Cigarette, electronic cigarette, and marijuana use among young adults under policy changes in California

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ABSTRACT

Introduction: Since 2016, California has implemented a series of policies, including prohibiting the sale of tobacco products and electronic cigarettes (e-cigarettes) to persons under 21, cigarette tax increase, and recreational marijuana legalization. The study aims to examine the use of cigarettes, e-cigarettes, and marijuana among young adults (ages 18–25) and their associations with other factors in the context of these policy changes.

Methods: We used the data from the California Health Interview Survey (CHIS) 2017–2018 to compare the rates of using cigarettes, e-cigarettes, and marijuana separately or any use of the three. Using CHIS 2018 data, weighted logistic regression models were used to examine associations of using cigarettes, e-cigarettes, and marijuana separately or any use of these products/substance with demo-socioeconomic factors, psychological distress, and use of each product/substances.

Results: Cigarette smoking remained flat while the use of e-cigarettes and marijuana escalated among young adults from 2017 to 2018. Using tobacco products increased the use of marijuana or vice versa among young adults. Severe psychological distress was significantly associated with cigarette use (adjusted odds ratio [AOR] = 4.06; 95% CI = 1.32, 12.55), marijuana use (AOR = 2.32; 95% CI = 1.10, 4.48), and any use (AOR = 4.11; 95% CI = 1.93, 8.77). Moderate psychological distress was also significantly associated with the use of these products/substance. Underage (ages 18–20) young adults had lower odds of using cigarettes than other young adults (ages 21–25).

Conclusions: Our findings highlight the importance of addressing the use of cigarettes, e-cigarettes, and marijuana simultaneously through policies to curtail tobacco and marijuana use among young adults.

1. Introduction

The U.S. Cannabis Administration and Opportunity Act introduced in 2021 would decriminalize marijuana federally. California’s policy changes related to tobacco and cannabis use would inform these discussions on the short-term and long-term impact of such policies, especially among young people. The state of California has legalized recreational marijuana use for adults who are aged 21 years or older from January 1, 2018, but the state also fortified a policy environment reducing cigarette and vaping use. Individuals under 21 years old were prohibited to purchase tobacco products and e-cigarettes in California since June 9, 2016; and because e-cigarettes have been counted in California’s smoke-free laws, both tobacco products and e-cigarettes are prohibited in workplaces and many public areas. The cigarette tax was raised by $2 per pack to discourage cigarette smoking in California on April 1, 2017. Thus, all these state-level policies adopted between June 2016 and January 2018 made the state to be a natural experimental ground to investigate young adults’ tobacco and marijuana use behaviors and related risk factors in the context of the adoption of the policies (Meng and Ponce, 2020).

Young adults are particularly at risk for harm and addiction, as the use of tobacco products in any form and long-term recreational marijuana use (National Academies of Sciences, Engineering, and Medicine, 2017) can be harmful to their health and well-being (National Center for...
enabling the provision of timely population-representative health in
you smoked at least 100 or more cigarettes in your entire lifetime?
respondents who answered yes to the CHIS question,
tified and retained for the main analyses. We also used 2018 CHIS data
administered in English, Spanish, Cantonese, Mandarin, Korean,
ticipants provided informed consent.
In this study, we focus on the current use (any use in the past 30 days)
of cigarettes, e-cigarettes, and marijuana among Californians ages 18 to
25. We compared the rates in current use between 2017 (the year with the
25. We compared the rates in current use between 2017 (the year with the
to compare the rates of current cigarette/e-cigarette/marijuana use with
those in 2017.
products/substance separately, and the use of these
products/substance in relationship with psychological distress. This
population-based study on young adults gives us an important insight
into cigarette, e-cigarette, and marijuana use behaviors in the context of
major policy changes. The findings will enhance the understanding of
the use and inform the design of programs aimed at curbing the use of
these products/substances simultaneously by young adults.

2. Materials and methods

2.1. Data and samples

All procedures described here were approved by the Institutional
Review Boards of the Universities of California, Los Angeles. All par-
ticipants provided informed consent.

The study population was drawn from the 2018 California Health
Interview Survey (CHIS) in conjunction with data from the 2017 CHIS
annual data file. Starting in 2011, CHIS became a continuous survey,
generating an annual household sample of approximately 20,000,
with the CHIS 2018 data file, a total of 3,929 young adults were iden-
tified and retained for the main analyses. We also used 2018 CHIS data
to compare the rates of current cigarette/e-cigarette/marijuana use with
those in 2017.

2.2. Outcome measures

We used the responses to several questions to define the outcome
variables: current users (any use of cigarettes, e-cigarettes, or marijuana
in the past 30 days). Specifically, to define current cigarette smoking,
respondents who answered yes to the CHIS question, “Altogether, have
you smoked at least 100 or more cigarettes in your entire lifetime?” were
asked, “Do you now smoke cigarettes every day, some days, or not at
all?” If the respondents said they were now smoking every day or some
days, they were also asked “In the past 30 days, when you smoked, how
many cigarettes did you smoke per day?” For the respondents who had
positive responses to these questions or had more than one cigarette in
the past 30 days, they were defined as current users. For e-cigarette
smoking, CHIS asked adult respondents: “Have you ever used any type of
e-cigarette, vape pen, or e-hookah, such as Blu, NJOY, or Vuse, or any
larger devices for vaping, sometimes called vapes, tanks, or mods?” Among
those who responded positively, a follow-up question was asked:
“During the past 30 days, on how many days did you use electronic
cigarettes?” For marijuana use, the question was: “Have you ever, even
once, tried marijuana or hashish in any form?” Then, to determine
marijuana’s current use, CHIS asked the question: “How long has it been
since you last used marijuana or hashish in any form?” For the re-
spondents who reported any use within the past month, they were
defined as current users.

2.3. Assessment of psychological distress

The Kessler 6 (K6) scale was administrated to adult respondents to
collect self-reports on non-specific psychological distress. It contains six
questions on a 5-point scale (0–4) about the frequency of anxiety and
depression symptoms (e.g., hopelessness, worthlessness) in the past 30
days (Kessler et al., 2002). The total score of K6 ranges from 0 to 24, K6
scores of 0–4 were usually defined as having no or mild distress, and K6
scores of 5–12 were defined as having moderate psychological distress,
and 13 and above were severe psychological distress (Prochaska et al.,
2012). Thus, we categorized psychological distress into 3 categories:(1)
no/mild psychological distress, (2) moderate psychological distress, and
(3) severe psychological distress for this study, as has been done in other
studies (Prochaska et al., 2012; Mitchell & Beals, 2011; Fushimi et al.,
2012).

2.4. Relevant covariates

Covariates that CHIS 2017 represent potential confounding were
included if they were known to be related to cigarette or marijuana use
behaviors (Ramo et al., 2013; Deasy et al., 2015). The fully adjusted
model contained individual/household level socio-demographic char-
acteristics collected during CHIS interviews (CHIS, 2017; CHIS, 2018),
including age (18–20, 21–25), race/ethnicity (Latino, Asian, Black,
White, American Indian/Alaska Native, other single or multiple races),
sex (male, female), household income standardized by federal poverty
level (FPL: 0–199% FPL, 200% FPL or above), psychological distress,
residence in urban/rural area which is assigned using the Claritas
urbanicity model (https://nhts.ornl.gov/assets/Assessing_the_Role
_of_Urbanicity.pdf), and seven regions by grouping 58 counties in Cali-
forlania according to their geographic locations, such as Greater Bay Area,
Sacramento Area, San Joaquin Valley, Los Angeles, other Southern
California, and North/Sierra Counties. The Asian, African American, and
White race categories were tabulated as non-Latino ethnicity. The
“Others” category aggregates non-Latino Native Hawaiians/Pacific Is-
landers, American Indians/Alaska Natives, and multi-racial individuals.

2.5. Statistical analyses

The bivariate analysis chi-squared tests were used to determine if
there were significant changes in the rates of using cigarettes, e-ciga-
ettes, and marijuana, separately or any use of the three between 2017
and 2018. We also did the same analyses to examine the differences in
the use across the subgroups by socio-demographic and other charac-
teristics using CHIS 2018 data. Logistic models regressing the odds of
using cigarettes, e-cigarettes, and marijuana, separately or any use of
the three while accounting for sampling weights were conducted. These
models have adjusted for covariates, which include age, race/ethnicity,
sex, FPL, urban/rural status, region of residence, and psychological distress using CHIS 2018 data. We also adjusted for the current use of each of these products/substances to address the potential confounding in all the models except for any use of the three. For example, we co- adjusted for the use of e-cigarettes and marijuana in the model regressing the odds of using cigarettes. A jackknife method based on design-based replicate weights was used to estimate variances and significance values of regression coefficients. The same types of analyses were conducted separately for use of different types of products/substances. All analyses were implemented using SAS 9.4 (SAS Institute Inc., Cary, NC).

3. Results

3.1. Trends in tobacco and marijuana use

In 2018, 1.66 million California young adults, ages 18 to 25, were currently using at least one form of cigarette, e-cigarette, or marijuana: 314,000 smoked cigarettes, 682,000 used (vaped) e-cigarettes, and 1.3 million used marijuana. There was no statistically significant change in cigarette use between 2017 and 2018 (Fig. 1). In contrast, there was escalating use of e-cigarettes and marijuana. Between 2017 and 2018, current e-cigarette use (vaping) climbed by 4.8% and current marijuana use rose by 4.6% among young adults. The proportion of young adults currently using any of these products/substance increased by 5.5% between 2017 and 2018 (Fig. 1).

3.2. Descriptive analyses

Table 1 presents descriptive analyses of the current use of cigarettes, e-cigarettes, marijuana, and any use of the three by age, gender, race/ethnicity, income (federal poverty level), psychological distress, urban/rural residence, and region of residence. Young adults aged 18–20 were smoking cigarettes at significantly lower rates (4.6%) than other young adults aged 21–25 (8.6%). Underage use (i.e., use among those aged 18–20) was substantial for e-cigarettes and marijuana. About 17% of underage young adults were current e-cigarette users. About 27% of underage young adults were current marijuana users.

A wide and significant male–female difference was seen in e-cigarette use (9.3 percentage points), with male e-cigarette use nearly doubled female e-cigarette use. Any use of cigarettes, e-cigarettes, or marijuana was also significantly higher for males than females. Young adults who were white have higher rates of cigarette and e-cigarette use than those who were Latino. Approximately 27% of young adult Latino, whites, and Asians used marijuana. Only e-cigarette rates differed significantly by income: young adults with incomes at or below 200% FPL used e-cigarettes at lower rates than young adults with incomes greater than 200% FPL. Young adults with psychological distress had higher rates of use of cigarettes, e-cigarettes, marijuana, or any use of the three.

3.3. Logistic regression results

After controlling for covariates in multivariable logistic regression, psychological distress, age, use of the other substances, sex, race/ethnicity, and income levels were significantly associated with the use of cigarettes, e-cigarettes, marijuana, or any use of the three (Table 2).

Specifically, among current cigarette users, using e-cigarettes (AOR = 5.25, 95% CI = 2.21, 12.50) was associated with higher odds of smoking cigarettes. Both severe (AOR = 4.06, 95% CI = 1.32, 12.55) and moderate (AOR = 2.59, 95% CI = 1.23, 5.40) psychological distress were also associated with increased cigarette smoking. The underage young adults (age 18 to 20) had lower odds of smoking cigarettes than older young adults (AOR = 0.42, 95% CI = 0.21, 0.82).

For current e-cigarette use, those who were currently using cigarettes (AOR = 5.32, 95% CI = 2.15, 13.16) or marijuana (AOR = 5.63, 95% CI = 3.13, 10.15) had higher odds of smoking e-cigarettes. Males had higher odds than females to use e-cigarettes (AOR = 2.00, 95% CI = 1.04, 3.84). Young adults with incomes greater than 200% FPL had higher odds of using e-cigarettes than those with incomes at or below 200% FPL (AOR = 2.19, 95% CI = 1.18, 4.06).

The odds of current marijuana use were 5 times higher for those who were currently smoking e-cigarettes than those not using them (AOR = 5.43, 95% CI = 3.03, 9.77). Those with severe psychological distress had nearly twice the odds of marijuana use than those with mild or no psychological distress (AOR = 2.32, 95% CI = 1.10, 4.88). Those with moderate psychological distress were also associated with increased marijuana use (AOR = 1.58, 95% CI = 1.01, 2.50) than those with mild or no psychological distress. Native Hawaiians/Pacific Islanders, other races, and multi-racial individuals also had increased odds of using marijuana than white (AOR = 2.43, 95% CI = 1.16, 5.12).

Among young adults with any use of the three products/substance, those with severe psychological distress had 4 times the odds of using any of the three products/substance than those with mild or no psychological distress (AOR = 4.11; 95% CI = 1.93, 8.77). Those with moderate psychological distress were also associated with increased use of any of the three products/substance (AOR = 1.87, 95% CI = 1.19, 2.93) than those with mild or no psychological distress. Males had
higher odds than females to use any of the three products/substance (AOR = 1.62; 95% CI = 1.08, 2.45). Young adults with incomes greater than 200% FPL had higher odds of using any of the three products/substance than those with incomes at or below 200% FPL (AOR = 1.43, 95% CI = 1.00, 2.07).

### 4. Discussion

From 2017 to 2018, California saw an increase in e-cigarette and marijuana use among young adults, while cigarette smoking remained flat. Psychological distress was observed to be associated with cigarette, e-cigarette, marijuana use, or any use of the three. Using cigarettes, e-cigarettes and marijuana were also found mutually correlated. California’s trends in cigarette and e-cigarette smoking are parallel to those observed nationwide (U.S. Department of Health and Human Services, 2016). What stands out in our findings are several aspects. One is that tobacco and marijuana use support and reinforce the use of each other (Ramo et al., 2012). There are several explanations for this association. One is that tobacco and marijuana use are related to initiation and dependence on other substances, such as marijuana (Schauer et al., 2018). Longitudinal studies that examined tobacco use before marijuana use generally supported a gateway sequence and progression, in that case, people

### Table 1

| Sociodemographic Patterns of Current Use of Cigarettes, E-Cigarettes, and Marijuana, Adults Ages 18–25, California, 2018. |
|----------------------------------|----------------|----------------|----------------|----------------|
| Percent of Population, Ages 18–25 | Cigarette | E-Cigarette | Marijuana | Any Use of Cigarettes or E-Cigarettes or Marijuana |
| Total | 100% | 6.9% | 14.9% | 28.5% | 36.3% |
| Age group | | | | | |
| 18–20 years old | 43.0% | 4.6% | 16.7% | 27.0% | 35.9% |
| 21–25 years old | 57.0% | 6.6% | 13.6% | 29.6% | 36.6% |
| Gender | | | | | |
| Male | 51.0% | 7.8% | 19.5% | 31.8% | 40.9% |
| Female | 49.0% | 5.9% | 10.2% | 25.1% | 31.6% |
| Race/Ethnicity* | | | | | |
| Latino | 30.0% | 4.9% | 10.4% | 27.1% | 32.1% |
| White | 27.0% | 10.5% | 19.0% | 27.6% | 38.4% |
| Asian | 17.0% | NR | 16.0% | 27.1% | 35.4% |
| African American | 5.0% | NR | NR | 38.1% | 43.6% |
| Other Single Race/Multiracial | 21.0% | NR | 16.4% | 30.8% | 38.9% |
| Income as % of Federal Poverty Level (FPL) | | | | | |
| 0–200% FPL | 43.0% | 8.0% | 10.1% | 27.1% | 33.0% |
| >200% FPL | 57.0% | 6.0% | 18.5% | 29.5% | 38.8% |
| Psychological Distress | | | | | |
| Severe Distress (K6-score ≥ 13) | 8.0% | 17.0% | 20.0% | 41.6% | 54.5% |
| Moderate Distress (K6-score: 5–12) | 44.0% | 8.6% | 12.9% | 30.0% | 38.0% |
| No or Mild Distress (K6-score: 0–4) | 48.3% | 4.3% | 10.9% | 20.1% | 25.9% |
| Urban and Rural Residence | | | | | |
| Urban | 91.0% | 7.0% | 12.8% | 26.5% | 33.9% |
| Rural | 9.0% | NR | 9.2% | 23.2% | 30.2% |
| Region | | | | | |
| North/Sierra Counties | 4.0% | 14.3% | 15.1% | 31.7% | 40.2% |
| Greater Bay Area | 16.0% | NR | 15.1% | 30.9% | 40.3% |
| Sacramento Area | 6.0% | NR | NR | 26.2% | 32.4% |
| San Joaquin Valley | 11.0% | 7.5% | 7.9% | 20.5% | 25.5% |
| Central Coast | 6.0% | NR | 13.4% | 28.6% | 35.7% |
| Los Angeles | 27.0% | 6.3% | 12.2% | 26.8% | 33.4% |
| Other Southern Cal | 30.0% | 7.4% | 13.3% | 24.1% | 32.1% |

Note: NR: Not reported due to instability of estimate. Data source: 2018 California Health Interview Survey.

*Race tabulation is based on the UCLA Center for Health Policy Research tabulation, “racehp2.p1”, which classifies multiracial individuals and Latino individuals according to their reported primary race identification. Other Single Race/Multiracial includes individuals who report Other Race, American Indian/Alaska Native, Native Hawaiian/Pacific Islander, or more than one race. Estimates for American Indian/Alaska Native and Native Hawaiian/Pacific Islander were unstable for reporting.

1. Significantly different from 21 to 25-year-olds at p<0.05.
2. Significantly different from males at p<0.05.
3. Significantly different from whites at p<0.05.
4. Significantly different from income > 200% FPL at p<0.05.
Factors Associated with Current Use of Cigarettes, E-Cigarettes, and Marijuana, Adults Ages 18–25, California, 2018.

| Effect                              | Cigarette (CD) | E-Cigarette (CD) | Marijuana (CD) | Any Use (CD) |
|-------------------------------------|----------------|------------------|----------------|--------------|
| Moderate                            | 2.59 (1.23)    | 1.06 (0.54)      | 1.58 (1.01)    | 1.87         |
| Psychological Distress vs. No Distress | 2.50 (1.20)    | 1.27 (1.00)      | 1.58 (1.01)    | 3.20 (1.20)  |
| Severe Psychological Distress       | 4.06 (1.32)    | 1.39 (0.50)      | 2.32 (1.10)    | 4.11         |
| Distress                            |                | 3.17 (1.00)      | 1.58 (1.01)    | 3.13         |
| Age 18–20 vs 21–25                  | 0.42 (0.21)    | 1.62 (0.88)      | 0.78 (0.53)    | 0.93         |
| Male vs Female                      | 1.20 (0.58)    | 2.00 (1.04)      | 1.26 (0.81)    | 1.62         |
| Latino vs. White                    | 0.45 (0.18)    | 0.58 (0.28)      | 1.40 (0.80)    | 0.92         |
| African American vs. White          | 0.54 (0.21)    | 0.91 (0.48)      | 1.33 (0.74)    | 1.10         |
| American Indian/White Native vs. White| 0.64 (0.01)  | 0.64 (0.01)      | 1.70 (0.27)    | 0.97         |
| Asian vs White                      | 0.46 (0.10)    | 0.84 (0.36)      | 0.99 (0.49)    | 0.79         |
| Others Single/ Multiple Race vs White| 0.66 (0.13)    | 0.43 (0.12)      | 2.43 (1.16)    | 1.55         |
| White                               | 0.48 (0.12)    | 0.78 (0.39)      | 1.58 (1.01)    | 1.20 (0.77)  |
| PFL 200% vs Under 200%              | 0.55 (0.23)    | 2.19 (1.18)      | 1.10 (0.70)    | 2.07 (1.30)  |
| Urban vs Rural                      | 1.02 (0.32)    | 1.78 (0.72)      | 1.26 (0.51)    | 1.50         |
| North./Sierra Counties vs San Joaquin Valley | 0.85 (0.25)    | 1.64 (0.35)      | 1.42 (0.57)    | 1.50         |
| Greater Bay Area vs San Joaquin Valley | 0.42 (0.06)    | 1.84 (0.43)      | 1.39 (0.55)    | 1.69         |
| Sacramento Area vs San Joaquin Valley | 0.98 (0.11)    | 0.95 (0.16)      | 1.09 (0.36)    | 1.16         |
| Central Coast vs San Joaquin Valley | 0.30 (0.06)    | 2.82 (0.67)      | 1.00 (0.40)    | 1.45         |
| Los Angeles vs San Joaquin Valley   | 0.65 (0.21)    | 2.09 (0.65)      | 0.87 (0.35)    | 1.24         |
| Other Southern Calif vs San Joaquin Valley | 0.79 (0.26)    | 2.22 (0.77)      | 0.66 (0.29)    | 0.95         |

Note: * P < 0.05, **P < 0.01. Current use is defined as past 30-day use of the specified product/substance.

Table 2

effect between substance use and mental health could not be established. If substance use is an antecedent to psychological distress, our estimated proportion of those remaining to smoke. (Zvolensky et al., 2018). Given our study is cross-sectional, the direction of the association between substance use and mental health could not be established. If substance use is an antecedent to psychological distress, our estimated effects of psychological distress on smoking cigarettes and marijuana use may be biased upward. A few longitudinal studies provide causal evidence that smoking or marijuana use increased with psychological distress. For instance, a study using longitudinal data showed that smoking uptake was associated with an increase in psychological distress (Carter et al., 2014). Another birth cohort study that tracks youth longitudinally from before marijuana onset also reinforced that early-onset and chronic marijuana use was associated with a greater risk of psychiatric disorders (McLaren et al., 2010). Data from a cohort study in Sweden women (Danielsson et al., 2016). Regardless of the causal direction, to protect the health and well-being of young adults, decision-makers need to consider both the mental health and substance use behavior for implications of less restrictive substance use laws elsewhere.

California laws (T21) banned sales of cigarettes, e-cigarettes in 2016, and marijuana to young adults under 21 years old. Though underage young adults (age 18 to 20) had lower odds of smoking cigarettes than older young adults, the underage use was substantial for e-cigarettes and marijuana. Studies on the effectiveness of these laws were limited but showed some promising results. The studies did show that California law reduced illegal sales to youth under 18 (Zhang et al., 2018; Ali et al., 2020; Dove et al., 2021). Researchers from UC Davis used data from the
2012–2019 Behavioral Risk Factor Surveillance System (n = 15,863) and observed that although the trends of ever and current smoking did not change significantly before and after California’s T21 policy, while there was an 8% annual decrease of daily smoking before the policy and a 26% annual decrease after the policy among underage in California (Dove et al., 2021). Our study and others showed that underage use could still be an issue due to limited knowledge of such laws and other influencing factors (e.g. perceived support for such a law). A study found that the knowledge of the minimum legal age (MLA) was inversely associated with the intention to use tobacco among youth. Educational campaigns to raise awareness and support for MLA among youth may improve the impact of MLA policies (Dai et al., 2021).

The strength of this study is that it is based on CHIS data, which is the largest state health survey in the nation, and it collects extensive information for assessing the health and health behaviors of adults, adolescents, and children in California. Each year, CHIS surveys over 20,000 households. Also, from 2016 to January 2018, California implemented a series of policies, including prohibiting the sale of tobacco products and e-cigarettes to persons under 21, a cigarette tax increase, and recreational marijuana legalization. All these state-level policy changes made California a natural experimental ground for studies on tobacco and marijuana use behaviors and risk factors associated with smoking behaviors among young adults. It is worth noting that the findings in this study are subject to some limitations. First, data were self-reported, which might have resulted in recall and social desirability biases. Specifically, we were unable to examine whether decriminalization and legalization of adult marijuana use affected self-reporting bias; that is, respondents might have felt more comfortable reporting marijuana use as it became legal in California. Second, the survey does not include institutionalized populations and persons in the military in its sample, so the results might not be generalizable to those populations. Lastly, as noted, it is based on cross-sectional data, it is difficult to determine the direction of the relationships we estimated, for instance, if cigarette use caused marijuana use or vice versa.

5. Conclusions
In this changing smoking environment where young adults are experimenting with tobacco, e-cigarettes, and marijuana, policies that affect the access and social environments of all three products/substances should be considered together. Policies need to ensure that young adults do not choose one product over the other because of differential prices, access, and availability across products/substances (Saffer et al., 2019). Targeted tobacco and cannabis prevention strategies are needed for youth, especially in states that have implemented a policy with more access to recreational use of cannabis. Given the nationwide adoption of minimum legal age policies for tobacco sales, educational campaigns to promote knowledge of the policy may improve its impact. In tandem with these policies and education and outreach activities, a holistic strategy is imperative in addressing psychosocial distress and the use of other substances to effectively curtail tobacco and marijuana use among young adult users.

Declaration of Competing Interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability
Data will be made available on request.

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