



# Cannabis use, social support and social engagement among working-age adults in rural America

Yiping Li, Danielle Rhubart<sup>\*</sup>

Department of Biobehavioral Health, The Pennsylvania State University, Biobehavioral Health Building, University Park, PA 16802, USA

## ARTICLE INFO

### Keywords:

Cannabis use  
Rural working-age adults  
Informal social support  
Tangible support  
Emotional support  
Formal social engagement

## ABSTRACT

**Objective:** Cannabis use has been linked to physical, psychological, and behavioral changes. Although research indicates separately that informal social support and formal social engagement – which are correlated measures – serve as protective factors in cannabis use, much of this research focuses on youth and more urban samples, limiting our understanding of if these findings are true for rural populations where social support and social engagement are particularly important for health and health behaviors. To fill the research gap, this study examines the effects of informal social support (tangible support and emotional support) and formal social engagement on cannabis use among rural working-age adults.

**Methods:** This research analyzed 1,122 observations from a cross-sectional online survey conducted in 2022 of working-age adults (18–64) from rural America. Multilevel logistic regression models were used to predict cannabis use in the past 12 months using informal social support (tangible support and emotional support) and formal social engagement and other sociodemographic covariates and state legalization status.

**Results:** Multilevel logistic modeling indicates that low emotional support and low formal social engagement are associated with a higher odds of reporting cannabis use in the past 12 months among rural working-age adults, net of other sociodemographic variables and state legalization status.

**Conclusions:** The study suggests that emotional support and social engagement may contribute to cannabis use prevention among rural working-age adults. These findings should inform future research as well as the development of tailored health interventions targeting rural working-age adults.

## 1. Introduction

Cannabis consumption is linked to numerous health morbidities, including cannabis-related traffic accidents, overdoses, or hospitalizations (National Academies of Sciences & Medicine, 2017). Like urban areas, the prevalence of cannabis use in rural contexts has steadily risen in the past two decades (Coughlin et al., 2019). While there is robust literature documenting the role of formal social engagement and informal social support in shaping physical, mental, and behavioral health in rural contexts (Chruściel et al., 2018; Utz et al., 2002; Miller et al., 2023; Henning-Smith et al., 2019), there is no research investigating whether a similar association is present for rural cannabis use. Moreover, previous research on cannabis use has mainly focused on rural youth or older adults, neglecting rural working-age adults who play a crucial role in rural economic development. In this paper we determine if informal social support and formal social engagement are associated with lower cannabis use among a sample of 1,122 rural

working-age adults in the United States (U.S.), net of other sociodemographic characteristics and state legalization status.

Cannabis consumption is associated with a range of physical, psychological, and behavioral changes. In addition to traffic deaths, overdoses, or hospitalizations (National Academies of Sciences & Medicine, 2017), initiation and prolonged use can impair cognitive function and emotion regulation (Zalesky et al., 2012). Adults who initiate cannabis use at an early age face an increased risk of impulsivity and lifetime dependence (Gruber et al., 2014; Winters & Lee, 2008). While research on the potential health impacts of cannabis use continues to grow, the evidence that does exist suggests various adverse health outcomes.

While annual data on rural cannabis use prevalence is not regularly reported, research has suggested an upward trend in use (Coughlin et al., 2019). Rural populations report using cannabis to manage the chronic physical pain from agriculture and manufacturing work (Rafferty et al., 2021). Similar research has shown that farm and ranch operators use recreational substances as a self-medication to cope with stress

<sup>\*</sup> Corresponding author.

E-mail address: [dcr185@psu.edu](mailto:dcr185@psu.edu) (D. Rhubart).

<https://doi.org/10.1016/j.pmedr.2024.102794>

Received 27 March 2024; Received in revised form 4 June 2024; Accepted 7 June 2024

Available online 11 June 2024

2211-3355/© 2024 The Author(s). Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

(Radunovich et al., 2022; Watanabe-Galloway et al., 2022). Further, rural adults who feel isolated perceive cannabis as a temporary method to alleviate their sense of loneliness and emotional distress (Deckman et al., 2014; Rural Health Information Hub, 2024). At the same time, limited health services prevent rural populations from accessing appropriate pain management and mental health care (Cai & Lalani, 2022; Rural Health Information Hub, 2024). Cross-sectional research has shown a positive association between unmet health service needs and cannabis use among rural populations (Danek et al., 2023). Given these findings coupled with the consistent upward trend in cannabis consumption among rural residents (Coughlin et al., 2019), there is a need for research that identifies additional risk factors for cannabis use.

Informal social support and formal social engagement are important resources for supporting positive health behaviors in rural regions. Informal social support includes tangible and emotional support received from family members, friends, or neighbors (Chruściel et al., 2018; Drury et al., 2022; Miller et al., 2023). Formal social engagement refers to participation in meetings, community activities, political events, religious organizations, and volunteer opportunities (Glass et al., 2006; Lydon et al., 2021; Utz et al., 2002; Yang et al., 2021). Research has shown that rural adults tend to receive greater emotional support and tangible support from family members, relatives, and friends than their urban counterparts (Henning-Smith et al., 2019; Miller et al., 2023). Similarly, children of rural parents provide more tangible support to older adults than children of urban parents (Clark et al., 2022). Social engagement also varies across rural–urban contexts (Jones et al., 2023). The proportion of adults who attend service club activities is higher among rural adults (Jones et al., 2023). Faith-based organizations in rural regions serve as social centers for social engagement and health promotion (Grieve et al., 2007; Schoenberg & Swanson, 2017). Informal social support and formal social engagement are essential components of rural health. Therefore, understanding if informal social support and formal social engagement are associated with lower risk of cannabis use within this population could be especially useful in designing interventions tailored to rural contexts.

Prior research has documented links between cannabis use and informal social support and social engagement, separately, and without a focus on rural populations. In these research, higher levels of emotional and tangible support are linked to reduced reliance on cannabis use (Rapier et al., 2019; Rathinam & Ezhumalai, 2022). Positive emotional support can mitigate the social isolation linked to the initiation of cannabis use (Reblin & Uchino, 2008). While stress has been linked to maladaptive coping mechanism (eg. smoking, binge drinking, overeating, etc.), participating in the social activities can help reduce stress and subsequent coping mechanisms (Tindle et al., 2022; Buckner et al., 2016; Fischer et al., 2017). At the same time, informal social support and social engagement can incite cannabis use under certain circumstances. For example, individuals who were not socially isolated during the COVID-19 lockdown demonstrated a positive association between perceived friend support and increased cannabis use (Blumberg et al., 2022). Approximately fifty percent of people who use cannabis indicate that the initiation of cannabis use is attributed to exposure to family members or friends who use cannabis (Reilly et al., 1998). Emerging adults who experience peer pressure may use cannabis to maintain their social connections (Haug et al., 2014; Studer et al., 2016). Therefore, the association between cannabis use and informal social support and social engagement appears to vary in direction.

To the authors' knowledge, no studies have examined the impact of both informal social support and formal social engagement on cannabis use among rural working-age adults. On average, working-age adults make up a disproportionately smaller share of the rural population than in urban areas because of outmigration of working-age adults and immigration of older adults to rural retirement destinations (Davis et al., 2022; Council of Economic Advisers, 2023). They are pivotal in driving local economic growth in rural areas (Council of Economic Advisers, 2023). Identifying protective factors – such as informal social support

and formal social engagement – from cannabis use of rural working-age adults not only protects population health but also promotes rural development. In addition, including both in the same model is important given that social engagement and informal social support are likely correlated. Not accounting for both may over-estimate the effect of one.

Therefore, we utilize data from a cross-sectional nationally demographically representative survey of rural working-age adults in the U.S. (N = 1,122) to determine if informal social support and formal social engagement are associated with cannabis use net of each other as well as socio-demographic characteristics that are shown to be associated with cannabis use (e.g. race, gender, income, and education) (Jeffers et al., 2021) and state legalization status.

## 2. Methods

### 2.1. Participants

We used cross-sectional data derived from Rural Health and Engagement Survey (RHES), an online survey conducted between September 19, 2022, and December 22, 2022, through Qualtrics panels. Participants were recruited by Qualtrics using their network of participant pools, which are invited to participate in surveys through email lists, member referrals, banner advertisements, online and mobile games, mail-based recruitment, and TV and radio advertisements (Callegaro et al. 2014). Respondents were invited to complete the survey (i.e. inclusion criteria) if they were between ages 18 and 64 and if their self-identified county and state responses – which were linked to Rural-Urban Continuum Codes (RUCCs) (Economic Research Service (ERS), 2020) on the back end of the survey – indicated that they lived in a rural county in the 48 lower contiguous states of the U.S. In addition, to ensure a representative sample, age, sex, and race and ethnicity quotas were determined using 2020 American Community Survey (American Community Survey, 2021) estimates and 2013 ERS RUCCs (ERS, 2020). Compensation for participation was distributed by Qualtrics in varied forms (e.g. airline miles, gift cards).

In total, 3,368 eligible participants met the inclusion criteria and entered the survey and 1,135 participants were included in the final dataset. This resulted in a 33.7 % quality completion rate which represents the share of eligible participants who completed the survey and with quality responses (e.g. checked for straight-lining, speeding (i.e. took less than one half the median time to complete the survey), inappropriate text responses, and contradictory responses) divided by the total number of eligible participants who opened the survey. While reducing the quality completion rate, the rigorous quality checks outlined above represent an advantage for ensuring quality responses from those who are retained in the sample. A poststratification weight was constructed to account for sample differences in age, sex, race, ethnicity, household income and education to ensure a representative rural sample along these characteristics. The survey was approved by The Pennsylvania State University Institutional Review Board and met institutional guidelines for protection of human subjects. Additional details about the survey, recruitment, and data quality checks can be found in Rhubar et al. (2023).

### 2.2. Measures

Cannabis use was measured by using two single-choice questions from the 2020 National Survey on Drug Use and Health (NSDUH) (Substance Abuse and Mental Health Services Administration, 2013). Participants were asked to respond to the following questions: Have you, even once, used any of the following substances in the past year? (Please remember that your responses are confidential and will be used only for research purposes) 1) marijuana, smoked (do not include medical marijuana), and 2) marijuana, edibles or gummies (do not include medical marijuana). Participants who answered “Yes” to either question were recoded as 1, while those who selected “No” for both questions

were recoded as 0. In total, 13 participants who answered “Don’t know” to both questions or “Don’t know” in one question and “No” in another were excluded from the final analysis.

Two measures of informal social support were available in the RHES data: tangible support and emotional support. Tangible support was assessed through two questions that were drawn from the Fragile Families and Child Well-being Study (Center for Research on Child Wellbeing, 2011): 1) whether they had someone they could rely on to lend them \$200 when needed in the next year, and 2) whether they had someone they could depend on to provide them with a place to live. Each single-choice question had three answer options: Yes, No, and Don’t know. The responses from these two questions were then combined into a new variable with three categories. Participants who answered “Yes” to both questions were recoded as high tangible support. Participants who answered “Yes” to only one question were recoded as medium tangible support. Participants who answered “No” or “Don’t know” to both questions or who answered, “Don’t know” in one question and “No” in the other were recoded as “low tangible support”. Emotional support was measured with a question from the Americans’ Changing Lives study (House, 2018). Participants were asked how many friends or relatives were willing to listen when they needed to talk about their worries or problems. Answers included Not at all, A little, Some, Quite a bit, A great deal, and Don’t know. Answers of “Not at all” or “Don’t know” were recoded as “low emotional support”. Those who responded “A little” and “Some” were recoded as “medium emotional support”. “Quite a bit” and “A great deal” were recoded as “high emotional support”.

Formal social engagement was measured using questions from the National Social Life, Health, and Aging Project (NSHAP) Wave 2 In-Person and Leave-Behind Questionnaires (Waite et al., 2011). Participants were asked 1) how often they attended meetings, events, or get-togethers of any organized group (e.g., choir, committee/board, support group, sports/exercise group, hobby group, professional society) in person in the past 12 months, and 2) how often they attended a religious service in person in the past 12 months. Both measures had the following categories: at least once a week, about once a month, several times a year, once or twice a year, less than once a year or never. A social engagement variable with three categories was created by combining these two questions. Participants who indicated “at least once a week” or “about once a month” to at least one of the questions were recoded as high social engagement. Of the remaining participants, those who indicated “several times a year” or “once or twice a year” to either question were recoded as medium social engagement. Participants who selected “less than a year or never” in both questions were recoded as low social engagement.

Model covariates included sex, age, race and ethnicity, household income, education, and employment status (Jeffers et al., 2021). Sex was recorded as male and non-male. Individuals self-identified as non-binary or other were recoded as non-male, which is consistent with other approaches when non-binary respondents represent a small share of participants (Urlacher, 2023). Gender was not available in the survey. Age was treated as a continuous variable. Following with U.S. Census Bureau categories, race and ethnicity variables were recorded as Hispanic, non-Hispanic White, non-Hispanic Black, and non-Hispanic other race (McKenney & Bennett, 1994). Household income was categorized into five groups: very low income (<\$25,000), low income (\$25,000-\$50,000), medium income (\$50,000-\$75,000), high income (>\$75,000), and “don’t know” income. Participants who worked more than 35 hours per week were categorized as fully employed. We also controlled for state legalization status, which was determined by each state’s legalization status as of December 2022. States that fully legalized cannabis use were coded as “full legalization”, those permitting only medical use were coded as “partial legalization”, and those that completely prohibited cannabis use were coded as “no legalization” (National Conference of State Legislatures, 2023).

### 2.3. Statistical analyses

The frequency and percentage distributions of the model variables are provided as descriptive statistics. Multilevel logistic modeling was used to predict the likelihood of cannabis use using tangible support (Models 1A and 1B), emotional support (Models 2A and 2B), and formal social engagement (Models 3A and 3B), both tangible and emotional support (i.e. informal social support) (Models 4A and 4B) and informal social support and formal social engagement (Models 5A and 5B). A Models do not include sociodemographic covariates, and B Models do include covariates. This modeling approach allows us to examine changes in the independent variables from unadjusted to adjusted models. State legalization status is treated as a level two predictor that is included in both Model A and Model B. Random intercept models were used as these assume that level one predictors may have different starting points depending on state legalization status (Schabenberger, 2005). In addition, these models produced better fit statistics (i.e. AIC, BIC,  $-2$  Log Likelihood) than fixed effects models. All models use the post-stratification weight. Model diagnostics (VIF/TOL) did not indicate concerns about multicollinearity. As described earlier, less than 1% of observations (N = 13) were excluded from the analyses because of insufficient data on the dependent variable. SAS 9.4 (Windows) (© 2020 SAS Institute Inc) was used in all analyses.

## 3. Results

### 3.1. Descriptive statistics

Table 1 presents descriptive statistics for the model variables. Less than half (42.13%) of rural working-age adults reported having used cannabis in the past year. In terms of tangible support, 26.34% had low tangible support, 25.25% had medium tangible support, and 48.41% had high tangible support. Roughly had high emotional support (50.54%), followed by medium emotional support (38.84%), and low emotional support (10.62%). For social engagement, 44.11% had low social engagement, 22.95% had medium social engagement, and 32.94% had high social engagement. The sample was evenly split by sex (50.22% male; 49.78% non-male). Non-Hispanic Whites constituted the largest ethnorracial group (77.62%), followed by Hispanic (9.02%), non-Hispanic Black (7.91%) and non-Hispanic other race (5.45%). The mean age of participants was 41.40. Across income, 34.08% had high incomes (>\$75,000), 17.38% had medium incomes (\$50,000-\$75,000), 22.68% had low incomes (\$25,000-\$50,000), and 21.66 had very low incomes (<\$25,000). The remaining 3.75% did not know their income. The prevalence of full-time employment was 58.39%. Nearly half of respondents (50.50%) were from states that did not legalize cannabis, 35.66% were from states that partially legalized it, and 14.85% were from states that fully legalized it.

### 3.2. Multilevel logistic regression models

Table 2 presents logistic regression models predicting cannabis use in the past year. Models 1A through 3A show the unadjusted effects of tangible support, emotional support, and social engagement on cannabis use. Models 1B through 3B show those same effects net of the sociodemographic covariates. We find that rural working-age adults with low tangible support had 86% higher odds of reporting cannabis use compared to those with a high level of tangible support (Model 1A). This remained true net of sociodemographic covariates (Model 1B), though the odds ratio decreased slightly. In Models 2A and 2B, those with low emotional support had significantly higher odds (OR: 2.41; OR: 2.05) of reporting cannabis use compared to those with high emotional support. In addition, in both the unadjusted and adjusted model, rural working-age adults with medium emotional support had 62% and 46% higher odds of using cannabis compared to those with high emotional support. Rural working-age adults with low or medium levels of social

**Table 1**  
Descriptive statistics for model variables for sample of rural working-age adults in the U.S., 2022.

	Freq (UNWEIGHTED).	Pct. (UNWEIGHTED)	Pct. (WEIGHTED)
Cannabis Use			
Yes	496	44.21	42.13
No	626	55.79	57.87
Tangible support			
Low support	336	29.95	26.34
Medium support	300	26.74	25.25
High support	486	43.32	48.41
Emotional support			
Low support	143	12.75	10.62
Medium support	469	41.80	38.84
High support	510	45.45	50.54
Social Engagement			
Low social engagement	536	47.77	44.11
Medium social engagement	268	23.89	22.95
High social engagement	318	28.34	32.94
Sex			
Female, non-binary, other	596	53.12	49.78
Male	526	46.88	50.22
Race			
Non-Hispanic White	902	80.39	77.62
Hispanic	105	9.36	9.02
Non-Hispanic Black	74	6.60	7.91
Non-Hispanic other	41	3.65	5.45
Age	1122		Mean = 41.40
Household Income			
Very Low (Less than 25,000)	380	33.87	21.66
Low (25,000–50,000)	341	30.39	22.68
Medium (50,000–75,000)	200	17.83	17.83
High (More than 75,000)	153	13.64	34.08
Do not know	48	4.28	3.75
Employed Full-time			
Yes	583	51.96	58.39
No	539	48.04	41.61
Legalization Status			
Not Legalized	550	49.02	50.50
Partially Legalized	408	36.36	35.66
Fully Legalized	164	14.62	14.85

N = 1122.

engagement had about two times higher odds of reporting cannabis use compared to those with high levels of social engagement in Model 3A. This remained true in the adjusted model (Model 3B).

Models 4A and 4B include both tangible support and emotional support as predictors. While emotional support remains significant, the effects of tangible support become insignificant in the unadjusted and adjusted models. Compared to those with high emotional support, those with medium and low emotional support have about 69% and 2.16 times higher odds of using cannabis in the past year, net of other model covariates.

Models 5A and 5B include informal social support (tangible support and emotional support) and formal social engagement. Similar to Models 4A and 4B, the association between tangible support and cannabis use is insignificant, but emotional support and social engagement remain significant predictors of cannabis use in the unadjusted model (5A). The results remain significant in the fully adjusted model (5B) except for medium emotional support which loses significance. The odds of cannabis use for individuals with low emotional support is 69%

higher than for those with high emotional support, net of model covariates. Additionally, compared to those with high social engagement, those with medium and low social engagement have odds that are two times higher of using cannabis in the past year net of other model covariates.

#### 4. Discussion

Cannabis has emerged as a widely used substances in the U.S. (Oser et al., 2011) with implications for physical, psychological and behavioral health. Prior research has shown that social support and social engagement, separately, are associated with cannabis use (Reblin & Uchino, 2008; Schoenberg & Swanson, 2017). We have built on that prior work by 1) examining this topic among rural populations – for whom social support and social engagement are particularly important for supporting health and well-being, 2) focusing on working-age adults who are essential for maintaining the local economy but represent a disproportionately smaller share of the population in rural areas, and 3) by examining both social support and social engagement – two related factors – in the same model.

Using data from RHES, a nationally demographically representative sample of rural working-age adults, we found low levels of emotional support and formal social engagement are significantly associated with higher odds of cannabis use. Our finding of the relationship between emotional support and cannabis use aligns with previous research, but with a rural sample. Emotional support provides reassurance and helps bolster stress resilience (Calhoun et al., 2022; Hu et al., 2022). Reassurance predicts stress reduction and resilience promotes the use of active coping strategies (Moos et al., 1993; Pradhan et al., 2012). Our findings build on this previous work to suggest the importance of emotional support for cannabis use in the broader population is also true for rural working-age adults. The effect of tangible support disappearing when we accounted for emotional support in the same model could be explained by the fact that tangible support and emotional support are moderately correlated (Pearson’s R = 0.507) (Appendix B). However, VIF values for tangible and emotional support were <2 (Appendix C), suggesting no multicollinearity concerns (Tsagris and Pandis, 2021). While previous research has shown that informal social support provides material needs and alleviates feelings of hopelessness that may trigger cannabis use (Calhoun et al., 2022; Malmberg et al., 2010), our work suggests the effects of tangible social support may be explained by emotional support. This also supports the need to account for more nuanced measures of social support (e.g. tangible vs. emotional).

Finally, our findings affirm the positive role of social engagement in reducing the odds of cannabis use. Previous work has suggested that engaging in formal social activities not only offers a sense of belonging but also establishes social norms and constructive alternative activities to combat cannabis use driven by loneliness (Hussain et al., 2023; Tang et al., 2017; Grant Weinandy & Grubbs, 2021). In this paper, we showed that while social engagement was correlated with social support (see Appendix A), social engagement continued to be a significant predictor of cannabis use net of social support, sociodemographic covariates, and state-level legalization policies.

The findings presented here suggest that emotional support and social engagement may serve as preventive factors against cannabis use among rural working-age adults. Efforts to foster programming that leverages emotional support and social engagement may be important for cannabis prevention. This might include investing in programs and organizations that provide positive opportunities for social engagement and addressing barriers to accessing such opportunities (e.g. via transportation, childcare). Organizing wellness workshops, recreational activities, and support groups could be pivotal in helping rural working-age adults strengthen their social bonds and emotional well-being. Such initiatives may contribute to reducing cannabis use by fostering alternative means for stress management and community support.

**Table 2**  
Multilevel binary logistic regression models predicting cannabis use in the past year among rural working-age adults in the U.S., 2022.

Unadjusted Models	Model 1A		Model 2A		Model 3A		Model 4A		Model 5A	
	OR	p-value	OR	p-value	OR	p-value	OR	p-value	OR	p-value
Tangible Support ( <i>ref: high tangible support</i> )										
Medium tangible support	1.29	0.095					1.15	0.384	1.08	0.623
Low tangible support	1.86	<0.001					1.40	0.055	1.26	0.200
Emotional support ( <i>ref: high emotional support</i> )										
Medium emotional support			1.62	<0.001			1.47	0.007	1.39	0.022
Low emotional support			2.41	<0.001			1.96	0.004	1.83	0.011
Social engagement ( <i>ref: high social engagement</i> )										
Medium social engagement					2.14	<0.001			1.98	<0.001
Low social engagement					2.12	<0.001			1.83	<0.001
Legalization ( <i>ref: not legalized</i> )										
Legalization of medical marijuana	1.24	0.191	1.26	0.144	1.20	0.273	1.27	0.146	1.25	0.192
Fully legalized	1.36	0.151	1.32	0.185	1.26	0.287	1.35	0.158	1.32	0.221
AIC	1521		1519		1507		1514		1497	
BIC	1532		1528		1518		1528		1516	
-2 Log Likelihood	1487		1488		1473		1477		1452	
<b>Adjusted Models</b>										
	Model 1B		Model 2B		Model 3B		Model 4B		Model 5B	
	OR	p-value	OR	p-value	OR	p-value	OR	p-value	OR	p-value
Tangible Support ( <i>ref: high tangible support</i> )										
Medium tangible support	1.01	0.950					1.16	0.537	0.86	0.367
Low tangible support	1.58	0.047					1.47	0.159	1.12	0.557
Emotional support ( <i>ref: high emotional support</i> )										
Medium emotional support			1.46	0.012			1.69	0.032	1.31	0.073
Low emotional support			2.05	0.003			2.16	0.044	1.69	0.036
Social engagement ( <i>ref: high social engagement</i> )										
Medium social engagement					2.36	<0.001			2.26	<0.001
Low social engagement					2.23	<0.001			2.06	<0.001
Male ( <i>ref: female, non-binary, other</i> )	1.49	0.026	1.51	0.007	1.56	0.009	1.46	0.066	1.54	0.002
Age	0.96	0.640	0.96	<0.001	0.96	<0.001	1.01	0.338	1.96	<0.001
Race ( <i>ref: non-Hispanic White</i> )										
Hispanic	1.12	0.611	1.13	0.002	1.23	0.368	1.57	0.192	1.22	0.398
Non-Hispanic Black	1.18	0.504	1.21	0.586	1.25	0.378	1.39	0.355	1.30	0.304
Non-Hispanic Other	0.96	0.897	1.01	0.428	0.92	0.758	1.14	0.766	0.90	0.728
Household Income ( <i>ref: very low income</i> )										
Low Income	0.79	0.233	0.79	0.238	0.74	0.121	0.72	0.227	0.76	0.170
Medium Income	0.85	0.435	0.83	0.385	0.81	0.321	0.83	0.526	0.87	0.499
High Income	0.47	<0.001	0.48	0.002	0.49	<0.001	0.41	0.010	0.54	0.002
Don't know Income	0.33	0.028	0.34	0.034	0.31	0.015	0.29	0.034	0.31	0.002
Employed Full Time ( <i>ref: not fully employed</i> )	1.01	0.947	1.01	0.938	1.05	0.079	1.38	0.135	1.06	0.697
Legalization ( <i>ref: not legalized</i> )										
Legalization of medical marijuana	1.26	0.162	1.28	0.134	1.24	0.187	1.42	0.115	1.29	0.138
Fully legalized	1.35	0.177	1.33	0.189	1.26	0.287	1.62	0.118	1.30	0.251
AIC	1457		1543		1496		1443		1431	
BIC	1486		1481		1483		1533		1468	
-2 Log Likelihood	1425		1404		1468		1477		1455	

N = 1,122; OR: Odds ratios

**5. Limitations**

The findings should be contextualized in several limitations. First, this is a cross-sectional study. Therefore, causality cannot be demonstrated. Second, the cannabis use measure is broad and fails to capture the frequency of cannabis use. The impact of informal social support and formal social engagement on cannabis use may vary by frequency of use. Third, the social engagement measure relies on in-person engagement and therefore we are not able to capture how online or virtual engagement may also be at play. Fourth, given this was an internet-based survey, the sample might not fully represent those who do not have internet access.

**6. Conclusion**

To our knowledge, this is the first study to focus on individual effects of emotional support, tangible support, and social engagement on

cannabis use among rural working-age adults. Emotional support and social engagement are significant protective factors for cannabis use within a population that – on average – faces disproportionately lower geographic access to physical and mental health services as well as other supportive infrastructure. The analytical findings provide support for health interventions in rural areas that prioritize these mechanisms.

**7. Ethics**

This research was reviewed by The Pennsylvania State University's Office for Research Protections and was determined to not require formal IRB review because the research met the criteria for exempt research according to the policies of this institution and the provisions of applicable federal regulations (Study ID: STUDY00019631).

## CRediT authorship contribution statement

**Yiping Li:** Writing – original draft, Software, Formal analysis, Data curation, Conceptualization. **Danielle Rhubar:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization.

## 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.

## Acknowledgements

Yiping Li wishes to acknowledge Dr. Robert Turrisi and Dr. Michael Russell for their valuable feedback and suggestions during the initial stages of manuscript preparation.

## Disclosures

The authors have no conflicts of interest to report.

## Funding

Rhubart acknowledges support from a pilot grant for this research from the Department of Biobehavioral Health at Penn State University.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.pmedr.2024.102794>.

## References

- American Community Survey [ACS]. 2021. ACS 5-year data download In SocialExplorerer.com. Retrieved July 24, 2023, from [https://www.socialexplorer.com/tables/ACS2021\\_5yr/R13441819](https://www.socialexplorer.com/tables/ACS2021_5yr/R13441819).
- Blumberg, M. J., Lo, L. A., Harrison, G. W., Dodwell, A., Irwin, S. H., & Olmstead, M. C. (2022). Differential impacts of perceived social support on alcohol and cannabis use in young adults: Lessons from the COVID-19 pandemic. *medRxiv*. <https://doi.org/10.1101/2022.08.04.22278446>.
- Buckner, J.D., Zvolensky, M.J., Ecker, A.H., Jeffries, E.R., 2016. Cannabis craving in response to laboratory-induced social stress among racially diverse cannabis users: The impact of social anxiety disorder. *J. Psychopharmacol.* 30 (4), 363–369. <https://doi.org/10.1177/02698811166629115>.
- Cai, Y., Lalani, N., 2022. Examining barriers and facilitators to palliative care access in rural areas: A scoping review. *Am. J. Hosp. Palliat. Care* 39 (1), 123–130. <https://doi.org/10.1177/10499091211101145>.
- Calhoun, C.D., Stone, K.J., Cobb, A.R., Patterson, M.W., Danielson, C.K., Bendezú, J.J., 2022. The role of social support in coping with psychological trauma: An Integrated biopsychosocial model for posttraumatic stress recovery. *Psychiatr. Q.* 93 (4), 949–970. <https://doi.org/10.1007/s11126-022-10003-w>.
- Center for Research on Child Wellbeing at Princeton University & Columbia Population Research Center at Columbia University. (2011, October). *The Fragile Families and Child Wellbeing Study: Mothers' Nine-Year Follow-Up Survey (Public Use Version)*. Westat, Inc.
- Chrusciel, P., Kulik, T., Jakubowska, K., Nalepa, D., 2018. Differences in the perception of social support among rural area seniors-a cross-sectional survey of polish population. *Int. J. Environ. Res. Public Health* 15 (6). <https://doi.org/10.3390/ijerph15061288>.
- Clark, S., Lawrence, E.M., Monnat, S.M., 2022. Support from adult children and parental health in rural America. *J. Rural Soc. Sci.* 37 (1).
- Coughlin, L.N., Bonar, E.E., Bohnert, K.M., Jannausch, M., Walton, M.A., Blow, F.C., Ilgen, M.A., 2019. Changes in urban and rural cigarette smoking and cannabis use from 2007 to 2017 in adults in the United States. *Drug Alcohol Depend.* 205, 107699. <https://doi.org/10.1016/j.drugalcdep.2019.107699>.
- Council of Economic Advisers, 2023. Strengthening the rural economy - the current state of rural America. Retrieved from <https://obamawhitehouse.archives.gov/administration/eop/cea/factsheets-reports/strengthening-the-rural-economy/the-current-state-of-rural-america>.
- Danek, R., Blackburn, J., Greene, M., Mazurenko, O., Menachemi, N., 2023. Unmet mental health need and subsequent substance use in individuals with a history of depression: Are there differences between metro and nonmetro areas? *Am. J. Addict.* 32 (4), 360–366. <https://doi.org/10.1111/ajad.13393>.
- Davis, J. C., Rupasingha, A., Cromartie, J., & Sanders, A. (2022). *Rural America at a Glance: 2022 Edition*. (USDA Miscellaneous Publication No. 333529). United States Department of Agriculture.
- Deckman, T., DeWall, C.N., Way, B., Gilman, R., Richman, S., 2014. Can marijuana reduce social pain? *Soc. Psychol. Personal. Sci.* 5 (2), 131–139.
- Drury, J., Stancombe, J., Williams, R., Collins, H., Lagan, L., Barrett, A., French, P., Chitsabesan, P., 2022. Survivors' experiences of informal social support in coping and recovering after the 2017 Manchester Arena bombing. *BJPsych Open* 8 (4), e124. Economic Research Service. (2020, December 10). Documentation. Retrieved January 29, 2023, from <https://www.ers.usda.gov/data-products/rural-urban-continuum-codes/documentation/>.
- Fischer, B., Russell, C., Sabioni, P., van den Brink, W., Le Foll, B., Hall, W., Rehm, J., Room, R., 2017. Lower-risk cannabis use guidelines: A comprehensive update of evidence and recommendations. *Am. J. Public Health* 107 (8), e1–e12. <https://doi.org/10.2105/ajph.2017.303818>.
- Glass, T.A., De Leon, C.F.M., Bassuk, S.S., Berkman, L.F., 2006. Social engagement and depressive symptoms in late life: Longitudinal findings. *J. Aging Health* 18 (4), 604–628.
- Grant Weinandy, J.T., Grubbs, J.B., 2021. Religious and spiritual beliefs and attitudes towards addiction and addiction treatment: A scoping review. *Addict. Behav. Rep.* 14, 100393. <https://doi.org/10.1016/j.abrep.2021.100393>.
- Grieve, J., Jochum, V., Pratten, B., Steel, C., 2007. *Faith in the Community*. NCVO, London.
- Gruber, S.A., Dahlgren, M.K., Sagar, K.A., Gönenç, A., Lukas, S.E., 2014. Worth the wait: Effects of age of onset of marijuana use on white matter and impulsivity. *Psychopharmacology (Berl)* 231 (8), 1455–1465. <https://doi.org/10.1007/s00213-013-3326-z>.
- Haug, S., Núñez, C.L., Becker, J., Gmel, G., Schaub, M.P., 2014. Predictors of onset of cannabis and other drug use in male young adults: Results from a longitudinal study. *BMC Public Health* 14, 1202. <https://doi.org/10.1186/1471-2458-14-1202>.
- Henning-Smith, C., Moscovice, I., Kozhimannil, K., 2019. Differences in social isolation and its relationship to health by rurality. *J. Rural Health* 35 (4), 540–549. <https://doi.org/10.1111/jrh.12344>.
- House, J. S. (2018). *Americans' Changing Lives: Waves I, II, III, IV, and V, 1986, 1989, 1994, 2002, and 2011*. Inter-university Consortium for Political and Social Research [distributor]. <https://doi.org/10.3886/ICPSR04690.v9>.
- Hu, X., Song, Y., Zhu, R., He, S., Zhou, B., Li, X., Bao, H., Shen, S., Liu, B., 2022. Understanding the impact of emotional support on mental health resilience of the community in the social media in Covid-19 pandemic. *J. Affect. Disord.* 308, 360–368. <https://doi.org/10.1016/j.jad.2022.04.105>.
- Hussain, B., Mirza, M., Baines, R., Burns, L., Stevens, S., Asthana, S., Chatterjee, A., 2023. Loneliness and social networks of older adults in rural communities: A narrative synthesis systematic review. *Front. Public Health* 11, 1113864. <https://doi.org/10.3389/fpubh.2023.1113864>.
- Jeffers, A.M., Glantz, S., Byers, A., Keyhani, S., 2021. Sociodemographic characteristics associated with and prevalence and frequency of cannabis use among adults in the U.S. *JAMA Netw. Open* 4 (11), e2136571.
- Jones, C.A., Jhangri, G.S., Yamamoto, S.S., et al., 2023. Social participation of older people in urban and rural areas: Canadian Longitudinal Study on Aging. *BMC Geriatr.* 23 (439). <https://doi.org/10.1186/s12877-023-04127-2>.
- Lydon, E.A., Nguyen, L.T., Nie, Q., Rogers, W.A., Mudar, R.A., 2021. An integrative framework to guide social engagement interventions and technology design for persons with mild cognitive impairment. *Frontiers in Public Health*. <https://doi.org/10.3389/fpubh.2021.750340>.
- Malmberg, M., Overbeek, G., Monshouwer, K., Lammers, J., Vollebergh, W.A., Engels, R. C., 2010. Substance use risk profiles and associations with early substance use in adolescence. *J. Behav. Med.* 33 (6), 474–485. <https://doi.org/10.1007/s10865-010-9278-4>.
- McKenney, N.R., Bennett, C.E., 1994. Issues regarding data on race and ethnicity: The Census Bureau experience. *Public Health Rep.* 109 (1), 16.
- Miller, K.E.M., Ornstein, K.A., Coe, N.B., 2023. Rural disparities in use of family and formal caregiving for older adults with disabilities. *J. Am. Geriatr. Soc.* 71 (9), 2865–2870. <https://doi.org/10.1111/jgs.18376>.
- Moos, R.H., Schaefer, J.A., Goldberger, L., Breznitz, S., 1993. *Handbook of stress: Theoretical and clinical aspects*. Free Press New York, NY, USA.
- National Academies of Sciences, E., & Medicine. (2017). *The health effects of cannabis and cannabinoids: The current state of evidence and recommendations for research*. National Conference of State Legislatures. (2023, June 22). *State medical cannabis laws*. <https://www.ncsl.org/health/state-medical-cannabis-laws>.
- Oser, C.B., Leukefeld, C.G., Tindall, M.S., Garrity, T.F., Carlson, R.G., Falck, R., Wang, J., Booth, B.M., 2011. Rural drug users: Factors associated with substance abuse treatment utilization. *Int. J. Offender Ther. Comp. Criminol.* 55 (4), 567–586. <https://doi.org/10.1177/0306624x10366012>.
- Pradhan, B. B., Brox, J. I., & Indahl, A. (2012). CHAPTER 6 – Watchful Waiting and Brief Education. In S. Dagenais & S. Haldeman (Eds.), *Evidence-Based Management of Low Back Pain* (pp. 55-72). Mosby. <https://doi.org/https://doi.org/10.1016/B978-0-323-07293-9.00006-4>.
- Radunovich, H.L., Younker, T., Rung, J.M., Berry, M.S., 2022. The effects of the opioid crisis on agricultural industries. *Int. J. Environ. Res. Public Health* 19 (9), 5343. <https://doi.org/10.3390/ijerph19095343>.

- Rafferty, A.P., Luo, H., Egan, K.L., Bell, R.A., Little, N., Imai, S., 2021. Rural, suburban, and urban differences in chronic pain and coping among adults in North Carolina: 2018 Behavioral Risk Factor Surveillance System. *Prev. Chronic Dis.* 18, 200352 <https://doi.org/10.5888/pcd18.200352>.
- Rapier, R., McKernan, S., Stauffer, C.S., 2019. An inverse relationship between perceived social support and substance use frequency in socially stigmatized populations. *Addict. Behav. Rep.* 10, 100188 <https://doi.org/10.1016/j.abrep.2019.100188>.
- Rathinam, B., Ezhumalai, S., 2022. Perceived social support among abstinent individuals with substance use disorder. *J. Psychosoc. Rehabil. Ment Health* 9 (1), 81–87. <https://doi.org/10.1007/s40737-021-00237-5>.
- Reblin, M., Uchino, B.N., 2008. Social and emotional support and its implication for health. *Curr. Opin. Psychiatry* 21 (2), 201–205. <https://doi.org/10.1097/YCO.0b013e3282f3ad89>.
- Reilly, D., Didcott, P., Swift, W., Hall, W., 1998. Long-term cannabis use: Characteristics of users in an Australian rural area. *Addiction* 93 (6), 837–846. <https://doi.org/10.1046/j.1360-0443.1998.9368375.x>.
- Rhubart, D., Kowalkowski, J., Pillay, T., 2023. Third places in rural America: Prevalence and disparities in use and meaningful use. *J. Rural. Stud.* 104 (103153) <https://doi.org/10.1016/j.jrurstud.2023.103153>.
- Rural Health Information Hub. (2024). Substance Use and Misuse in Rural Areas. Retrieved from <https://www.ruralhealthinfo.org/topics/substance-use>.
- Schabenberger, O. (2005). Introducing the GLIMMIX procedure for generalized linear mixed models. *SUGI 30 Proceedings*, 196, 1–20.
- Schoenberg, N.E., Swanson, M., 2017. Rural religious leaders' perspectives on their communities' health priorities and health. *South. Med. J.* 110 (7), 447–451. <https://doi.org/10.14423/smj.0000000000000671>.
- Studer, J., Baggio, S., Grazioli, V.S., Mohler-Kuo, M., Daeppen, J.-B., Gmel, G., 2016. Risky substance use and peer pressure in Swiss young men: Test of moderation effects. *Drug Alcohol Depend.* 168, 89–98. <https://doi.org/10.1016/j.drugalcdep.2016.08.633>.
- Substance Abuse and Mental Health Services Administration. (2014). Results from the 2013 National Survey on Drug Use and Health: Mental Health Findings (NSDUH Series H-49, HHS Publication No. (SMA) 14-4887).
- Tang, F., Chi, I., Dong, X., 2017. The relationship of social engagement and social support with sense of community. *J. Gerontol. A Biol. Sci. Med. Sci.* 72 (suppl 1), S102–S107. <https://doi.org/10.1093/gerona/glw187>.
- Tindle, R., Hemi, A., Moustafa, A.A., 2022. Social support, psychological flexibility and coping mediate the association between COVID-19 related stress exposure and psychological distress. *Sci. Rep.* 12 (1), 8688.
- Tsagris, M., Pandis, N., 2021. Multicollinearity. *Am. J. Orthod. Dentofac. Orthop.* 159 (5), 695–696. <https://doi.org/10.1016/j.ajodo.2021.02.005>.
- Urlacher, B.R., 2023. Gender Identification and Survey Weighting: A Shifting Landscape. *PS. Polit. Sci. Polit.* 56 (1), 56–60. <https://doi.org/10.1017/S1049096522001081>.
- Utz, R.L., Carr, D., Nesse, R., Wortman, C.B., 2002. The effect of widowhood on older adults' social participation: An evaluation of activity, disengagement, and continuity theories. *Gerontologist* 42 (4), 522–533. <https://doi.org/10.1093/geront/42.4.522>.
- Waite, L., Cagney, K., Cornwell, B., Dale, W., Huang, E., Laumann, E., Schumm, L., 2011. National Social Life, Health, and Aging Project (NSHAP) Wave 2 In-Person and Leave-Behind Questionnaires. NORC at the University of Chicago, Chicago, IL.
- Watanabe-Galloway, S., Chasek, C., Yoder, A.M., Bell, J.E., 2022. Substance use disorders in the farming population: Scoping review. *J of Rural Health* 38 (1), 129–150. <https://doi.org/10.1111/jrh.12575>.
- Winters, K.C., Lee, C.Y., 2008. Likelihood of developing an alcohol and cannabis use disorder during youth: Association with recent use and age. *Drug Alcohol Depend.* 92 (1–3), 239–247. <https://doi.org/10.1016/j.drugalcdep.2007.08.005>.
- Yang, E.Z., Kotwal, A.A., Lisha, N.E., Wong, J.S., Huang, A.J., 2021. Formal and informal social participation and elder mistreatment in a national sample of older adults. *J Am. Geriatr. Soc.* 69 (9), 2579–2590. <https://doi.org/10.1111/jgs.17282>.
- Zalesky, A., Solowij, N., Yücel, M., Lubman, D.I., Takagi, M., Harding, I.H., Lorenzetti, V., Wang, R., Searle, K., Pantelis, C., Seal, M., 2012. Effect of long-term cannabis use on axonal fibre connectivity. *Brain* 135 (Pt 7), 2245–2255. <https://doi.org/10.1093/brain/aws>.