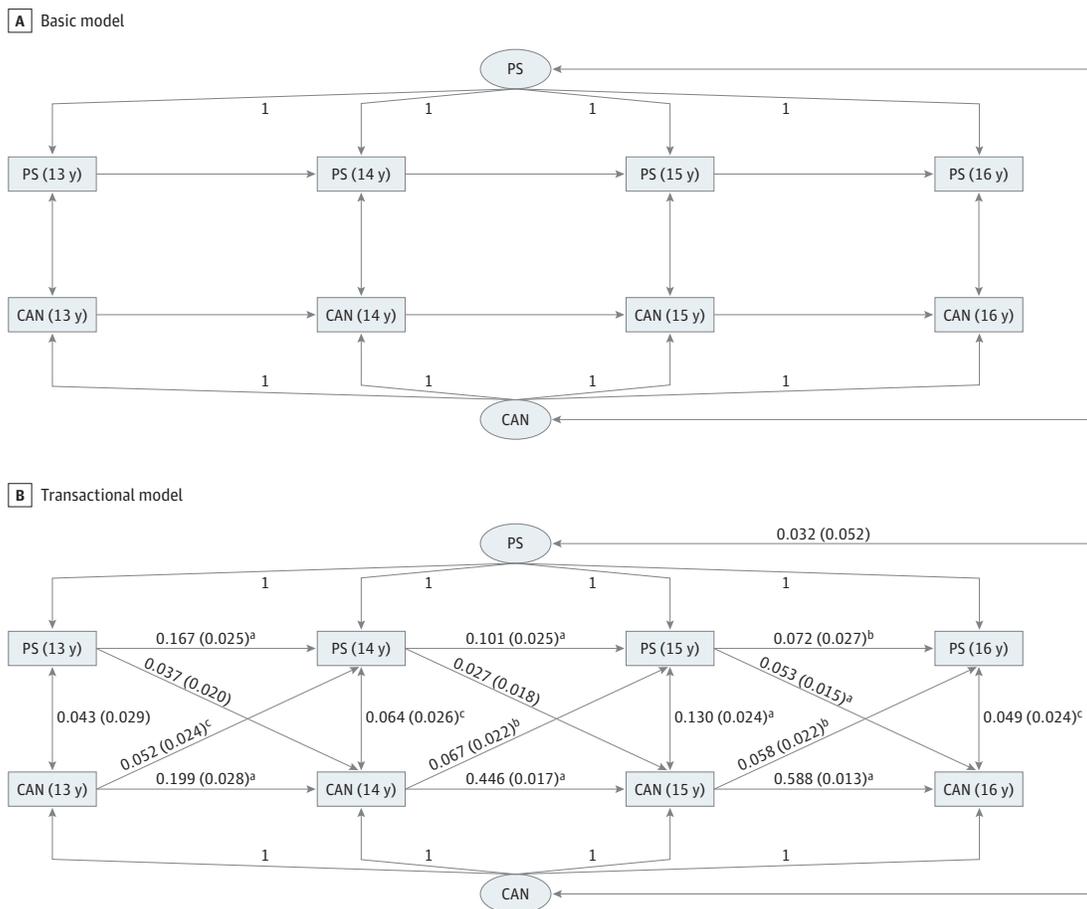
**Additional Contributions:** These data are from open access public use data files that can be downloaded as Public Use Files from the US Substance Abuse and Mental Health Data Archive web site (<https://pdas.samhsa.gov/#/>). The authors agree to provide Stata do-files to create the study variables by request to the senior author (Dr Anthony).

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## Association of Cannabis Use With Adolescent Psychotic Symptoms

Considering that jurisdictions are moving toward cannabis legalization and the anticipated changes to the Canadian policy planned for July 2018, there is a need to understand whether cannabis use has a causal role in the development of psychiatric diseases, such as psychosis. Prospective stud-

**Figure. The Basic and Transactional Versions of the Random-Intercept Cross-Lagged Panel Model Between Cannabis Use (CAN) Frequency and Psychosis Symptoms (PS) During Adolescence (Age Range, 13-16 Years)**



A, The basic model includes random intercepts (traitlike stability, also known as between-person differences), autoregressive paths (stability within a specific variable across time points), and cross-sectional correlations at each time point (within-time correlations across variables) but does not include cross-lagged paths (directional lagged associations between variables). B, The transactional model includes random intercepts, autoregressive paths, cross-sectional correlations, and cross-lagged paths. Only standardized parameter estimates are reported in the model. Both the basic model and the transactional model fitted the data well according to all 4 fit measures. For the basic model,  $\chi^2_{15} = 48.22, P < .001$  (root-mean-square error of approximation [RMSEA], 0.02; Comparative Fit Index [CFI], 0.99; and standardized root-mean-square residual

[SRMR], 0.02); for the transactional model,  $\chi^2_5 = 26.07, P = .002$  (RMSEA, 0.02; CFI, 1.00; and SRMR, 0.01). The  $\chi^2$  difference test favored the transactional model ( $\Delta\chi^2_6 = 22.15, P = .001$ ). The first time point occurred at a mean age of 12.8 years. Twelve months separate each assessment. In total, 3226 (86.7%) and 3510 (94.4%) of participants had a minimum of 2 time points out of 4 on PS and CAN, respectively. The parenthetical after CAN and PS represents cannabis use frequency at the specified age.

<sup>a</sup>  $P < .001$ .

<sup>b</sup>  $P < .01$ .

<sup>c</sup>  $P < .05$ .

ies report a temporal precedence of cannabis use before later onset of psychosis,<sup>1</sup> but the evidence is limited with respect to causality due to studies only assessing psychosis symptoms (PS) at a single follow-up and by relying on analytic models that might confound intra-individual processes with initial between-person differences. In the absence of an experimental design, random intercept cross-lagged panel models (RI-CLPMs) provide the most rigorous test of causal predominance between 2 outcomes by quantifying the temporal association over multiple follow-up periods and by dissociating within-person and between-person variance.<sup>2</sup> Using this approach, we investigated year-to-year associations between cannabis use and PS over 4 years in youth aged 13 years at study onset.

**Methods |** This analysis capitalizes on the developmentally informed Co-Venture cohort,<sup>3</sup> which includes 76% of all grade 7 students attending 31 secondary schools in the greater Montreal, Quebec, Canada, area, representing 15% of all schools in the area and each of their respective school districts in size and deprivation indexes within 1.5 SD. A total of 3966 adolescents actively assented to be part of the study and completed a confidential annual web-based survey from age 13 to 16 years involving self-report of past-year cannabis use and PS. Psychosis symptoms were assessed with the Adolescent Psychotic-Like Symptoms Screener,<sup>4</sup> and cannabis use frequency was assessed with a 6-point scale (0 indicates never, and 5 indicates every day). The CHU Sainte-Justine Research Center ethics committee approved this research.

Reliability of substance use was evaluated using a sham drug item. Students with at least 1 data point were included in the analysis. A “missing completely at random test” using the R package “MissMech” (<https://CRAN.R-project.org/package=MissMech>) confirmed that the data were missing at random.

The RI-CLPM uses a multilevel approach to test for within-person differences that inform on the extent to which an individual’s increase in cannabis use precedes an increase in this individual’s PS (and vice versa).<sup>2</sup> The models were implemented in MPLUS 8 (<http://www.statmodel.com>), with  $\alpha = .05$ , using the full information maximum likelihood (FIML) method.

**Results** | The final sample included 3720 adolescents (mean [SD] age, 12.8 [0.4] years; 1828 [49.1%] female). A basic model containing only autoregressive paths, random intercepts, and within-time correlations across variables was first tested, followed by a transactional model that also contained cross-lagged associations (Figure). The  $\chi^2$  difference test favored the transactional model ( $\Delta\chi^2_6 = 22.15$ ,  $P = .001$ ).

The transactional model revealed statistically significant positive cross-lagged associations, at every time point, from cannabis use to PS reported 12 months later, over and above the random intercepts of cannabis use and PS (between-person differences). These cross-lagged associations were similar in size to the autoregressive link (annual stability) between PS from ages 15 to 16 years. Psychosis symptoms at age 15 years had a statistically significant positive association with cannabis use at age 16 years. All autoregressive links and within-time correlations at ages 14, 15, and 16 years were also statistically significant.

**Discussion** | This analysis demonstrates a predominant association at the individual level of cannabis use frequency with increased PS, and not the opposite, in the general population at a developmental stage when both phenomena have their onset. One limitation was that cannabis use and PS were not confirmed with clinician or collateral reports. However, previous work has shown positive predictive values ranging from 80% to 100% from 3 self-report items to identify interview-verifiable PS.<sup>5</sup> Furthermore, self-report is the most efficient way to assess substance use when there are no consequences to reporting because collateral reports and biologic measures are not sensitive to the sporadic nature of adolescent substance use.<sup>6</sup>

Considering that PS are associated with risk for psychosis, as well as nonpsychotic disorders, these results emphasize the need for targeted cannabis use prevention as jurisdictions revise their cannabis regulatory policies. Promoting evidence-based interventions and policies that reduce access to and demand for cannabis among youth could lead to population-based reductions in risk for major psychiatric conditions.

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## CORRECTION

**Incomplete Author Name Indexed:** In the Original Article titled “Glucose Metabolism in Patients With Schizophrenia Treated With Atypical Antipsychotic Agents: A Frequently Sampled Intravenous Glucose Tolerance Test and Minimal Model Analysis,”<sup>1</sup> published in January 2005 in *JAMA Psychiatry* (then *Archives of General Psychiatry*), an incomplete author name was indexed. The fifth coauthor’s name should have been indexed as Evins AE instead of Evins E.

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