Experience of Being Bullied, Depressive Symptoms, Suicidality, and Substance Use among Adolescents

Miranda Delawalla

A dissertation

Submitted in partial fulfillment of the

Requirements for the degree of

Doctor of Philosophy

University of Washington

2022

Reading Committee:

Daniel A. Enquobahrie, Chair

Yolanda Evans

Isaac Rhew

Program Authorized to Offer Degree:

Epidemiology

University of Washington

Abstract

Experience of Being Bullied, Depressive Symptoms, Suicidality, and Substance Use among Adolescents

Miranda Delawalla

Chair of the Supervisory Committee:

Daniel A. Enquobahrie

Department of Epidemiology

Background: Depressive symptoms, suicidality, and the experience of having been bullied are prevalent among adolescents in the United States. In addition, substance use is also common among adolescents in the United States. Both the experience of depressive symptoms and suicidality and of having been bullied have been associated with substance use. However, the context in which these adolescent experiences and behaviors are occurring are changing (e.g., changing state-level cannabis laws, the advent of electronic vapor products, increased use of social media, and the COVID-19 pandemic), warranting updated, comprehensive investigations in this area.

Objectives: We aimed to 1) determine if depressive symptoms and suicidality are associated with current use of alcohol, electronic vapor products, cannabis, and prescription pain medicine among adolescents; 2) determine if the associations of depressive symptoms and suicidality with use of alcohol, electronic vapor products, cannabis, and prescription pain medicine have changed over time in adolescents; 3) determine if the experience of being bullied electronically or at school is associated with the current use of alcohol, electronic vapor products, cannabis,

and prescription pain medicine among adolescents; and 4) describe the impact of COVID-19 on adolescent-reported substance use, social media use, and depressive symptoms.

Methods: We utilized 2019 Youth Risk Behavior Study (YRBS) data to assess cross-sectional associations of the experience of having been bullied, depressive symptoms, and suicidality with substance use and YRBS data from 1991 to 2019 to assess for changes in cross-sectional associations of depressive symptoms and suicidality with substance use over time. We applied appropriate survey weights and utilized multivariable logistic regression to model associations between past 12 month depressive symptoms and suicidality indicators (considering suicide, suicide plans, suicide attempts, and injurious suicide attempts) as independent variables in Aims 1 and 2, past 12 month experience of being bullied electronically and at school as independent variables in Aim 3, and past 30 day ever use of substances (cannabis use, alcohol use, binge drinking, electronic vapor product use, or prescription pain medicine misuse) as dependent variables in Aims 1, 2, and 3. Due to lack of time points for which data on past 30 day prescription pain medicine was available, we additionally considered lifetime prescription pain medicine misuse as a dependent variable in Aim 2. We presented odds ratios (ORs), adjusted ORs (aORs), and corresponding 95% confidence intervals (CIs) for unadjusted, partially adjusted (including covariates for sex, racial/ethnic identity, sexual identity, and age), and fully adjusted (additionally including other substance use) models. To assess the impact of the COVID-19 pandemic (Aim 4), we conducted a scoping review and a survey-based study. For the scoping review, we utilized Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines and searched PubMed, PsycINFO, and Embase. Inclusion criteria were quantitative or qualitative studies among 12 to

17 year-olds or their caregivers and provided results that were specific to adolescents (age 10 to 19 years or middle school to high school) in the United States and data collected at least at one time point since March 1, 2020 (reflecting the beginning of the impact of the pandemic on daily life for the public). For the survey-based study, we conducted an anonymous, REDCap-based online survey of adolescents (ages 13 to 19 years) in the United States assessing retrospective reports of social media use, substance, and depressive symptoms in April 2019, April 2020, and April 2021. We summarized participant responses with frequencies and percentages and assessed for differences over time with Fisher's exact tests.

Results: In weighted analyses of 2019 YRBS participants, 36.2% of participants reported depressive symptoms in the past 12 months and 30.9% of participants reported any use of electronic vapor products in the past 30 days. We found that depressive symptoms in the past 12 months were statistically significantly associated with ever past 30 day alcohol use (aOR: 1.28; 95% CI: 1.09, 1.51; $p = 0.004$), ever past 30 day cannabis use (aOR: 1.43; 95% CI: 1.20, 1.70; $p < 0.001$), ever past 30 day electronic vapor product use (aOR: 1.55; 95% CI: 1.30, 1.84; $p < 0.001$), and ever past 30 day prescription pain medicine misuse (aOR: 2.62; 95% CI: 1.97, 3.48; $p < 0.001$) except for ever past 30 day binge drinking (aOR: 1.42; 95% CI: 1.02, 1.99; $p = 0.041$) in fully adjusted models including demographics and other substance use. Significant positive associations were also observed for suicidality indicators. In assessment for changes in these associations over time, for all past 12 month depressive symptom and suicidality indicators, associations with past 30 day ever use of alcohol and cannabis have increased slightly over time. Assessments of time trends of associations for past 30 day binge drinking, past 30 day electronic vapor product use, and lifetime prescription pain medicine misuse were limited by

few available time points, but these associations remained relatively stable over assessed time points. Assessing associations of having been bullied and substance use with 2019 YRBS data, we found significant associations of being bullied at school and electronically in the past 12 months with any past 30 day use of electronic vapor products (school: aOR: 1.49; 95% CI: 1.21, 1.84; $p < 0.001$; electronic: aOR: 1.89; 95% CI: 1.55, 2.31; $p < 0.001$) and prescription pain medicine misuse (school: aOR: 2.10; 95% CI: 1.72, 2.55; $p < 0.001$; electronic: aOR: 1.99; 95% CI: 1.48, 2.67; $p < 0.001$) after full adjustment. Fully adjusted associations were not statistically significant for past 12 month alcohol use, binge drinking, or prescription pain medicine misuse, but significant in most partially adjusted models excluding use of other substances as a covariate. In our scoping review, we identified 29 relevant studies (social media use n = 7; substance use n = 4; depressive symptoms n = 22). Though we observed a variety of methods of measuring depressive symptoms, cross-sectional assessments indicated a high prevalence of depressive symptoms during the pandemic, but longitudinal trajectories suggested a possible decrease in the first few months after the onset of the pandemic. High social media use was reported and two studies suggested lower e-cigarette use during the pandemic. In our survey-based study, we observed a statistically significant increase in reported social media use over time ($p = 0.04$) in participants reporting using social media at least once a day in April 2019 (70.4%), April 2020 (81.5%), and April 2021 (88.9%). We also observed increases, though not statistically significantly different, across years in substance use (April 2019: cannabis: 11.1%, electronic vapor product use: 7.4%, alcohol use: 7.4%, binge drinking: 7.4%, prescription pain medicine misuse: 0%; April 2021: cannabis: 18.5%, electronic vapor product use: 25.9%, alcohol

use: 14.8%, binge drinking: 11.1%, prescription pain medicine misuse: 7.4%) and depressive symptoms (April 2019: 48.1;, April 2020: 70.4%; April 2021: 66.7%).

Conclusion and Discussion: We identified evidence for positive associations of the experience of having been bullied, depressive symptoms, and suicidality with substance use in a recent, representative sample of adolescents. Further, the associations of depressive symptoms and suicidality with alcohol use and cannabis use may have increased slightly over time. The COVID-19 pandemic may be associated with greater social media use and increased depressive symptoms. Adults with prominent roles in adolescent lives should aim to teach and encourage healthy coping skills. Further, they should be aware that adolescents who experience being bullied or depressive symptoms may be more likely to engage in substance use, and vice versa. In the face of the COVID-19 pandemic, adolescents may require additional mental health support. Future research directions include longitudinal studies to elucidate directionality of associations, studies with diverse participants to comprehensively assess the potential moderating role of identity factors, and ongoing monitoring of the present and future impacts of the COVID-19 pandemic.

Sources of Support and Acknowledgements: This work was supported in part by a student project stipend from the Northwest Public Health Training Center at the Northwest Center for Public Health Practice (sponsored by the Health Resources and Services Administration (HRSA) of the U.S. Department of Health and Human Services (HHS) (grant # 6 UB6HP31690-04-01)) and by the Health Resources and Services Administration (HRSA) of the U.S. Department of Health and Human Services (HHS) under grant #T76MC00011. REDCap at ITHS is supported by the National Center For Advancing Translational Sciences of the National Institutes of Health

under Award Number UL1 TR002319. Ruchi Tiwari was the second reviewer for this scoping review.

Acknowledgements

First and foremost, I would like to thank the members of my dissertation committee, who have continuously and generously given their time for the sake of my education and development as an epidemiologist. Dr. Daniel A. Enquobahrie has been a mentor to me for nearly five years, including the past two and a half years as my dissertation chair. I have so appreciate his continued guidance, advice, and kindness as I have navigated graduate school. Dr. Isaac Rhew has also been a long time mentor and I am incredibly grateful to have been able to learn psychiatric epidemiologic methods from him in class, through my MPH thesis, and in this doctoral dissertation. Dr. Yolanda Evans has very kindly offered so many insights into adolescent medicine that have offered additional context for this work and suggested many venues for sharing our findings. Finally, Dr. Lloyd Mancl has perfectly fulfilled the requirements of a GSR and, thus, made the dissertation process run very smoothly.

This dissertation would not be possible without the participants of both our own survey-based study and of the Youth Risk Behavior Survey. I sincerely appreciate many adolescents who have participated in these studies and shared things about their lives that may feel vulnerable. I hope that our efforts can help to make the world a happier, healthier, and more equitable place for the youth of today and youth in the future. This work would also not be possible without the contributions of Ruchi Tiwari to our scoping review. Ruchi, we're co-authors! May we have many, many more opportunities to continue to work together.

It is abundantly clear to me that this dissertation would not be possible without the support of both those who I have already mentioned and all the other people who have supported my education and goals along the way. I have been blessed to have been taught by

many teachers and mentors who encouraged critical thinking and my love of learning, including Randy Fields, Emily Adams, Dr. Ann Vander Stoep, and Dr. Maja Kodani and many more. In graduate school, I have found lifelong friendship with Ruchi Tiwari, Ashenafi Cherkos, and Nicole Loroña. It has been so fun being on this journey with you, watching your successes and feeling your support! I have also been cheered on by so many other dear friends, like Jeniffer and Danielle and so many others that it would probably be unprofessional for me to list them all. I cannot understate the ways in which my whole family has nurtured my curious mind and supported all my academic pursuits. Momma, Daddy, Michael, Papa Delawalla, Mama Delawalla, Adil, and Cecilia, thank you for all that you have done for me. Last, but not least, my husband Asif: there are simply no words that can sum up your support and encouragement. Thank you.

Funding Support Acknowledgement

This dissertation was supported in part by a student project stipend from the Northwest Public Health Training Center at the Northwest Center for Public Health Practice (sponsored by the Health Resources and Services Administration (HRSA) of the U.S. Department of Health and Human Services (HHS) (grant # 6 UB6HP31690-04-01)) and by the Health Resources and Services Administration (HRSA) of the U.S. Department of Health and Human Services (HHS) under grant #T76MC00011 through a dissertation stipend from the University of Washington Center of Excellence in Maternal and Child Health.

Table of Contents

List of Tables

List of Figures

Chapter 1. Background and Overview

1.1 Background

Substance use is common among adolescents in the United States. Estimates from the 2021 Monitoring the Future study indicate that 54.1% of twelfth graders reported use of alcohol in their lifetimes, with similarly high figures for any type of vaping (40.5 %) and cannabis use (38.6%) (1). Notably, the prevalence of lifetime alcohol use has decreased over time from 88.0% in 1991, while the prevalence of cannabis use increased from 1991 (36.7%) to 2010 (43.8%) and has remained approximately steady through 2021 (38.6%) apart from a decrease from 2020 (43.7%). Electronic vapor product use has, however, exploded with an increase from 35.5% in 2015 to 47.2% in 2020, with a decrease in 2021 to 40.5% possibly reflecting the impact of the COVID-19 pandemic.

Adolescents also experience a high prevalence of depressive symptoms, with the 2020 National Surveys on Drug Use and Health estimating that 17.0% of 12 to 17 year-olds had a major depressive episode in the past year, up from 8.0% in 2010 (2). The burden of depressive symptoms is substantially higher among adolescents than adults, at 6.0% of adults having a major depressive episode in the past year in 2020. It is additionally important to note that depressive symptoms and substance use prevalence varies by key demographic factors such as racial and ethnic identity and sexual identity (3,4).

Also, unfortunately prevalent among adolescents is the experience of having been bullied. In the 2019 Youth Risk Behavior Survey (YRBS), 19.5% of adolescents reported being bullied on school property in the past year and 15.7% of adolescents reported being bullied electronically in the past year (5). Social media use and internet use among adolescents has

become the norm. Estimates from the 2018 Pew Research Center indicate that 45% of adolescents use the internet “almost constantly” and that 95% of adolescents have access to a smartphone (6).

Evidence in the literature point to associations of both the experience of having been bullied (7–13) and depressive symptoms and suicidality (14–18) with substance use in adolescents. Further, depressive symptoms may be a mediator on the pathway from the experience of having been bullied to substance use in adolescents (8,19,20). Social media use has been associated with depressive symptoms and being a victim of cyberbullying, though it also plays an important role for adolescent development, identity formation, and connection (21).

Each of these adolescent experiences does not occur in isolation. Rather, current events and trends may influence adolescent life. In the present, the influence of the COVID-19 pandemic is at the forefront. The onset of the pandemic in the United States resulted in precautionary measures that substantially changed daily lives of adolescents, including transitions to online learning, cancellation of in-person academic and extracurricular activities, social distancing, heightened reliance on technology and the internet, and spending increased time in the home environment (22,23). The year 2020 was also fraught with traumas resulting from both the COVID-19 pandemic and highly publicized acts of racism (24).

Beyond the impacts of the pandemic, the context of adolescent mental health and substance use is shifting. State-level cannabis laws are changing, with more states legalizing recreational cannabis use for adults (25). Additionally, adolescent reported reasons for using cannabis are also changing, with a higher prevalence of coping reasons (26). Electronic vapor

product use has rapidly increased in recent years (1), which reflects a new way through which adolescents may be exposed to cannabis, nicotine, and other potentially toxic substances (27). Recent evidence also suggests that the observed associations between adolescent depressive symptoms and substance use may be changing. In an analysis of Monitoring the Future study data using time-varying effect modeling, the strength of the cross-sectional associations between depressive symptoms and binge drinking was observed to be decreasing over time (28).

With this context in mind, we sought to update existing knowledge and address gaps using data from the YRBS, a scoping literature review, and a descriptive survey of adolescents.

1.2 Specific Aims

Aim 1: To determine if depressive symptoms and suicidality are associated with current use of alcohol, electronic vapor products, cannabis, and prescription pain medicine among adolescents.

Sub Aim 1.1: To test if racial/ethnic identity, sex, and/or sexual orientation modify these associations.

Sub Aim 1.2: To examine the potential bidirectionality of the association, by modeling substance use as an exposure and depressive symptoms and suicidality as an outcome.

Aim 2: To determine if the associations of depressive symptoms and suicidality with use of alcohol, electronic vapor products, cannabis, and prescription pain medicine have changed over time in adolescents.

Aim 3: To determine if the experience of being bullied electronically or at school is associated with the current use of alcohol, electronic vapor products, cannabis, and prescription pain medicine among adolescents.

Sub Aim 3.1: To test if racial/ethnic identity, sex, and/or sexual orientation modify these associations.

Sub Aim 3.2: To conduct an exploratory mediation analysis of association of experience of bullying and depressive symptoms by substance use.

Aim 4: To describe the impact of COVID-19 on adolescent-reported substance use, social media use, and depressive symptoms using literature review and a survey-based study.

1.3 Overview of the Dissertation

Chapter 2 describes analyses and results of our assessment of cross-sectional associations of depressive symptoms and suicidality with substance use (Aim 1). Chapter 3 describes assessment of cross-sectional associations of depressive symptoms and suicidality and substance use over time, beginning in 1991 through 2019. Chapter 4 describes analyses and results of our assessment of cross-sectional associations of the experience of being bullied with substance use. Chapter 5 describes the results of our scoping review on the COVID-19 pandemic and adolescent social media use, substance use, and depressive symptoms. Chapter 6 describes the results of our online, anonymous survey-based study of adolescent social media use, substance use, and depressive symptoms during the COVID-19 pandemic. Finally, chapter 7 describes broad findings, strengths and limitations, and public health recommendations and future research directions.

The findings of this dissertation may inform priorities for prevention and intervention efforts for adolescent social, emotional, and physical health by identifying current trends. Further, our findings highlight gaps in the literature that may be addressed by future research.

1.4 References

1. Johnston LD, Miech RA, O'Malley PM, et al. Monitoring the Future national survey results on drug use 1975-2021: Overview, key findings on adolescent drug use. Ann Arbor: University of Michigan Institute for Social Research; 2022 (Accessed May 17, 2022).(http://www.monitoringthefuture.org//pubs/monographs/mtf-overview2021.pdf). (Accessed May 17, 2022)

2. Substance Abuse and Mental Health Services Administration. Key substance use and mental health indicators in the United States: Results from the 2020 National Survey on Drug Use and Health. Center for Behavioral Health Statistics and Quality, Substance Abuse and Mental Health Services Administration; 2021 (Accessed January 13, 2022).(https://www.samhsa.gov/data/sites/default/files/reports/rpt35325/NSDUHFFRPDFWHTMLFiles2020/2020NSDUHFFR1PDFW102121.pdf). (Accessed January 13, 2022)

3. Chadi N, Li G, Cerda N, et al. Depressive Symptoms and Suicidality in Adolescents Using e-Cigarettes and Marijuana. *Journal of Addiction Medicine*. 2019;13(5):1.

4. Luk JW, Gilman SE, Haynie DL, et al. Sexual orientation and depressive symptoms in adolescents. *Pediatrics*. 2018;141(5).

5. Basile KC, Clayton HB, DeGue S, et al. Interpersonal Violence Victimization Among High School Students — Youth Risk Behavior Survey, United States, 2019. *MMWR Suppl.* [electronic article]. 2020;69(1):28–37. (http://www.cdc.gov/mmwr/volumes/69/su/SU6901a4.htm?s_cid=SU6901a4_w). (Accessed January 19, 2022)

6. Anderson M, Jiang J. Teens, Social Media & Technology 2018. Pew Research Center; 2018.(https://www.pewresearch.org/internet/2018/05/31/teens-social-media-technology-2018/)

7. Radliff KM, Wheaton JE, Robinson K, et al. Illuminating the relationship between bullying and substance use among middle and high school youth. *Addictive Behaviors* [electronic article]. 2012;37(4):569–572. (http://dx.doi.org/10.1016/j.addbeh.2012.01.001)

8. Luk JW, Wang J, Simons-Morton BG. Bullying Victimization and Substance Use Among U.S. Adolescents: Mediation by Depression. *Prev Sci* [electronic article]. 2010;11(4):355–359. (http://link.springer.com/10.1007/s11121-010-0179-0). (Accessed April 28, 2022)

9. Kim MJ, Catalano RF, Haggerty KP, et al. Bullying at elementary school and problem behaviour in young adulthood: A study of bullying, violence and substance use from age 11 to age 21. *Criminal Behav. Ment. Health* [electronic article]. 2011;21(2):136–144. (https://onlinelibrary.wiley.com/doi/10.1002/cbm.804). (Accessed April 28, 2022)

10. Orr M, Rajotte J, Jackson T, et al. E-cigarette Use and Rhode Island High School Students: What Providers Need to Know about the Characteristics of Initiation of E-cigarettes and Related Risk Behaviors. *Rhode Island Medical Journal* [electronic article]. 2020;103(1):51–54. (http://www.ncbi.nlm.nih.gov/pubmed/32013307)

11. Doxbeck CR. Up in Smoke: Exploring the Relationship between Bullying Victimization and E-Cigarette Use in Sexual Minority Youths. *Substance Use & Misuse* [electronic article]. 2020;55(13):2221–2229. (https://www.tandfonline.com/doi/full/10.1080/10826084.2020.1797809). (Accessed April 28, 2022)

12. Hansen J, Morgenstern M, Isensee B, et al. Association between bullying victimization and e-cigarette use among German students. *Aggressive Behavior.* [electronic article]. 2021;47(4):421–429. (https://onlinelibrary.wiley.com/doi/10.1002/ab.21951). (Accessed April 28, 2022)

13. Azagba S, Mensah NA, Shan L, et al. Bullying Victimization and e-Cigarette Use among Middle and High School Students. *J School Health* [electronic article]. 2020;90(7):545–553. (https://onlinelibrary.wiley.com/doi/10.1111/josh.12902). (Accessed April 28, 2022)

14. Edlund MJ, Forman-Hoffman VL, Winder CR, et al. Opioid abuse and depression in adolescents: Results from the National Survey on Drug Use and Health. *Drug and Alcohol Dependence* [electronic article]. 2015;152:131–138. (http://dx.doi.org/10.1016/j.drugalcdep.2015.04.010)

15. Scholes-Balog KE, Hemphill SA, Patton GC, et al. Relationships Between Substance Use and Depressive Symptoms: A Longitudinal Study of Australian Adolescents. *The Journal of Early Adolescence* [electronic article]. 2015;35(4):538–561. (http://journals.sagepub.com/doi/10.1177/0272431614540526). (Accessed April 14, 2022)

16. Cioffredi L-A, Kamon J, Turner W. Effects of depression, anxiety and screen use on adolescent substance use. *Preventive Medicine Reports* [electronic article]. 2021;22:101362. (https://linkinghub.elsevier.com/retrieve/pii/S221133552100053X). (Accessed April 14, 2022)

17. Wang P-W, Lin H-C, Yeh Y-C, et al. The relation of substance use with different levels of depressive symptoms and the moderating effect of sex and age in Taiwanese adolescents.

Comprehensive Psychiatry [electronic article]. 2012;53(7):1013–1020. (https://linkinghub.elsevier.com/retrieve/pii/S0010440X12000314). (Accessed April 14, 2022)

18. Pirkola SP, Marttunen MJ, Henriksson MM, et al. Alcohol-related problems among adolescent suicides in Finland. *Alcohol and Alcoholism*. 1999;34(3):320–329.

19. Hong JS, Davis JP, Sterzing PR, et al. A conceptual framework for understanding the association between school bullying victimization and substance misuse. *American Journal of Orthopsychiatry*. 2014;84(6):696–710.

20. Earnshaw VA, Elliott MN, Reisner SL, et al. Peer victimization, depressive symptoms, and substance use: A longitudinal analysis. *Pediatrics*. 2017;139(6).

21. Uhls YT, Ellison NB, Subrahmanyam K. Benefits and Costs of Social Media in Adolescence. *Pediatrics* [electronic article]. 2017;140(Supplement_2):S67–S70. (https://publications.aap.org/pediatrics/article/140/Supplement_2/S67/34168/Benefits-and-Costs-of-Social-Media-in-Adolescence). (Accessed March 29, 2022)

22. Fegert JM, Vitiello B, Plener PL, et al. Challenges and burden of the Coronavirus 2019 (COVID-19) pandemic for child and adolescent mental health: A narrative review to highlight clinical and research needs in the acute phase and the long return to normality. *Child and Adolescent Psychiatry and Mental Health* [electronic article]. 2020;14(1):1–11. (https://doi.org/10.1186/s13034-020-00329-3)

23. Singh S, Roy D, Sinha K, et al. Impact of COVID-19 and lockdown on mental health of children and adolescents: A narrative review with recommendations. *Psychiatry Research* [electronic article]. 2020;293:113429. (https://linkinghub.elsevier.com/retrieve/pii/S016517812031725X)

24. Silver RC, Holman EA, Garfin DR. Coping with cascading collective traumas in the United States. *Nature Human Behaviour* [electronic article]. 2020;(http://dx.doi.org/10.1038/s41562-020-00981-x)

25. National Conference of State Legislatures. Marijuana Overview. 2019;(http://www.ncsl.org/research/civil-and-criminal-justice/marijuana-overview.aspx). (Accessed December 9, 2019)

26. Patrick ME, Evans-Polce RJ, Kloska DD, et al. Reasons High School Students Use Marijuana: Prevalence and Correlations With Use Across Four Decades. *Journal of Studies on Alcohol and Drugs* [electronic article]. 2019;80(1):15–25. (https://www.jsad.com/doi/10.15288/jsad.2019.80.15)

27. Becker TD, Rice TR. Youth vaping: a review and update on global epidemiology, physical and behavioral health risks, and clinical considerations. *Eur J Pediatr* [electronic article]. 2022;181(2):453–462. (https://link.springer.com/10.1007/s00431-021-04220-x). (Accessed May 17, 2022)

28. Keyes KM, Hamilton A, Patrick ME, et al. Diverging Trends in the Relationship Between Binge Drinking and Depressive Symptoms Among Adolescents in the U.S. From 1991 Through 2018. *Journal of Adolescent Health* [electronic article]. 2020;66(5):529–535. (https://doi.org/10.1016/j.jadohealth.2019.08.026)

Chapter 2. Cross-sectional Associations of Depressive Symptoms and Suicidality with Substance Use In 2019

2.1 Abstract

Purpose: Adolescent depressive symptoms, suicidality, and substance use are prevalent in the United States. The context for these public health issues is changing, with increasing prevalence of depressive symptoms, changing substance laws, and new products such as electronic vapor products. We examined associations of depressive symptoms and suicidality with substance use in a large, recent, nationally representative sample of adolescents in the United States. We additionally assessed for differences in these associations by demographic factors.

Methods: The study sample comprised of respondents of the 2019 Youth Risk Behavior Survey data (13,677 participants). Applying appropriate survey weights, we utilized multivariable logistic regression to model associations between past 12 month depressive symptoms and suicidality indicators (considering suicide, suicide plans, suicide attempts, and injurious suicide attempts) and past 30 day ever use of substances (cannabis use, alcohol use, binge drinking, electronic vapor product use, or prescription pain medicine misuse). We assessed for interactions between depressive symptoms and suicidality and demographic factors (racial/ethnic identity, sex, and sexual identity) using Rao-Scott likelihood ratio tests. We additionally explored the potential for bidirectionality of the associations by modeling lifetime ever substance use as independent variables and past 12 month depressive symptoms and suicidality indicators as dependent variables.

Results: In the weighted sample, for the past 12 month period 36.2% of participants reported depressive symptoms, 18.5% considered suicide, 15.5% made a plan for suicide, 7.5% made at

least one suicide attempt, and 2.0% reported a suicide attempt that required treatment by a medical professional. Electronic vapor product use was the most prevalent form of substance use with 30.9% reporting any use in the past 30 days, followed by alcohol (27.2%), cannabis (21.1%), binge drinking (12.4%), and prescription pain medicine misuse (5.5%). In fully adjusted models including covariates for race/ethnicity, sex, sexual identity, age, and other substance use, depressive symptoms in the past 12 months were statistically significantly associated with past 30 day ever alcohol use (aOR: 1.28; 95% CI: 1.09, 1.51; p = 0.004), past 30 day ever cannabis use (aOR: 1.43; 95% CI: 1.20, 1.70; p < 0.001), past 30 day ever electronic vapor product use (aOR: 1.55; 95% CI: 1.30, 1.84; p < 0.001), and past 30 day ever prescription pain medicine misuse (aOR: 2.62; 95% CI: 1.97, 3.48; p < 0.001) except for past 30 day ever binge drinking (aOR: 1.42; 95% CI: 1.02, 1.99; p = 0.041). Seriously considering attempting suicide, making a suicide plan, and suicide attempts were significantly associated with past 30 day any alcohol use, cannabis use, electronic vapor product use, and prescription pain medicine misuse (aORs range: 1.27, 3.18; p-value range: <0.001, 0.004), except the independent and dependent variable combination of having made a suicide plan and alcohol use (aOR: 1.29; 95% CI: 1.04, 1.59; p = 0.021). Models for lifetime substance use and past 12 month depressive symptoms and suicidality supported bidirectionality in these associations. There was no evidence of multiplicative interaction between depressive symptoms and suicidality and demographic factors.

Conclusions: Findings were largely similar to existing reports of both cross-sectional and longitudinal studies for bidirectional associations of depression symptoms and suicidality with

substance use. Study findings may inform identification of adolescents at risk for poor mental health and/or substance use.

2.2 Introduction

Adolescent substance use, depressive symptoms, and suicide are pressing public health issues. In 2021, 54.1% of twelfth graders reported use of alcohol in their lifetimes with similarly high figures for any type of vaping (40.5 %) and cannabis use (38.6%) (1). Notably, the prevalence of alcohol use has decreased, while the prevalence of cannabis use has remained approximately steady and the prevalence of electronic vapor product use has increased quickly. Additionally, 12.8% reported using illicit drugs other than cannabis at least once in their lifetimes. The 2020 National Surveys on Drug Use and Health indicate that 17.0% of 12 to 17 year-olds are estimated to have had a major depressive episode in the past year, up from 8.0% in 2010 (2). Perhaps even more alarming, suicide rates among 15 to 24 year-olds are higher than homicide rates in the US, and suicide rates among 10 to 24 year-olds have increased from 6.8 deaths per 100,000 individuals in the year 2007 to 10.7 deaths per 100,000 in 2018 (3).

Existing evidence suggests that experience of depressive symptoms and suicidality may lead to substance use among adolescents (4–8). These findings are in alignment with a variety of psychological theories and models, including the self-medication hypothesis which posits that use of substances can alleviate uncomfortable affective states (9) and the reformulated negative reinforcement model through which preconscious cues influence substance use to mitigate negative affect and negatively reinforce substance use behavior (10,11). In addition to the potential for depressive symptoms and suicidality to lead to substance use, some evidence

points to substance use leading to depressive symptoms (12,13). Psychological theories suggest that substance use may lead to interpersonal conflict and increased isolation which may result in depressive symptoms via problem-behavior theory (14,15) and a stress model proposed by Wilkinson et al. (12).

While the associations between depressive symptoms and suicidality and substance use are well-characterized in the literature, few studies have examined these associations altogether in an up-to-date and representative sample of adolescents. The context for these public health issues is rapidly changing. With evolving cannabis use-related state laws (16), the advent and explosion of electronic vapor product use (17), and evidence for potential changes in relationships (e.g., decrease in the cross-sectional association between depressive symptoms and binge drinking over time (18)), it is of the utmost importance to characterize and understand the current trends and associations in adolescent depressive symptoms and substance use.

In addition, a comprehensive understanding of current associations between adolescent depressive symptoms and suicidality and substance use must include assessment for differences in these associations by key adolescent identity factors. The prevalence of substance use and mental health issues are known to vary by demographic factors such as race and sexual identity (19,20). Individuals with marginalized identities face additional stress due to the experience of discrimination on individual and systemic levels, which, in turn, results in impacts that added stress may have on both physical and mental health (21–24). The role of stress in the health of racial and ethnic minoritized populations is well-characterized in the literature. Among children and adolescents, the experience or expectations of racial

discrimination are associated with poor mental health outcomes (25–27), which may reflect maladaptive coping and stress responses as delineated by the biopsychosocial model (28) and psychosocial stress associated with chronic vigilance (29). The minority stress model posits that both experiences of discrimination and internal stress processes (e.g. concealment of sexual orientation, internalized homophobia) can lead to deleterious health outcomes (24). This model is supported by findings among both sexual (30–32) and gender minoritized groups (33–35).

Within this context, we sought to describe cross-sectional associations of adolescent depressive symptoms and suicidality with substance use (i.e., cannabis use, electronic vapor product use, alcohol use, binge drinking, and prescription pain medicine misuse) in a nationally representative sample of adolescents. Further, we assessed for differences in associations by key demographic factors (i.e., race/ethnicity, sex, and sexual identity) and for bidirectionality (i.e., substance use leading to depressive symptoms and suicidality) in these associations.

2.3 Methods

Study Sample

We used publicly available data from the 2019 National Youth Risk Behavior Survey (YRBS) to assess current associations of depressive symptoms and suicidality with adolescent substance use (36). The YRBS was designed using a three-stage cluster sampling scheme including counties and groups of counties as primary sampling units, schools with grades nine through 12 as secondary sampling units, and classrooms during a required period or subject in the third sampling stage (37). Both schools and individual classes were sampled using systematic equal probability sampling with a random start (36). All students in a selected class

were eligible to participate, and sampling units (i.e., schools, classes, and students) were not replaced in the sampling design upon refusal to participate (37). This sampling scheme is intended to result in a nationally representative sample of public and private high school students in grades nine to 12 in the United States after application of survey weights. In total, 181 schools were sampled, of which 136 schools participated (36). The total number of sampled students was 17,025, of which 13,872 students submitted questionnaires. After the data were edited for consistency and plausibility, the final analytic sample was 13,677 students. Therefore, the overall response percentage (i.e., school response rate X student response rate) was 60.3%.

In order to account for oversampling of Hispanic and Black students and nonresponse from schools and students, sampling weights were applied to each student, which were scaled in order to match the underlying population of students (36). In the final dataset, overall weights were scaled to match the total sample size. Additionally, weighted proportions of students in each grade were matched to the projection of the population size of each grade (grades nine to 12).

Data Collection and Human Subjects Protections

The protocol for the 2019 YRBS was approved by the Center for Disease Control and Prevention's Institutional Review Board (37). Local parental permission guidelines were followed prior to survey administration and students participated voluntarily and anonymously. Students completed the 2019 questionnaire booklet anonymously in approximately 45 minutes. Anonymous data resulting from the national 2019 YRBS are publicly available for download

(38). These analysis activities were reviewed by the University of Washington Human Subjects Division and deemed to not involve human subjects.

Analytic Variables

This analysis evaluated depressive symptoms, serious consideration of suicide attempts, suicide plans, suicide attempts, and injurious suicide attempts as independent variables. In addition, it evaluated cannabis use, alcohol use, binge drinking, electronic vapor product use, and prescription pain medication misuse as dependent variables. Independent variables were queried for experience in the past 12 months (e.g., "During the past 12 months, did you ever feel so sad or hopeless almost every day for two weeks or more in a row that you stopped doing some usual activities?"), while dependent variables were queried for the past 30 days (e.g. "During the past 30 days, how many times did you use marijuana?"). Covariates to address both confounding and effect modification included demographic characteristics (i.e., race/ethnicity with mutually exclusive categories of American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, White, Hispanic/Latino, Multiple—Hispanic/Latino, Multiple—Non-Hispanic/Latino; age with categories of 12 years old or younger, 13 years old, 14 years old, 15 years old, 16 years old, 17 years old, 18 years old or older; sex with categories of male and female; and sexual identity with categories of heterosexual (straight), gay or lesbian, bisexual, and not sure) and a combined variable for use of other substances besides the modeled substance use outcome (e.g., for models with cannabis use outcomes, ever lifetime use of cocaine, inhalants, heroin, methamphetamines, ecstasy, synthetic marijuana, steroid pills and shots, hallucinogens and injection drugs and past

30 day use of alcohol, binge drinking, electronic vapor products, and prescription pain medication misuse).

Bidirectional analyses considering substance use as independent variables and depressive symptoms and suicidality as dependent variables were similar, except that substance use independent variables were based on 2019 YRBS questions querying lifetime exposure to substances (e.g., "Have you ever used an electronic vapor product?"). Depressive symptoms and suicidality dependent variables were assessed for the period of the past 12 months. See Appendix Table 2.1 for full details on YRBS 2019 questions and response options utilized in this analysis.

Statistical Analysis

Descriptive statistics including percentages were calculated for the weighted survey sample. To estimate the associations of depressive symptoms and suicidality with substance use, we used binary logistic regression to model each exposure and outcome combination (e.g., past 12 month depressive symptoms and past 30 day cannabis use, past 12 month injurious suicide attempts and past 30 day binge drinking, etc.). Outcome variables were created from the original YRBS item response options to represent binary measures of use (i.e., did or did not use the substance in the past 30 days). Additional binary measures were created to assess the odds of higher levels of use (e.g., did or did not use the substance on 10 or more days in the past 30 days) for exploratory analyses. We ran unadjusted, partially adjusted (including race/ethnicity, sex, sexual orientation, and age), and fully adjusted models (additionally including a combined variable for use of substances besides the modeled outcome variable as described above; e.g., for models considering cannabis use, ever lifetime use of cocaine,

inhalants, heroin, methamphetamines, ecstasy, synthetic marijuana, steroid pills and shots, hallucinogens and injection drugs and past 30 day use of alcohol, binge drinking, electronic vapor products, and prescription pain medication misuse). We present both unadjusted odds ratios (ORs) and adjusted odds ratios (aORs), 95% confidence intervals (95% CIs), and p-values. Given the number of outcomes per exposure variable, we assessed for statistical significance at a two-sided p-value < 0.01 ($\alpha = 0.05/5 = 0.01$) to account for multiple hypothesis testing.

As an exploratory analysis to the main aims, we assessed the fully adjusted odds ratios associated with different levels of past 30 day electronic vapor product use which was the most prevalent substance use behavior reported. We present models assessing the odds associated with each level of use measured: past 30 day use versus no past 30 day use, use on 3 or more days versus less than 3 days, use on 6 or more days versus less than 6 days, use on 10 or more days versus less than 10 days, use on 20 or more days versus less than 20 days, and use on all 30 days versus use on less than 30 days.

We additionally assessed for effect modification by demographic factors (race/ethnicity, sex, and sexual identity) through inclusion of interaction terms between the demographic factor and exposure (e.g., depressive symptoms X sex) in fully adjusted models. Statistical significance of interactions between independent variables and demographic factors were assessed with Rao-Scott likelihood ratio tests with a two-sided p-value < 0.01 as the level of significance. Due to power concerns, we present stratified models for independent variable and demographic factor combinations for which the Rao-Scott likelihood ratio test p values were less than 0.10 as an exploratory analysis. Finally, we assessed for the potential for bidirectionality in the associations of depressive symptoms and suicidality with substance use

by modeling lifetime substance use variables as independent variables, with the exception of lifetime binge drinking which was not assessed in the YRBS 2019 questionnaire, and past 12 month depressive symptoms and suicidality variables as dependent variables. All analyses were conducted in R version 3.6.2 and the R *survey* package (39) was utilized to apply survey weights necessary for complex survey analyses.

2.4 Results

Demographics

After applying weights to the 13,677 responses, 48.9% of respondents reported their sex as female and 50.2% as male (Table 2.1). Nearly half the weighted sample was White (49.6%). The second most common racial/ethnic group was multiple races Hispanic/Latino (16.4%) followed by Black or African American (11.8%). Other racial/ethnic groups each represented less than 10% of weighted sample: Hispanic/Latino (8.9%), Asian (4.9%), multiple races non-Hispanic/Latino (4.3%), American Indian/Alaska Native (0.6%), Native Hawaiian/Other Pacific Islander (0.3%). Of note, 3.1% of the weighted sample had racial/ethnic data missing. With regard to sexual identity, the majority of the weighted sample was heterosexual (79.2%), followed by 8.2% who were bisexual, 6.1% with sexual identity responses missing, 4.2% who were “not sure”, and 2.3% who were gay or lesbian. Corresponding with the high school (grades nine through 12) setting of the survey, only 0.2% of the weighted sample were in another grade or ungraded and few in the weighted sample were 12 years old or younger (0.3%) or 13 years old (0.1%).

Prevalence of Past 12 Month Depressive Symptoms and Suicidality Indicators

In the weighted sample, 36.2% of participants reported feelings of sadness or hopelessness for a two week period in the past year that resulted in stopping some usual activities (Table 2.2). Nearly one-fifth (18.5%) of the weighted sample seriously considered attempting suicide in the past year. Making a plan for how to attempt suicide was similarly prevalent (15.5%). Suicide attempts in the past 12 months had a relatively large percentage of missing data (16.4%), but 4.1% of the weighted sample reported one suicide attempt, 2.3% reported two to three attempts, 0.5% reported four to five attempts, and 0.6% reported six or more attempts. Finally, 2.0% of the weighted sample had a suicide attempt that required treatment by a medical professional.

Prevalence of Past 30 Day Substance Use Behaviors

The most prevalent past 30 day substance use behavior reported in the weighted cohort was electronic vapor product use with 30.9% reporting use in the past 30 days (Table 2.3). Alcohol use was similarly prevalent with 27.2% of the weighted sample reporting past 30 day use. Past 30 day binge drinking was less common at 12.4%. Cannabis use in the past 30 days was reported by 21.1% of the weighted sample. The least prevalent was prescription pain medication misuse, which was reported by only 5.5% of the weighted sample.

Associations of Depressive Symptoms with Substance Use

Across all unadjusted and partially adjusted models, associations of depressive symptoms with all substance use behaviors were statistically significant ($p < 0.001$) (Table 2.4). In fully adjusted models additionally including covariates other substance use, depressive symptoms in the past 12 months were statistically significantly ($p \leq 0.001$) associated with all past 30 day ever use of substance use behaviors except for past 30 day ever binge drinking

(aOR: 1.31; 95% CI: 1.05, 1.64; p = 0.020). Statistically significant associations were observed for past 30 day ever alcohol use (aOR: 1.28; 95% CI: 1.09, 1.51; p = 0.004), past 30 day ever cannabis use (aOR: 1.43; 95% CI: 1.20, 1.70; p < 0.001), past 30 day ever electronic vapor product use (aOR: 1.55; 95% CI: 1.30, 1.84; p < 0.001), and past 30 day ever prescription pain medicine misuse (aOR: 2.62; 95% CI: 1.97, 3.48; p < 0.001). Notably, observed odds ratios were generally smaller for fully adjusted models than unadjusted and partially adjusted models.

Associations of Considering Suicide and Making a Suicide Plan with Substance Use

Associations between seriously considering attempting suicide in the past 12 months and past 30 day ever use of substances were all statistically significant at $\alpha = 0.01$ with no adjustment (p < 0.001) and partial adjustment (p < 0.001), as well as after full adjustment except for past 30 day ever binge drinking (aOR: 1.30; 95% CI: 1.06, 1.59, p = 0.015). Statistically significant associations included past 30 day ever misuse of prescription pain medicine (aOR: 3.08; 95% CI: 2.35, 4.04; p < 0.001), past 30 day ever use of alcohol (aOR: 1.38; 95% CI: 1.17, 1.63; p < 0.001), past 30 day ever cannabis use (aOR: 1.72; 95% CI; 1.46, 2.01; p < 0.001), and past 30 day ever electronic vapor product use (aOR: 1.52; 95% CI: 1.28, 1.80; p < 0.001).

For making a suicide plan in the past 12 months, all unadjusted and partially adjusted ORs were statistically significant (p < 0.001). In addition, all fully adjusted associations with past 30 day ever use were significant (cannabis: aOR: 1.57; 95% CI: 1.32, 1.86; p < 0.001; electronic vapor product: aOR: 1.47; 95% CI: 1.20, 1.80; p < 0.001; and prescription pain medicine misuse: aOR: 3.18; 95% CI: 2.40, 4.21; p < 0.001) with the exception of past 30 day ever binge drinking (aOR: 1.27; 95% CI: 1.00, 1.61, p = 0.048) and past 30 day ever alcohol use (aOR: 1.29; 95% CI: 1.04, 1.59; p = 0.021).

Associations of Suicide Attempts and Injurious Suicide Attempts with Substance Use

Past 12 month suicide attempts followed a similar pattern to that of depressive symptoms and seriously considering attempting suicide; all unadjusted and partially adjusted odds ratios were statistically significant ($p < 0.001$). Additionally, positive associations were observed in fully adjusted models with all past 30 day ever use of substances including the only significant association observed for binge drinking (aOR = 1.31; 95% CI: 1.09, 1.58; $p = 0.006$). Other significant associations observed included for past 30 day ever alcohol use (aOR: 1.27; 95% CI: 1.09, 1.47; $p = 0.004$), past 30 day ever cannabis use (aOR: 1.32; 95% CI: 1.16, 1.51; $p < 0.001$), past 30 day ever electronic vapor product use (aOR: 1.31; 95% CI: 1.15, 1.48; $p < 0.001$), and past 30 day ever prescription pain medicine misuse (aOR: 2.02; 95% CI: 1.75, 2.33; $p < 0.001$).

No statistically significant associations were found for injurious suicide attempts in the past 12 months and past 30 day ever use of substances with a significance level of $\alpha = 0.01$ in fully adjusted models (alcohol: aOR: 1.23; 95% CI: 0.66, 2.28; $p = 0.5$; binge drinking: aOR: 1.40; 95% CI: 0.87, 2.24; $p = 0.2$; cannabis: aOR: 1.45; 95% CI: 0.85, 2.46; $p = 0.2$; electronic vapor product: aOR: 1.30; 95% CI: 0.69, 2.43; $p = 0.4$; prescription pain medicine: aOR: 1.99; 95% CI: 1.09, 3.65; $p = 0.028$). However, significant associations were observed in unadjusted models for binge drinking ($p = 0.002$), cannabis use ($p = 0.007$), and prescription pain medicine misuse ($p = 0.002$).

Exploratory Analyses of Level of Electronic Vapor Product Use Outcomes

In exploratory analyses of associations of depressive symptoms and suicidality with differing levels of electronic vapor product use in the past 30 days, findings were generally

similar across all levels of use. The strongest association was observed for any past 30 day use (aOR: 1.55; 95% CI: 1.30, 1.84; p < 0.001) and the weakest was observed for use on all 30 days (aOR: 1.37; 95% CI: 1.11, 1.70; p = 0.006). Associations for depressive symptoms were significant for all other levels (p range: < 0.001 to 0.003).

Associations of having seriously considered attempting suicide (aOR range: 1.52 to 1.68; all p values < 0.001), having made a suicide plan (aOR range: 1.39 to 1.66; p value range: <0.001 to 0.026), and suicide attempts (aOR range: 1.27 to 1.34; p value range: < 0.001 to 0.002) were also similar across all independent and dependent variable combinations with the exception of having made a suicide plan and electronic vapor product use on all 30 days in the past 30 days (aOR: 1.39; 95% CI: 1.04, 1.85; p = 0.026) which was not statistically significant. No associations were statistically significant for injurious suicide attempts and all past 30 day electronic vapor product use categories (aOR range: 1.19 to 1.76; p value range: 0.043 to 0.4).

Exposure and Demographic Factor Interactions

Assessment of interactions between independent variables and demographic factors indicated no statistically significant interactions at the $\alpha = 0.01$ level between past 12 month depressive symptoms and suicidality and past 30 day ever use of substances by demographic factors (Table 2.5). We conducted exploratory analyses of stratified models for which Rao-Scott likelihood ratio test p values less than 0.1 (Appendix Tables 2.3 - 2.5). With regard to sex, both the association of past 12 month having seriously considered suicide and past 30 day ever binge drinking (females: aOR: 1.50; 95% CI: 1.22, 1.83; p < 0.001; males: aOR: 1.05; 95% CI: 0.72, 1.54; p = 0.8) and the association of past 12 month suicide attempts and past 30 day ever cannabis use (females: aOR: 1.47; 95% CI: 1.25, 1.72; p < 0.001; males: 1.21; 95% CI: 0.97, 1.51; p =

0.084) was significant for females but not for males. For associations of past 12 month having made a suicide plan (females: aOR: 2.84; 1.98, 4.07; $p < 0.001$; males: aOR: 3.98; 95% CI: 2.81, 5.64; $p < 0.001$) and past 12 month suicide attempts (females: aOR: 1.85; 95% CI: 1.57, 2.17, $p < 0.001$; males: aOR: 2.30; 95% CI: 1.82, 2.91; $p < 0.001$) with prescription pain medicine, associations were significant for both males and females, but stronger for males.

Analyses stratified by racial/ethnic groups were limited by sample size and should be considered within this context. However, we observed strongest associations for past 12 month depressive symptoms and past 30 day ever alcohol use among Hispanic/Latino youth (aOR: 2.60; 95% CI: 1.44, 4.67; $p = 0.003$). For the association of past 12 month having made a suicide plan and past 30 day prescription pain medicine misuse, all odds ratios suggested increased odds, but significant associations were only observed for Black or African American youth (aOR: 4.18; 95% CI: 1.75, 9.99; $p = 0.003$), White youth (aOR: 3.85; 95% CI: 2.68, 5.53; $p < 0.001$); and non-Hispanic multiracial youth (aOR: 7.94l 95% CI: 2.42, 26.1; $p = 0.002$). Observed associations of past 12 month injurious suicide attempts and past 30 day prescription pain medicine misuse were substantially impeded by sample size, as evidenced by missing estimates and wide CIs.

Comparing associations by sexual identity groups, associations of past 12 month having seriously considered attempting suicide and past 30 day ever cannabis use were similar in strength across groups, but only statistically significant for heterosexual youth (aOR: 1.60; 95% CI: 1.31, 1.96; $p < 0.001$) and youth who were “not sure” (aOR: 1.98; 95% CI: 1.27, 3.09; $p = 0.004$). For the association of having made a suicide plan with past 30 day ever prescription pain medicine misuse, associations were statistically significant for adolescents who were “not sure” (aOR: 11.0; 95% CI: 3.89, 31.0; $p < 0.001$), gay or lesbian adolescents (aOR: 10.2; 95% CI:

2.55, 40.6; p = 0.003), and heterosexual adolescents (aOR: 3.19; 95% CI: 2.29, 4.44; p < 0.001). For bisexual adolescents, the association was the weakest and not significant (aOR: 1.93; 95% CI: 1.12, 3.33; p = 0.021). Finally, for the association of past 12 month suicide attempts and past 30 day ever prescription pain medicine misuse, associations were statistically significant for adolescents who identified as "not sure" (aOR: 3.55; 95% CI: 2.20, 5.71; p < 0.001), bisexual (aOR: 2.49; 95% CI: 1.83, 3.39; p < 0.001), and heterosexual (aOR: 1.89; 95% CI: 1.60, 2.23; p < 0.001), but not for adolescents who identified as gay or lesbian (aOR: 1.63; 95% CI: 0.86, 3.10; p = 0.12).

Assessment for Bidirectionality

To assess for potential bidirectionality in the associations of depressive symptoms and suicidality with substance use, we modeled associations between report of ever lifetime substance use and past 12 month depressive symptoms and suicidality (Table 2.6). Lifetime ever use of prescription pain medicine was significantly associated with all past 12 month depressive symptoms and suicidality outcomes (all p < 0.001). Of these, the strongest effect was seen for suicide attempts such that, after controlling for race/ethnicity, sex, age, sexual identity, and other substance use, adolescents who reported one or more suicide attempts in the past 12 months had 3.88 (95% CI; 3.30, 4.57, p < 0.001) times the odds of reporting ever misusing prescription pain medicine in their lifetime.

Both lifetime ever use of cannabis and lifetime ever use of electronic vapor products were statistically significantly associated with depressive symptoms, seriously considering attempting suicide, making a suicide plan, and one or more suicide attempts in the past year after full adjustment (all p < 0.001), but not for injurious suicide attempts (ever cannabis use p =

0.10; ever electronic vapor product use p = 0.3). Lastly, lifetime ever use of alcohol was associated with depressive symptoms (aOR = 1.38; 95% CI: 1.17, 1.64; p < 0.001), seriously considering attempting suicide (aOR = 1.48; 95% CI: 1.25, 1.75; p < 0.001), and making a suicide plan (aOR = 1.42; 95% CI: 1.18, 1.73; p < 0.001), but not one or more suicide attempts (aOR = 1.52; 95% CI: 1.10, 2.08, p = 0.013) or injurious suicide attempts (aOR = 1.68; 95% CI: 1.01, 2.80; p = 0.048).

2.5 Discussion

Using a recent nationally representative sample of adolescents, we examined cross-sectional associations of the experience of depressive symptoms and suicidality in the past 12 months with alcohol use, cannabis use, electronic vapor product use, and prescription pain medicine misuse in the past 30 days. In models including covariates for demographic factors and use of other substances, the strongest associations were observed for prescription pain medicine misuse outcomes, such that we identified statistically significant associations of reports of past 12 month depressive symptoms (aOR: 2.62; 95% CI: 1.97, 3.48; p < 0.001), seriously considered attempting suicide (aOR: 3.08; 95% CI: 2.35, 4.04; p < 0.001), having made a suicide plan (aOR: 3.18; 95% CI: 2.40, 4.21; p < 0.001), and suicide attempts (aOR: 2.02; 95% CI: 1.75, 2.33; p < 0.001) and report of ever misusing prescription pain medicine in the past 30 days. Significant associations were also observed for past 12 month depressive symptoms, consideration of suicide attempts, suicide plans, and suicide attempts for past 30 day ever alcohol use, cannabis use, electronic vapor product use, and prescription pain medicine misuse (with the exception of having made a suicide plan and alcohol use).

We did not find differences in associations of depressive symptoms and suicidality with substance use among groups defined by demographic factors (i.e., race/ethnicity, sex, and sexual identity) as determined by Rao-Scott Likelihood Ratio Tests assessing the addition of interaction terms to fully adjusted models. Finally, we did find evidence of potential bidirectionality in the association, such that lifetime ever use of alcohol, cannabis, electronic vapor product use, and prescription pain medicine misuse was positively associated with depressive symptoms, seriously considering attempting suicide, making a suicide plan, and one or more suicide attempts in the past year (except for alcohol use). Ever misuse of prescription pain medicine was additionally associated with past year injurious suicide attempts.

Our findings of positive cross-sectional associations between depressive symptoms and substance use among adolescents echo those observed in both previous cross-sectional (4,6–8) and longitudinal analyses (5,12,40,41). These findings are consistent with the self-medication hypothesis (9) and reformulated negative reinforcement model (10,11) such that use of substances may relieve uncomfortable affective states associated with depressive symptoms and suicidality. Our findings regarding depressive symptoms and binge drinking do differ from those reported in a recent analysis of Monitoring the Future data which indicated positive associations between high depressive symptoms and odds of binge drinking using 2018 data (18), though the ways in which depressive symptoms were measured were substantially different from that of the 2019 YRBS and binge drinking was assessed for the past two weeks as opposed to past 30 days. Additionally, our findings suggesting the association occurring in the opposite direction (i.e., substance use leading to depressive symptoms and suicidality) are also

in keeping with those seen in the literature (5,40) and delineated by problem behavior theory (14,15) and the stress model proposed by Wilkinson et al. (12).

Our findings of no effect modification between identity factors for the association depressive symptoms and suicidality and substance use differ from existing studies of interaction by sex observed for the concurrent association between depressive symptoms and cannabis use which was stronger for females than males in the Add Health study (12) and stronger for males than females among adolescents in Chicago (42). Further, our results differ from those observed in Add Health for depressive symptoms and binge drinking, which suggested a stronger concurrent association for females than males (12). However, in our exploratory stratified models of interactions that were not significant but approached statistical significance, associations for considering suicide in the past 12 months and past 30 day ever binge drinking and for suicide attempts in the past 12 months and past 30 day ever cannabis use were positive and significant for females, but not significant for males.

Our findings also differ from those expected based on the minority stress model (24) and chronic stress due to race-based discrimination (25–27), both of which may suggest higher prevalence of poor mental health and maladaptive coping strategies among adolescents with marginalized identities. Given the small size of some racial/ethnic and sexual identity groups in the weighted sample (e.g., Native Hawaiian/Other Pacific Islander with 0.3% of the weighted sample and gay or lesbian with 2.3% of the weighted sample), our analyses may not have been powered to detect differences by race/ethnicity and sexual identity. Further, we assessed for differences in these associations by demographic factors on the multiplicative scale using Rao-Scott likelihood ratio tests, which may limit the comparability with other studies assessing

additive interaction or using different statistical tests (e.g., Wald's test of interaction terms in regression models). We assessed multiplicative interaction in order to assess the relative difference between groups, which could inform decision making and resource prioritization in the context of interventions. Further, we assessed for the presence of multiplicative interaction using the Rao-Scott likelihood ratio test given the favorable properties of this test (i.e., invariability, better properties for small samples) (43). We also chose to not aggregate across heterogenous groups (e.g., grouping bisexual and gay or lesbian adolescents), which may limit analytic power. Lastly, differences may also be attributable to the ways in which independent variables and dependent variables were measured and operationalized.

Our analyses have a number of key strengths, many of which are based in the use of YRBS 2019 data. The weighted sample is meant to be representative of youth in high schools in the United States and the 2019 data are the most up to date data currently available at the time of writing. Therefore, our analyses are generalizable to high schoolers in the United States and are reflective of recent trends in substance use and depressive symptoms. Further, informed by models reflecting the impact of chronic stress due to discrimination and using an equity-based lens, we assessed for differences by race/ethnicity, sexual identity, and sex.

Use of YRBS 2019 data is also associated with limitations. Our ability to infer causality is limited by the cross-sectional nature of the data. We have attempted to address this limitation by using past 12 month depressive symptoms and suicidality and past 30 day substance use in main analyses and lifetime substance use and past 12 month depressive symptoms and suicidality in bidirectional analyses, but it is possible that for some youth modeled dependent variables may have occurred before independent variables. Related to generalizability, due to

the setting of data collection, adolescents who are not present in the public, private, or Catholic school setting are not eligible for participation. Therefore, the study sample may exclude adolescents who are most vulnerable to mental health concerns and substance use. This represents a non-negligible portion of the population. According to the United States Department of Education National Center for Education Statistics, 5.1% of 16 to 24 year-olds were not enrolled in school and had not earned a high school credential in 2019 (44).

Because our analyses rely on self-reported data, our findings may be subject to misclassification of exposures and/or outcomes and diminished reliability and validity. In particular, questions assessing mental health and substance use may be subject to social desirability bias though survey responses are anonymous. The 2019 YRBS sample size was substantial, which may have influenced the power of our analyses to detect small (and possibly not meaningful) differences by exposure categories. We have attempted to ameliorate this issue by assessing for significance with a stricter significance level (i.e. $\alpha = 0.01$). Some independent variables were rare (e.g., past 12 month injurious suicide attempts) and therefore our analyses may not be powered to assess associations of injurious suicide attempts. Finally, because data were collected before the COVID-19 pandemic, our analyses are unable to take the impact of the pandemic into account and their generalizability to present day associations may therefore be limited.

Our findings of associations between depressive symptoms and suicidality and alcohol use, cannabis use, electronic vapor product use, and prescription pain medicine misuse can be used to inform current clinical practice for adolescent care, as well as serve as a guidance for all adults closely involved in adolescent lives to help identity potentially dangerous substance use

and/or mental health states. Due to particularly strong associations observed in both directions for depressive symptoms and suicidality and prescription pain medicine misuse, emphasis may be warranted for interventions focusing on prescription pain medicine misuse among adolescents. In light of our findings and limitations, future studies should strive to recruit participants with broad diversity in racial and ethnic identities and sexual identities. Further, longitudinal assessments of depressive symptoms and substance use in a large, current sample would allow researchers to better elucidate the directionality of these associations. Finally, studies are needed to assess whether these associations have remained steady or changed in the face of the COVID-19 pandemic.

2.6 References

1. Johnston LD, Miech RA, O'Malley PM, et al. Monitoring the Future national survey results on drug use 1975-2021: Overview, key findings on adolescent drug use. Ann Arbor: University of Michigan Institute for Social Research; 2022 (Accessed May 17, 2022).(http://www.monitoringthefuture.org//pubs/monographs/mtf-overview2021.pdf). (Accessed May 17, 2022)

2. Substance Abuse and Mental Health Services Administration. Key substance use and mental health indicators in the United States: Results from the 2020 National Survey on Drug Use and Health. Center for Behavioral Health Statistics and Quality, Substance Abuse and Mental Health Services Administration; 2021 (Accessed January 13, 2022).(https://www.samhsa.gov/data/sites/default/files/reports/rpt35325/NSDUHFFRPDFWHTMLFiles2020/2020NSDUHFFR1PDFW102121.pdf). (Accessed January 13, 2022)

3. Curtin SC. State suicide rates among adolescents and young adults aged 10–24 : United States, 2000–2018. *National vital statistics reports* [electronic article]. 2020;69(11). (https://stacks.cdc.gov/view/cdc/93667). (Accessed May 27, 2022)

4. Edlund MJ, Forman-Hoffman VL, Winder CR, et al. Opioid abuse and depression in adolescents: Results from the National Survey on Drug Use and Health. *Drug and Alcohol Dependence* [electronic article]. 2015;152:131–138. (http://dx.doi.org/10.1016/j.drugalcdep.2015.04.010)

5. Scholes-Balog KE, Hemphill SA, Patton GC, et al. Relationships Between Substance Use and Depressive Symptoms: A Longitudinal Study of Australian Adolescents. *The Journal of Early Adolescence* [electronic article]. 2015;35(4):538–561. (http://journals.sagepub.com/doi/10.1177/0272431614540526). (Accessed April 14, 2022)

6. Cioffredi L-A, Kamon J, Turner W. Effects of depression, anxiety and screen use on adolescent substance use. *Preventive Medicine Reports* [electronic article]. 2021;22:101362. (https://linkinghub.elsevier.com/retrieve/pii/S221133552100053X). (Accessed April 14, 2022)

7. Wang P-W, Lin H-C, Yeh Y-C, et al. The relation of substance use with different levels of depressive symptoms and the moderating effect of sex and age in Taiwanese adolescents. *Comprehensive Psychiatry* [electronic article]. 2012;53(7):1013–1020. (https://linkinghub.elsevier.com/retrieve/pii/S0010440X12000314). (Accessed April 14, 2022)

8. Pirkola SP, Marttunen MJ, Henriksson MM, et al. Alcohol-related problems among adolescent suicides in Finland. *Alcohol and Alcoholism*. 1999;34(3):320–329.

9. Khantzian EJ. The self-medication hypothesis of substance use disorders: A reconsideration and recent applications. *Harvard Review of Psychiatry*. 1997;4(5):231–244.

10. Baker TB, Piper ME, McCarthy DE, et al. Addiction Motivation Reformulated: An Affective Processing Model of Negative Reinforcement. *Psychological Review*. 2004;111(1):33–51.

11. McCarthy DE, Curtin JJ, Piper ME, et al. Negative reinforcement: Possible clinical implications of an integrative model. *Substance abuse and emotion.* 2010;(2009):15–42.

12. Wilkinson AL, Halpern CT, Herring AH, et al. Testing Longitudinal Relationships Between Binge Drinking, Marijuana Use, and Depressive Symptoms and Moderation by Sex. *Journal of Adolescent Health* [electronic article]. 2016;59(6):681–687. (http://dx.doi.org/10.1016/j.jadohealth.2016.07.010)

13. Danzo S, Connell AM, Stormshak EA. Associations between alcohol-use and depression symptoms in adolescence: Examining gender differences and pathways over time. *Journal of Adolescence* [electronic article]. 2017;56:64–74. (http://dx.doi.org/10.1016/j.adolescence.2017.01.007)

14. Jessor R. Problem-Behavior Theory, Psychosocial Development, and Adolescent Problem Drinking. *British Journal of Addiction*. 1987;82(4):331–342.

15. Galaif ER, Sussman S, Newcomb MD, et al. Suicidality, depression, and alcohol use among adolescents: A review of empirical findings. *International Journal of Adolescent Medicine and Health*. 2007;19(1):27–35.

16. National Conference of State Legislatures. Marijuana Overview. 2019;(http://www.ncsl.org/research/civil-and-criminal-justice/marijuana-overview.aspx). (Accessed December 9, 2019)

17. Miech R, Johnston L, O'Malley PM, et al. Trends in Adolescent Vaping, 2017–2019. *New England Journal of Medicine*. 2019;2018–2019.

18. Keyes KM, Hamilton A, Patrick ME, et al. Diverging Trends in the Relationship Between Binge Drinking and Depressive Symptoms Among Adolescents in the U.S. From 1991 Through 2018. *Journal of Adolescent Health* [electronic article]. 2020;66(5):529–535. (https://doi.org/10.1016/j.jadohealth.2019.08.026)

19. Chadi N, Li G, Cerda N, et al. Depressive Symptoms and Suicidality in Adolescents Using e-Cigarettes and Marijuana. *Journal of Addiction Medicine*. 2019;13(5):1.

20. Luk JW, Gilman SE, Haynie DL, et al. Sexual orientation and depressive symptoms in adolescents. *Pediatrics*. 2018;141(5).

21. Bailey ZD, Krieger N, Agénor M, et al. Structural racism and health inequities in the USA: evidence and interventions. *The Lancet* [electronic article]. 2017;389(10077):1453–1463. (http://dx.doi.org/10.1016/S0140-6736(17)30569-X)

22. Krieger N. Embodiment: A conceptual glossary for epidemiology. *Journal of Epidemiology and Community Health*. 2005;59(5):350–355.

23. Paradies Y, Ben J, Denson N, et al. Racism as a determinant of health: A systematic review and meta-analysis. *PLoS ONE*. 2015;10(9):1–48.

24. Meyer IH. Prejudice, Social Stress, and Mental Health in Lesbian, Gay, and Bisexual Populations: Conceptual Issues and Research Evidence. *Psychol ogical Bulletin*. 2003;129(5):674–697.

25. Pachter LM, Coll CG. Racism and Child Health: A Review of the Literature and Future Directions. *Journal of Developmental & Behavioral Pediatrics* [electronic article]. 2009;30(3):255–263. (http://journals.lww.com/00004703-200906000-00012)

26. Priest N, Paradies Y, Trenerry B, et al. A systematic review of studies examining the relationship between reported racism and health and wellbeing for children and young people. *Social Science and Medicine* [electronic article]. 2013;95:115–127. (http://dx.doi.org/10.1016/j.socscimed.2012.11.031)

27. Benner AD, Wang Y, Shen Y, et al. Racial/ethnic discrimination and well-being during adolescence: A meta-analytic review. *American Psychologist*. 2018;73(7):855–883.

28. Clark R, Anderson NB, Clark VR, et al. Racism As a Stressor For African Americans. In: LaVeist TA, Isaac LA, eds. *Race, Ethnicity, and Health: A Public Health Reader*. San Francisco, CA: John Wiley & Sons, Inc.; 2013:79–103.

29. Hicken MT, Stanton AG, Lee H. The Burden of Cultural Racism: Vigilance and Racial Health Inequities. In: Ford CL, Griffith DM, Bruce MA, et al., eds. *Racism: Science & Tools for the Public Health Professional*. Washington, D.C.: APHA Press; 2019:191–208.

30. Pachankis JE, Mahon CP, Jackson SD, et al. Sexual orientation concealment and mental health: A conceptual and meta-analytic review. *Psychological Bulletin*. 2020;146(10):831–871.

31. Dürrbaum T, Sattler FA. Minority stress and mental health in lesbian, gay male, and bisexual youths: A meta-analysis. *Journal of LGBT Youth* [electronic article]. 2020;17(3):298–314. (https://doi.org/10.1080/19361653.2019.1586615)

32. Goldbach JT, Tanner-Smith EE, Bagwell M, et al. Minority Stress and Substance Use in Sexual Minority Adolescents: A Meta-analysis. *Prevention Science*. 2014;15(3):350–363.

33. Hendricks ML, Testa RJ. A conceptual framework for clinical work with transgender and gender nonconforming clients: An adaptation of the minority stress model. *Professional Psychology: Research and Practice*. 2012;43(5):460–467.

34. McLemore KA. A minority stress perspective on transgender individuals' experiences with misgendering. *Stigma and Health*. 2018;3(1):53–64.

35. Breslow AS, Brewster ME, Velez BL, et al. Resilience and Collective Action: Exploring Buffers Against Minority Stress for Transgender Individuals. *Psychology of Sexual Orientation and Gender Diversity*. 2015;2(3):253–265.

36. Centers for Disease Control and Prevention. 2019 YRBS Data User's Guide. 2020.(https://www.cdc.gov/healthyyouth/data/yrbs/pdf/2019/2019_National_YRBS_Data_Users_Guide.pdf)

37. Underwood JM, Brener N, Thornton J, et al. Overview and Methods for the Youth Risk Behavior Surveillance System — United States, 2019. *MMWR Supplements*. 2020;69(1):1–10.

38. Youth Risk Behavior Surveillance System (YRBSS).

2018;(https://www.cdc.gov/healthyyouth/data/yrbs/index.htm). (Accessed May 5, 2020)

39. Lumley T. Package 'survey.' 2021;(https://cran.r-project.org/web/packages/survey/survey.pdf). (Accessed April 14, 2022)

40. Lechner WV, Janssen T, Kahler CW, et al. Bi-directional associations of electronic and combustible cigarette use onset patterns with depressive symptoms in adolescents. *Preventive Medicine* [electronic article]. 2017;96:73–78. (http://dx.doi.org/10.1016/j.ypmed.2016.12.034)

41. Edwards AC, Joinson C, Dick DM, et al. The association between depressive symptoms from early to late adolescence and later use and harmful use of alcohol. *European Child and Adolescent Psychiatry*. 2014;23(12):1219–1230.

42. Crane NA, Langenecker SA, Mermelstein RJ. Gender differences in the associations among marijuana use, cigarette use, and symptoms of depression during adolescence and young adulthood. *Addictive Behaviors* [electronic article]. 2015;49:33–39. (http://dx.doi.org/10.1016/j.addbeh.2015.05.014)

43. Lumley T, Scott A. Tests for Regression Models Fitted to Survey Data. *Aust. N. Z. J. Stat.* [electronic article]. 2014;56(1):1–14. (https://onlinelibrary.wiley.com/doi/10.1111/anzs.12065). (Accessed April 21, 2022)

44. National Center for Education Statistics. Status Dropout Rates. Condition of Education. U.S. Department of Education, Institute of Education Sciences; 2021 (Accessed April 14, 2022).(https://nces.ed.gov/programs/coe/indicator/coj). (Accessed April 14, 2022)

2.7 Tables

Table 2.1: Demographics of the Weighted 2019 YRBS Weighted Sample

Characteristic	Percent (%)*
Sex	
Male	50.2
Female	48.9
Missing	0.9
Race/Ethnicity	
American Indian/Alaska Native	0.6
Asian	4.9
Black or African American	11.8
Native Hawaiian/Other Pacific Islander	0.3
White	49.6
Hispanic/Latino	8.9
Multiple Races – Hispanic/Latino	16.4
Multiple Races – Non-Hispanic/Latino	4.3
Missing	3.1
Sexual Identity	
Heterosexual	79.2
Gay or Lesbian	2.3
Bisexual	8.2
Not Sure	4.2
Missing	6.1
Age	
12 years old or younger	0.3
13 years old	0.1
14 years old	11.8
15 years old	24.6
16 years old	25.4
17 years old	23.5
18 years old or older	13.6
Missing	0.6
Grade in School	
9th grade	26.4
10th grade	25.3
11th grade	24.1
12th grade	23.4
Ungraded or other grade	0.2
Missing	0.7

*Note: Percentages may not sum to 100 due to rounding. All racial/ethnic groups are non-Hispanic/Latino unless otherwise specified.

Table 2.2: Prevalence of Past 12 Month Depressive Symptoms and Suicidality Indicators (Exposures) in 2019 YRBS Weighted Sample

	Percent (%)*
Depressive Symptoms	
Yes	36.2
No	62.4
Missing	1.4
Seriously Considered Attempting Suicide	
Yes	18.5
No	80.1
Missing	1.5
Made a Suicide Plan	
Yes	15.5
No	83.1
Missing	1.5
Suicide Attempts	
0	76.1
1	4.1
2-3	2.3
4-5	0.5
6+	0.6
Missing	16.4
Injurious Suicide Attempts	
Yes	2.0
No	5.0
Missing or Did Not Attempt Suicide	93.0

*Note: Percentages may not sum to 100 due to rounding.

Table 2.3: Prevalence of Past 30 Day Substance Use Behaviors (Outcomes) in 2019 YRBS Weighted Sample

Substance Use	Percent (%)*
Alcohol Use	
0 days	65.7
1 or 2 days	14.9
3 to 5 days	6.6
6 to 9 days	3.3
10 to 19 days	1.4
20 to 29 days	0.4
All 30 days	0.6
Missing	7.2
Binge Drinking	
0 days	77.8
1 day	4.3
2 days	3.3
3 to 5 days	2.6
6 to 9 days	1.3
10 to 19 days	0.5
20 or more days	0.4
Missing	9.8
Cannabis Use	
0 times	76.4
1 or 2 times	7.8
3 to 9 times	4.6
10 to 19 times	2.7
20 to 39 times	2.2
40 or more times	3.8
Missing	2.4
Electronic Vapor Product Use	
0 days	63.1
1 or 2 days	9.1
3 to 5 days	4.8
6 to 9 days	3.0
10 to 19 days	4.0
20 to 29 days	3.3
All 30 days	6.7
Missing	6.1
Prescription Pain Medicine Use	
0 times	72.5
1 or 2 times	3.0
3 to 9 times	1.3

10 to 19 times	0.5
20 to 39 times	0.2
40 or more times	0.5
Missing	21.9

*Note: Percentages may not sum to 100 due to rounding.

Table 2.4: Odds Ratios for the Associations Between Past 12 Month Depressive Symptoms and Suicidality Indicators and Past 30 Day Ever Use of Substances

	Any Alcohol Use OR (95% CI) p-value			Any Binge Drinking OR (95% CI) p-value			Any Cannabis Use OR (95% CI) p-value			Any Electronic Vapor Product Use OR (95% CI) p-value			Any Prescription Pain Medicine Misuse OR (95% CI) p-value		
	U	**P**	**F**	**U**	**P**	**F**	**U**	**P**	**F**	**U**	**P**	**F**	**U**	**P**	**F**
Depressive Symptoms	**2.05 (1.86, 2.26) <0.001**	**2.00 (1.78, 2.24) <0.001**	**1.28 (1.09, 1.51) 0.004**	**2.03 (1.67, 2.86) <0.001**	**2.09 (1.71, 2.55) <0.001**	1.31 (1.05, 1.64) 0.020	**2.08 (1.83, 2.35) <0.001**	**2.11 (1.81, 2.46) <0.001**	**1.43 (1.20, 1.70) <0.001**	**2.14 (1.93 2.36) <0.001**	**2.30 (2.03, 2.60) <0.001**	**1.55 (1.30, 1.84) <0.001**	**3.46 (2.71, 4.42) <0.001**	**3.25 (2.50, 4.23) <0.001**	**2.62 (1.97, 3.48) <0.001**
Seriously Considered Attempting Suicide	**2.16 (1.89, 2.47) <0.001**	**2.27 (1.94, 2.66) <0.001**	**1.38 (1.17, 1.63) <0.001**	**2.01 (1.68, 2.40) <0.001**	**2.14 (1.77, 2.59) <0.001**	1.30 (1.06, 1.59) 0.015	**2.44 (2.10, 2.85) <0.001**	**2.50 (2.10, 2.98) <0.001**	**1.72 (1.46, 2.01) <0.001**	**2.19 (1.93, 2.49) <0.001**	**2.45 (2.13, 2.81) <0.001**	**1.52 (1.28, 1.80) <0.001**	**3.90 (3.18, 4.78) <0.001**	**3.85 (2.99, 4.94) <0.001**	**3.08 (2.35, 4.04) <0.001**
Made a Suicide Plan	**2.06 (1.74, 2.44) <0.001**	**2.11 (1.78, 2.52) <0.001**	1.29 (1.04, 1.59) 0.021	**2.01 (1.63, 2.47) <0.001**	**2.10 (1.66, 2.66) <0.001**	1.27 (1.00, 1.61) 0.048	**2.31 (1.98, 2.70) <0.001**	**2.29 (1.92, 2.73) <0.001**	**1.57 (1.32, 1.86) <0.001**	**2.10 (1.80, 2.45) <0.001**	**2.25 (1.92, 2.64) <0.001**	**1.47 (1.20, 1.80) <0.001**	**3.91 (3.10, 4.94) <0.001**	**3.97 (3.03, 5.19) <0.001**	**3.18 (2.40, 4.21) <0.001**
Suicide Attempts*	**1.57 (1.38, 1.78) <0.001**	**1.67 (1.45, 1.92) <0.001**	**1.27 (1.09, 1.47) 0.004**	**1.55 (1.36, 1.78) <0.001**	**1.69 (1.41, 2.01) <0.001**	**1.31 (1.09, 1.58) 0.006**	**1.71 (1.53, 1.92) <0.001**	**1.65 (1.44, 1.88) <0.001**	**1.32 (1.16, 1.51) <0.001**	**1.57 (1.40, 1.75) <0.001**	**1.69 (1.51, 1.89) <0.001**	**1.31 (1.15, 1.48) <0.001**	**2.30 (1.99, 2.66) <0.001**	**2.21 (1.92, 2.55) <0.001**	**2.02 (1.75, 2.33) <0.001**
Injurious Suicide Attempts	1.78 (1.06, 3.00) 0.030	1.64 (0.92, 2.92) 0.090	1.23 (0.66, 2.28) 0.5	**1.93 (1.30, 2.86) 0.002**	1.71 (1.11, 2.63) 0.017	1.40 (0.87, 2.24) 0.2	**1.97 (1.22, 3.17) 0.007**	**1.69 (1.00, 2.85) 0.048**	1.45 (0.85, 2.46) 0.2	1.72 (1.01, 2.92) 0.046	1.76 (0.97, 3.19) 0.061	1.30 (0.69, 2.43) 0.4	**2.19 (1.35, 3.56) 0.002**	2.10 (1.19, 3.69) 0.013	1.99 (1.09, 3.65) 0.028

Notes: Partially adjusted models are adjusted for race/ethnicity, sex, age, and sexual identity. Fully adjusted models are adjusted for race/ethnicity, sex, age, sexual identity, and other substance use (any past 30 day use of other substances included in the analysis or any lifetime use of cocaine, inhalants, heroin, methamphetamines, ecstasy, synthetic marijuana, steroid pills and shots, hallucinogens, and injection drugs). **Bolded** values are those that are statistically significant when assessed at $\alpha = 0.01$.
Abbreviations: CI = confidence interval, F = fully adjusted, OR = odds ratio, P = partially adjusted, U = unadjusted
*Recode: numeric; 0 = 0, 1 = 1, 2 = 2-3, 3 = 4-5, 4 = 6+

Table 2.5: Results of Likelihood Ratio Tests of Fully Adjusted Models for Past 30 Day Ever Substance Use Including Terms for Interaction Between Independent Variables and Demographic Factors

	Ever Alcohol Use p-value	Ever Binge Drinking p-value	Ever Cannabis Use p-value	Ever Electronic Vapor Product Use p-value	Ever Prescription Pain Medicine Misuse p-value
Depressive Symptoms					
Sex	0.92	0.12	0.16	0.15	0.83
Race/ethnicity	**0.06**	0.35	0.15	0.38	0.69
Sexual identity	0.38	0.43	0.23	0.64	0.62
Seriously Considered Attempting Suicide					
Sex	0.97	**0.07**	0.21	0.13	0.19
Race/ethnicity	0.24	0.49	0.61	0.68	0.17
Sexual identity	0.23	0.49	**0.09**	0.51	0.14
Made a Suicide Plan					
Sex	0.59	0.94	0.23	0.59	**0.03**
Race/ethnicity	0.60	0.35	0.25	0.41	**0.04**
Sexual identity	0.13	0.27	0.13	0.40	**0.03**
Suicide Attempts*					
Sex	0.40	0.58	**0.09**	0.16	**0.05**
Race/ethnicity	0.18	0.27	0.47	0.95	0.30
Sexual identity	0.16	0.02	0.29	0.59	**0.07**
Injurious Suicide Attempts					
Sex	0.34	0.94	0.64	0.99	0.38
Race/ethnicity	0.78	0.46	0.66	0.26	**0.02**
Sexual identity	0.61	0.69	0.60	0.52	0.52

Notes: Fully adjusted models are adjusted for race/ethnicity, sex, age, sexual identity, and other substance use (any past 30 day use of other substances included in the analysis or any lifetime use of cocaine, inhalants, heroin, methamphetamines, ecstasy, synthetic marijuana, steroid pills and shots, hallucinogens, and injection drugs. **Bolded** values are those that are $p < 0.1$.
*Recode: numeric; 0 = 0, 1 = 1, 2 = 2-3, 3 = 4-5, 4 = 6+

Table 2.6: Fully Adjusted Odds Ratios for the Associations Between Lifetime Ever Use of Substances and Past 12 Month Depressive Symptoms and Suicidality Indicators

	Depressive Symptoms OR (95% CI) p-value			Seriously Considered Attempting Suicide OR (95% CI) p-value			Made a Suicide Plan OR (95% CI) p-value			Suicide Attempt(s) OR (95% CI) p-value			Injurious Suicide Attempts OR (95% CI) p-value		
	U	**P**	**F**	**U**	**P**	**F**	**U**	**P**	**F**	**U**	**P**	**F**	**U**	**P**	**F**
Ever Alcohol Use	**2.25 (2.00, 2.52) <0.001**	**2.15 (1.91, 2.42) <0.001**	**1.38 (1.17, 1.64) <0.001**	**2.34 (2.04, 2.70) <0.001**	**2.41 (2.08, 2.79) <0.001**	**1.48 (1.25, 1.75) <0.001**	**2.26 (1.93, 2.64) <0.001**	**2.23 (1.93, 2.56) <0.001**	**1.43 (1.18, 1.73) <0.001**	**2.52 (1.93, 3.29) <0.001**	**2.47 (1.87, 3.24) <0.001**	1.52 (1.10, 2.08) 0.013	**2.64 (1.65, 4.22) <0.001**	**2.29 (1.42, 3.68) 0.002**	1.68 (1.01, 2.80) 0.048
Ever Cannabis Use	**2.40 (2.16, 2.66) <0.001**	**2.47 (2.18, 2.80) <0.001**	**1.85 (1.59, 2.16) <0.001**	**2.62 (2.28, 3.02) <0.001**	**2.80 (2.43, 3.24) <0.001**	**2.08 (1.81, 2.38) <0.001**	**2.39 (2.03, 2.82) <0.001**	**2.47 (2.06, 2.95) <0.001**	**1.85 (1.54, 2.22) <0.001**	**3.07 (2.42, 3.89) <0.001**	**2.97 (2.27, 3.87) <0.001**	**2.31 (1.74, 3.06) <0.001**	**2.04 (1.34, 3.11) 0.002**	1.81 (1.17, 2.81) 0.011	1.53 (0.91, 2.58) 0.10
Ever Electronic Vapor Product Use	**2.15 (1.97, 2.35) <0.001**	**2.25 (2.05, 2.46) <0.001**	**1.50 (1.33, 1.69) <0.001**	**2.33 (2.02, 2.70) <0.001**	**2.50 (2.12, 2.95) <0.001**	**1.65 (1.36, 1.99) <0.001**	**2.23 (1.89, 2.64) <0.001**	**2.30 (1.91, 2.76) <0.001**	**1.56 (1.25, 1.95) <0.001**	**2.54 (2.03, 3.17) <0.001**	**2.56 (2.01, 3.26) <0.001**	**1.76 (1.37, 2.27) <0.001**	1.70 (0.99, 2.93) 0.054	1.80 (0.97, 3.32) 0.060	1.48 (0.71, 3.07) 0.3
Ever Prescription Pain Medicine Misuse	**3.02 (2.71, 3.37) <0.001**	**2.75 (2.41, 3.15) <0.001**	**2.28 (1.95, 2.66) <0.001**	**3.76 (3.27, 4.32) <0.001**	**3.67 (3.16, 4.27) <0.001**	**3.17 (2.73, 3.69) <0.001**	**3.69 (3.21, 4.24) <0.001**	**3.48 (2.96, 4.10) <0.001**	**3.05 (2.58, 3.61) <0.001**	**5.14 (4.38, 6.05) <0.001**	**4.45 (3.75, 5.29) <0.001**	**3.88 (3.30, 4.57) <0.001**	**2.69 (1.78, 4.08) <0.001**	**2.76 (1.73, 4.41) <0.001**	**2.65 (1.64, 4.28) <0.001**

Notes: Fully adjusted models are adjusted for race/ethnicity, sex, age, sexual identity, and other substance use (any lifetime use of cocaine, inhalants, heroin, methamphetamines, ecstasy, synthetic marijuana, steroid pills and shots, hallucinogens, injection drugs, and other substances included in the bidirectionality analysis). **Bolded** values are those that are statistically significant when assessed at $\alpha = 0.01$.

Abbreviations: CI = confidence interval, F = fully adjusted, OR = odds ratio, P = partially adjusted, U = unadjusted

*Recoded to binary: 0 = no suicide attempts in the past twelve months, 1 = suicide attempts in the past twelve months

2.8 Appendix

Appendix Table 2.1: Analytic Constructs and Corresponding Youth Risk Behavior Survey 2019 Survey Questions

	Survey Question	Response Options
Depressive Symptom and Suicidality		
Past 12 Month Depressive Symptoms	During the past 12 months, did you ever feel so sad or hopeless almost every day for two weeks or more in a row that you stopped doing some usual activities?	Binary: Yes/No
Past 12 Month Considered Suicide Attempt	During the past 12 months, did you ever seriously consider attempting suicide?	Binary: Yes/No
Past 12 Month Suicide Plan	During the past 12 months, did you make a plan about how you would attempt suicide?	Binary: Yes/No
Past 12 Month Suicide Attempts	During the past 12 months, how many times did you actually attempt suicide?	Categorical: 0 times, 1 time, 2 or 3 times, 4 or 5 times, 6 or more times
Past 12 Month Injurious Suicide Attempts	If you attempted suicide during the past 12 months, did any attempt result in an injury, poisoning, or overdose that had to be treated by a doctor or nurse?	Categorical: I did not attempt suicide during the past 12 months, Yes, No
Substance Use		
Past 30 Day Alcohol Use	During the past 30 days, on how many days did you have at least one drink of alcohol?	Categorical: 0 days, 1 or 2 days, 3 to 5 days, 6 to 9 days, 10 to 19 days, 20 to 29 days, all 30 days
Past 30 Day Binge Drinking	During the past 30 days, on how many days did you have 4 or more drinks of alcohol in a row, that is, within a couple of hours (if you are female) or 5 or more drinks of alcohol in a row, that is, within a couple of hours (if you are male)?	Categorical: 0 days, 1 day, 2 days, 3 to 5 days, 6 to 9 days, 10 to 19 days, 20 or more days
Past 30 Day Cannabis Use	During the past 30 days, how many times did you use marijuana?	Categorical: 0 times, 1 or 2 times, 3 to 9 times, 10 to 19 times, 20 to 39 times, 40 or more times

Past 30 Day Electronic Vapor Product Use	During the past 30 days, on how many days did you use an electronic vapor product?	Categorical: 0 days, 1 or 2 days, 3 to 5 days, 6 to 9 days, 10 to 19 days, 20 to 29 days, all 30 days
Past 30 Day Prescription Pain Medicine Misuse	During the past 30 days, how many times have you taken prescription pain medicine without a doctor's prescription or differently than how a doctor told you to use it?	Categorical: 0 times, 1 or 2 times, 3 to 9 times, 10 to 19 times, 20 to 39 times, 40 or more times
Covariates		
Race/Ethnicity	Are you Hispanic or Latino? AND What is your race? (Select one or more responses.)	Categorical: American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, White, Hispanic/Latino, Multiple—Hispanic/Latino, Multiple—Non-Hispanic/Latino
Sex	What is your sex?	Categorical: Male, Female
Sexual Identity	Which of the following best describes you?	Categorical: Heterosexual (straight), Gay or Lesbian, Bisexual, Not Sure
Ever Other Illicit Drug Use	Combination of questions about lifetime use of cigarette cocaine, inhalants, heroin, methamphetamines, ecstasy, synthetic marijuana, steroid pills and shots, and injection drugs and past 30 day use of other analytic substance except for the specific modeled outcome	Binary: Yes/No
Age	How old are you?	Categorical: 12 years old or younger, 13 years old, 14 years old, 15 years old, 16 years old, 17 years old, 18 years old or older

Appendix Table 2.2: Odds Ratios for the Associations Between Past 12 Month Depressive Symptoms and Suicidality Indicators and Past 30 Day Ever Use, 3 or More Days of Use, and 10 or More Days of Use of Electronic Vapor Products

	Any Use in the Past 30 Days	3 or More Days of Use in Past 30 Days	6 or More Days of Use in Past 30 Days	10 or More Days of Use in Past 30 Days	20 or More Days of Use in Past 30 Days	All 30 Days of Use in Past 30 Days
	OR (95% CI) p-value	OR (95% CI) p-value	OR (95% CI) p-value	OR (95% CI) p-value	OR (95% CI) p-value	OR (95% CI) p-value
Depressive Symptoms	**1.55 (1.30, 1.84) <0.001**	**1.41 (1.23, 1.61) <0.001**	**1.48 (1.28, 1.70) <0.001**	**1.45 (1.25, 1.68) <0.001**	**1.34 (1.12, 1.61) 0.003**	**1.37 (1.11, 1.70) 0.006**
Seriously Considered Attempting Suicide	**1.52 (1.28, 1.80) <0.001**	**1.50 (1.28, 1.76) <0.001**	**1.65 (1.42, 1.92) <0.001**	**1.68 (1.40, 2.01) <0.001**	**1.68 (1.34, 2.12) <0.001**	**1.60 (1.27, 2.01) <0.001**
Made a Suicide Plan	**1.47 (1.20, 1.80) <0.001**	**1.59 (1.29, 1.97) <0.001**	**1.63 (1.33, 2.01) <0.001**	**1.66 (1.30, 2.12) <0.001**	**1.53 (1.16, 2.03) 0.004**	1.39 (1.04, 1.85) 0.026
Suicide Attempts*	**1.31 (1.15, 1.48) <0.001**	**1.27 (1.10, 1.46) 0.002**	**1.34 (1.16, 1.55) <0.001**	**1.31 (1.13, 1.53) 0.001**	**1.30 (1.13, 1.51) 0.001**	**1.34 (1.13, 1.60) 0.002**
Injurious Suicide Attempts	1.30 (0.69, 2.43) 0.4	1.76 (1.02, 3.05) 0.043	1.68 (1.02, 2.78) 0.043	1.32 (0.84, 2.10) 0.2	1.19 (0.82, 1.73) 0.3	1.28 (0.77, 2.13) 0.3

Notes: Fully adjusted models are adjusted for race/ethnicity, sex, age, sexual identity, and other substance use (any lifetime use of cocaine, inhalants, heroin, methamphetamines, ecstasy, synthetic marijuana, steroid pills and shots, hallucinogens, injection drugs, and other substances included in the bidirectionality analysis). **Bolded** values are those that are statistically significant when assessed at $\alpha = 0.01$.

Abbreviations: CI = confidence interval, OR = odds ratio

*Recoded to binary: 0 = no suicide attempts in the past twelve months, 1 = suicide attempts in the past twelve months

Appendix Table 2.3: Sex-Stratified Odds Ratios for Fully Adjusted Interaction Models with Rao-Scott Likelihood Ratio Test p < 0.10

	Past 12 Month Seriously Considered Attempting Suicide and Past 30 Day Ever Binge Drinking OR (95% CI) p-value	Past 12 Month Suicide Attempts* and Past 30 Day Ever Cannabis Use OR (95% CI) p-value	Past 12 Month Made a Suicide Plan and Past 30 Day Prescription Pain Medicine Misuse OR (95% CI) p-value	Past 12 Month Suicide Attempts* and Past 30 Day Prescription Pain Medicine Misuse OR (95% CI) p-value
Female	**1.50** **(1.22, 1.83)** **<0.001**	**1.47** **(1.25, 1.72)** **<0.001**	**2.84** **(1.98, 4.07)** **<0.001**	**1.85** **(1.57, 2.17)** **<0.001**
Male	1.05 (0.72, 1.54) 0.8	1.21 (0.97, 1.51) 0.084	**3.98** **(2.81, 5.64)** **<0.001**	**2.30** **(1.82, 2.91)** **<0.001**

Notes: Fully adjusted models are adjusted for race/ethnicity, sex, age, sexual identity, and other substance use (any past 30 day use of other substances included in the analysis or any lifetime use of cocaine, inhalants, heroin, methamphetamines, ecstasy, synthetic marijuana, steroid pills and shots, hallucinogens, and injection drugs). **Bolded** values are those that are statistically significant when assessed at $\alpha = 0.01$.

Abbreviations: CI = confidence interval, OR = odds ratio

*Recode: numeric; 0 = 0, 1 = 1, 2 = 2-3, 3 = 4-5, 4 = 6+

Appendix Table 2.4: Race/Ethnicity-Stratified Odds Ratios for Fully Adjusted Interaction Models with Rao-Scott Likelihood Ratio Test p < 0.10

	Past 12 Month Depressive Symptoms and Past 30 Day Ever Alcohol Use OR (95% CI) p-value	Past 12 Month Made a Suicide Plan and Past 30 Day Prescription Pain Medicine Misuse OR (95% CI) p-value	Past 12 Month Injurious Suicide Attempts and Past 30 Day Prescription Pain Medicine Misuse OR (95% CI) p-value
American Indian/Alaska Native	0.51 (0.11, 2.42) 0.4	4.30 (0.31, 59.5) 0.2	*
Asian	0.79 (0.41, 1.55) 0.5	11.0 (1.77, 68.6) 0.013	**
Black or African American	1.64 (0.95, 2.83) 0.076	**4.18** **(1.75, 9.99)** **0.003**	16.0 (0.38, 671) 0.086
Native Hawaiian/Other Pacific Islander	*	*	*
White	1.13 (0.92, 1.40) 0.2	**3.85** **(2.68, 5.53)** **<0.001**	1.72 (0.70, 4.24) 0.2
Hispanic/Latino	**2.60** **(1.44, 4.67)** **0.003**	1.27 (0.57, 2.85) 0.5	0.05 (0.00, 1.00) 0.050
Multiple Races – Hispanic/Latino	1.23 (0.89, 1.71) 0.2	2.15 (1.03, 4.49) 0.041	2.95 (1.23, 7.08) 0.019
Multiple Races – Non-Hispanic/Latino	1.78 (1.02, 3.10)	**7.94** **(2.42, 26.1)**	5.00 (0.03, 905)

	0.042	**0.002**	0.3

Notes: Fully adjusted models are adjusted for race/ethnicity, sex, age, sexual identity, and other substance use (any past 30 day use of other substances included in the analysis or any lifetime use of cocaine, inhalants, heroin, methamphetamines, ecstasy, synthetic marijuana, steroid pills and shots, hallucinogens, and injection drugs). **Bolded** values are those that are statistically significant when assessed at $\alpha = 0.01$.

Abbreviations: CI = confidence interval, OR = odds ratio

*Zero or negative residual df

**Model did not converge; small cell sizes or zero cells.

Appendix Table 2.5: Sexual Identity-Stratified Odds Ratios for Fully Adjusted Interaction Models with Rao-Scott Likelihood Ratio Test p < 0.10

	Past 12 Month Seriously Considered Attempting Suicide and Past 30 Day Ever Cannabis Use OR (95% CI) p-value	Past 12 Month Made a Suicide Plan and Past 30 Day Ever Prescription Pain Medicine Misuse OR (95% CI) p-value	Past 12 Month Suicide Attempts* and Past 30 Day Ever Prescription Pain Medicine Misuse OR (95% CI) p-value
Heterosexual	**1.60** **(1.31, 1.96)** **<0.001**	**3.19** **(2.29, 4.44)** **<0.001**	**1.89** **(1.60, 2.23)** **<0.001**
Gay or Lesbian	2.10 (0.69, 6.38) 0.2	**10.2** **(2.55, 40.6)** **0.003**	1.63 (0.86, 3.10) 0.12
Bisexual	1.64 (1.03, 2.60) 0.037	1.93 (1.12, 3.33) 0.021	**2.49** **(1.83, 3.39)** **<0.001**
Not Sure	**1.98** **(1.27, 3.09)** **0.004**	**11.0** **(3.89, 31.0)** **<0.001**	**3.55** **(2.20, 5.71)** **<0.001**

Notes: Fully adjusted models are adjusted for race/ethnicity, sex, age, sexual identity, and other substance use (any past 30 day use of other substances included in the analysis or any lifetime use of cocaine, inhalants, heroin, methamphetamines, ecstasy, synthetic marijuana, steroid pills and shots, hallucinogens, and injection drugs). **Bolded** values are those that are statistically significant when assessed at $\alpha = 0.01$.

Abbreviations: CI = confidence interval, OR = odds ratio

*Recode: numeric; 0 = 0, 1 = 1, 2 = 2-3, 3 = 4-5, 4 = 6+

Chapter 3. Cross-sectional Associations of Depressive Symptoms and Suicidality with Substance Use Over Time

3.1 Abstract

Purpose: Adolescents have high prevalence of both depressive symptoms, suicidality, and substance use. Existing evidence suggests a weakening in the association between depressive symptoms and binge drinking over time among American adolescents. Given changing trends in adolescent depressive symptoms and substance use, we investigated change over time of cross-sectional associations of adolescent depressive symptoms and suicidality with substance use, and the potential role of effect modifiers.

Methods: We utilized 2019 Youth Risk Behavior Survey national combined data (on 217,340 participants) from 1991 to 2019. Independent variables were depressive symptom and suicidality related variables including past 12 month depressive symptoms, serious consideration of suicide, having made a suicide plan, suicide attempts, and injurious suicide attempts. Dependent variables were substance use related variables including past 30 day ever alcohol use, binge drinking, cannabis use and electronic vapor product use and lifetime ever prescription pain medicine misuse. Applying appropriate survey weights and using logistic regression, we estimated adjusted odds ratios (aORs), 95% confidence intervals (CIs), and p-values. We conducted stratified analyses among groups defined by sex, race/ethnicity, and sexual identity to assess potential effect modification. We also conducted exploratory analyses with time varying effect modeling to visually assess changes in aORs over time.

Results: Comparing 1991 to 2019, the prevalence of past 12 month having seriously considered suicide decreased (26.7% to 18.5%), but other suicidality indicators remained similar. Past 30

day alcohol use was less prevalent in 1991 (49.0%) than in 2019 (27.2%), but past 30 day cannabis use was more prevalent (1991: 14.6%; 2019: 21.2%). We found that for all past 12 month depressive symptom and suicidality indicators, associations with past 30 day ever use of alcohol and cannabis have increased slightly over time. Associations for alcohol use remained relatively stable over time, after an increase from 1999 (aOR: 1.66; 95% CI: 1.37, 2.00; $p < 0.001$) to 2001 (aOR: 2.10; 95% CI: 1.89, 2.33; $p < 0.001$). For cannabis use, the association increased from 2009 (aOR: 1.95; 95% CI: 1.68, 2.27; $p < 0.001$) to 2017 (aOR: 2.65; 95% CI: 2.26, 3.12; $p < 0.001$), then decreased in 2019 (aOR: 2.16; 95%: 1.89, 2.47; $p < 0.001$). For available time points for past 30 day ever binge drinking, past 30 day ever use of electronic vapor products, and lifetime ever prescription pain medicine misuse, associations for each individual substance were similar through time.

Conclusions: We found that for all past 12 month depressive symptom and suicidality indicators associations with past 30 day ever use of alcohol and cannabis have increased slightly over time. Our findings may inform efforts to identify adolescents at high risk for substance use and to understand how associations between adolescent depressive symptoms and suicidality and substance use have changed over time. Further research is needed to monitor recent trends in associations comprehensively.

3.2 Introduction

Adolescents in the United States experience a high prevalence of depressive symptoms. According to 2020 estimates, 17% of youth ages 12 to 17 experienced a major depressive episode in the past year, representing a substantial increase from 8.0% in 2010 (1). Adolescents

face a uniquely high burden of depressive symptoms compared to adults ages 18 and older for whom the prevalence of a past-year major depressive episode in 2020 was 6.0%.

Substance use among adolescents is also prevalent and prevalence estimates of different substances are changing. According to estimates from the nationally-representative Monitoring the Future survey, lifetime ever use of alcohol reported by twelfth graders in 2021 was 54.1%, though this has decreased from 71.5% in 2010 and from 88.0% in 1991 (2). Similarly, reports of five or more drinks in a row in the past two weeks have decreased over time from 27.1% in 2005 to 23.2% in 2010 to 11.8% in 2021. In comparison, lifetime ever cannabis use increased from 1991 (36.7%) to 2010 (43.8%) and has remained approximately steady through 2021 (38.6%) besides a decrease from 2020 (43.7%). Lifetime ever misuse of any prescription drugs has decreased over time from 21.6% in 2010 to 14.2% in 2020 to 8.8 in 2021. Finally, more recently, reported ever use of any type of electronic vapor product has increased from 35.5% in 2015 to 47.2% in 2020, with a decrease in 2021 to 40.5%. New cannabis-related laws (3–5), availability of new products (6), and evidence for changes in adolescent-reported motivations for use of substances (7) may account for some of these observed trends.

Previous studies have suggested that depressive symptoms may result in substance use (8–11). However, a recent analysis of data from twelfth grade participants of the Monitoring the Future study, using time-varying effect modeling (TVEM), suggests that the strength of cross-sectional associations between binge drinking and depressive symptoms are declining over time (12). Given this observation, the context of changing cannabis laws, and introduction of new methods of substance use (i.e., electronic vapor products), it is important to assess the

associations between depressive symptoms and use of other substances, as well as assess how associations over time may differ by demographic factors. Therefore, we investigated cross-sectional associations of adolescent depressive symptoms and suicidality with substance use for change over time, and potential effect modifiers. These analyses may provide knowledge that may allow adolescent providers and caregivers to identify youth who may be at higher risk of substance use based on present trends. Further, an updated understanding of how associations of depressive symptoms and suicidality with substance use have (or have not) changed may inform development and implementation of prevention and intervention measures for adolescent mental health and substance use for today's youth.

3.3 Methods

Study Setting and Survey Administration

We utilized the 2019 Youth Risk Behavior Survey (YRBS) national combined data, which includes all weighted national high school surveys from 1991 to 2019 conducted among a total of 217,340 participants (13). The YRBS is conducted in odd numbered years and produces a nationally representative sample of adolescents in public and private high schools (grades nine to 12) in the United States with a three-stage, cluster sampling design (14). The first sampling stage consists of large counties or clusters of counties (i.e., the primary sampling units), the second of public and private schools, and the third of classes (either homeroom or a required subject). Schools, classes, and students are sampled without replacement. Based on grade, race/ethnicity, and sex, students who participate are assigned a weight to account for nonresponse from students and oversampling of Black and Hispanic students.

The YRBS questionnaire is administered in schools to students by trained data collectors and prior to questionnaire administration, relevant local parental permission procedures are followed. Students participate voluntarily and anonymously. The 2019 YRBS questionnaire items are mapped to identical items from previous years (15). The 2019 YRBS national combined dataset contains, when available, responses to 2019 YRBS questions from 1991 to 2019. YRBS data are publicly available on the Centers for Disease Control and Prevention website (16). These analysis activities were reviewed by the University of Washington Human Subjects Division and deemed to not involve human subjects.

Analytic Constructs and Variables

In our analyses, we considered past 12 month depressive symptoms (i.e., feelings of sadness or hopelessness for two or more weeks that resulted in stopping of some usual activities) and suicidality indicators (i.e., serious consideration of a suicide attempt, made a suicide plan, suicide attempts, and injurious suicide attempts) as independent variables and substance use (i.e., alcohol, binge drinking, cannabis, electronic vapor products, and prescription pain medicine) as dependent variables. For all substance use categories, we assessed for past 30 day ever use (i.e., used in past 30 days vs. did not use in past 30 days), with the exception of prescription pain medicine for which past 30 day use was first queried in 2019. Therefore, in order to be able to evaluate for changes in associations over time, we assessed for lifetime ever use of prescription pain medicine, which was first included in the YRBS in 2017.

Other variables that were not assessed at all time points between 1991 and 2019 in the current 2019 question form include depressive symptoms (beginning 1999), binge drinking (beginning 2017), electronic vapor products (beginning 2015), and sexual identity (beginning

2015). For components of the analyses that include these variables, we only present estimates for years in which all relevant questions were asked. For full details on survey questions and response options for all variables included in these analyses, see Appendix Table 3.1.

Analytic Methods

To compare the earliest YRBS participants to the most recent YRBS participants, we presented descriptive statistics (i.e., percentages) for demographic characteristics of the 1991 and 2019 weighted samples. We then assessed for changes in the associations between independent variables (depressive symptoms and suicidality) and dependent variables (substance use) with weighted multivariable logistic regression models adjusted for age (12 years old or younger, 13 years old, 14 years old, 15 years old, 16 years old, 17 years old, 18 years old or older), sex (male, female), and race/ethnicity (American Indian/Alaska Native, Asian, Black or African American, Hispanic/Latino, Native Hawaiian/Other Pacific Islander, White, Multiple Races (Non-Hispanic)) for each depressive symptom or suicidality indicator and substance use combination (e.g., considered suicide in the past 12 months and past 30 day ever use of alcohol). We presented adjusted odds ratios (aORs), 95% confidence intervals (CIs), and p-values for each association for each survey year and plotted the aORs and 95% CIs to visually assess changes over time. Because of the number of outcomes per exposure variable, to address multiple testing concerns, we assessed for statistical significance at a two-sided p-value < 0.01 ($\alpha = 0.05/5 = 0.01$). As an exploratory analyses, we additionally conducted analyses by fitting models (described above) stratified by demographic factors (i.e., sex, race/ethnicity, and sexual identity) for associations between the most prevalent independent variable (depressive

symptoms) and the two dependent variables assessed at all time points (past 30 day ever alcohol use and past 30 day ever cannabis use).

Also, as exploratory analyses, we utilized TVEM to assess differences in the associations between depressive symptoms and substance use. TVEM builds on linear regression methods by eliminating assumptions that the change that occurs in an outcome over time is parametric and that coefficients in models are constant over time (17). TVEM does however assume that change in associations over time occurs smoothly. Due to constraints of the data, including limited number of time points assessed, we ran unadjusted TVEM logistic regression models with two knots for associations between past 12 month depressive symptoms (independent variable) and past 30 day ever alcohol use and cannabis use (dependent variables). We applied individual-level survey weights, but not other sample design variables which account for primary sampling units or secondary strata (schools), as the available TVEM functionality in R currently only accommodates a single sampling weight. We presented figures displaying estimated ORs over time from TVEM and visually assessed trends over time.

Analyses were conducted in R version 3.6.2 with survey weights and other sample design variables applied with the R *survey* package (18) for descriptive statistics and logistic regression models. Exploratory TVEM analyses were also conducted in R version 3.6.2 with the R *tvem* package (19).

3.4 Results

The weighted samples in the earliest (1991) and latest year (2019) of the YRBS national surveys were similar (Table 3.1) with respect to sex and age. The 1991 weighted sample had a

much larger percentage of students who reported their racial/ethnic identity as White (69.9%) compared to the 2019 weighted sample (49.6%). Substantially fewer students reported a racial/ethnic identity of Hispanic/Latino in 1991 (8.8%) than in 2019 (25.3%). Sexual identity was not queried in 1991.

In 2019, 36.2% of adolescents reported having experienced depressive symptoms in the past 12 months. While a question on depressive symptoms was not included in the 1991 YRBS questionnaire, suicidality indicators were queried (Table 3.2). The prevalence of having seriously considered attempting suicide was higher in 1991 (26.7%) than in 2019 (18.5%). The prevalence of having made a suicide plan was similar (1991: 16.8%; 2019: 15.5%), though there were substantially more missing responses in 1991 (9.9%) than 2019 (1.5%). The prevalence of at least one suicide attempt in the past twelve months was also similar in 1991 (6.7%) and 2019 (7.5%), though missingness in 2019 (16.4%) was higher than in 1991 (8.1%). Injurious suicide attempts were reported at similar rates in 1991 (1.6%) and 2019 (2.0%).

Only two of the substance use indicators were included in 1991 (Table 3). In 1991, 49.0% of the weighted sample reported ever use of alcohol in the past 30 days, as compared to 27.2% in 2019. However, the prevalence of ever use of cannabis in the past 30 days was greater in 2019 (21.2%) than in 1991 (14.6%). The 2019 prevalence of past 30 day ever binge drinking, past 30 day ever electronic vapor product use, and lifetime ever use of prescription pain medicine misuse was 12.4%, 30.9%, and 6.9%, respectively.

Associations of Depressive Symptoms with Substance Use Over Time

For all years, associations between depressive symptoms and substance use (all types) were statistically significant (all p-values < 0.001) (Appendix Table 3.2). The weakest observed

aOR was for past 30 day cannabis use in 1999 (aOR: 1.52; 95% CI: 1.29, 1.79; p < 0.001) and the strongest was for lifetime prescription pain medicine misuse in 2017 (aOR: 3.28; 95% CI: 2.75, 3.92; p < 0.001). In 1999, the first year in which depressive symptoms were queried, the association was similar for alcohol (aOR: 1.66; 95% CI: 1.37, 2.00; p < 0.001) and cannabis (aOR: 1.52; 95% CI: 1.29, 1.79; p < 0.001) (Figure 3.1). Associations for alcohol use remained relatively stable over time, after an increase from 1999 (aOR: 1.66; 95% CI: 1.37, 2.00; p < 0.001) to 2001 (aOR: 2.10; 95% CI: 1.89, 2.33; p < 0.001). For cannabis use, the association increased from 2009 (aOR: 1.95; 95% CI: 1.68, 2.27; p < 0.001) to 2017 (aOR: 2.65; 95% CI: 2.26, 3.12; p < 0.001), then decreased in 2019 (aOR: 2.16; 95%: 1.89, 2.47; p < 0.001). Associations for lifetime ever prescription pain medicine, past 30 day ever binge drinking, and past 30 day ever electronic vapor product use did not change substantially over time.

Associations of Considering Suicide and Making a Suicide Plan with Substance Use Over Time

Associations between having seriously considered suicide and having made a suicide plan and all substances were significant (p ≤ 0.002) at all time points (Appendix Table 3.3 and Appendix Table 3.4). For both associations of having seriously considered suicide and having made a suicide plan with substance use, past 30 day ever alcohol use and cannabis use were relatively similar to each other over time (Figure 3.2 and Table 3.3). For having seriously considered suicide and alcohol, the association was strongest in 2007 (aOR: 2.56; 95% CI: 2.25, 2.92; p < 0.001) and weakest in 2017 (aOR: 1.85; 95% CI: 1.62, 2.12; p < 0.001). For having seriously considered suicide and cannabis use, the association was the strongest in 2003 (aOR: 2.76; 95% CI: 2.42, 3.15; p < 0.001) and weakest in 2005 (aOR: 2.07; 95% CI: 1.82, 2.34). For having made a suicide plan, associations for both cannabis use (aOR: 2.00; 95% CI: 1.32, 3.04; p

= 0.002) and alcohol use (aOR: 1.92; 95% CI: 1.48, 2.49; p < 0.001) were weakest in 2003. However, the association was strongest for cannabis in 2017 (aOR: 2.61; 95% CI: 2.14, 3.19; p < 0.001) and for alcohol in 2001 (aOR: 2.46; 95% CI: 2.13, 2.83; p < 0.001). For the years in which past 30 day ever binge drinking, past 30 day use of electronic vapor products, and lifetime ever misuse of prescription pain medicine were assessed, each individual association was similar over time.

Associations of Suicide Attempts and Injurious Suicide Attempts with Substance Use Over Time

While associations between past 12 month suicide attempts and substance use were significant for all substances across time (p < 0.001), associations were not consistently significant for past 12 month injurious suicide attempts over time at the $\alpha = 0.01$ level (Appendix Table 3.5 and Appendix Table 3.6). For past 12 month suicide attempts, aORs for alcohol ranged from 1.53 in 1993 (95% CI: 1.40, 1.66; p < 0.001) and 2017 (95% CI: 1.32, 1.79; p < 0.001) to 2.07 (95% CI: 1.76, 2.42; p < 0.001) in 2007. For cannabis use, aORs ranged from 1.61 (95% CI: 1.40, 1.84; p < 0.001) in 1993 to 1.97 (95% CI: 1.77, 2.19; p < 0.001) in 2003. Associations for lifetime prescription pain medicine, past 30 day ever binge drinking, and past 30 day ever use of electronic vapor products were similar across measured time points.

For past 12 month injurious suicide attempts, broader ranges of aORs were observed. For past 30 day alcohol use, the weakest association was observed in 2003 (aOR: 1.24; 95% CI: 0.70, 2.21; p = 0.4) and the strongest association in 1995 (aOR: 3.43; 95% CI: 1.78, 6.62; p < 0.001). For past 30 day cannabis use, the weakest association was observed in 2013 (aOR: 1.63; 95% CI: 1.16, 2.40; p = 0.006) and 2015 (aOR: 1.63; 95% CI: 1.05, 2.53; p = 0.031) and the strongest in 1995 (aOR: 4.53; 95% CI: 2.64, 7.79; p < 0.001). Though assessed at fewer time

points, some variation was also observed for past 30 day binge drinking, past 30 day electronic vapor product use, and lifetime prescription pain medicine misuse.

Analysis of Demographics-Stratified Associations of Depressive Symptoms with Substance Use Over Time

Sex-stratified adjusted odds ratios revealed that the associations of depressive symptoms with both alcohol use (Appendix Figure 3.1) and cannabis use (Appendix Figure 3.2) were stronger for females than males at nearly all time points. For both males and females, associations remained similar over time for alcohol use, but increased in recent years for cannabis use.

Race/ethnicity-stratified results showed evidence of wider variation, likely due to small sample size for some racial/ethnic groups (Appendix Figure 3.3 and Appendix Figure 3.4). For racial groups for which there were larger samples, associations for alcohol use appeared to be similar over time. However, for cannabis use, the association was similar over time for groups with larger sample sizes, except for White adolescents, who showed a potential increase in the association in recent years. Generally, associations of depressive symptoms with alcohol use were similar across racial/ethnic groups, while associations with cannabis use were almost always stronger for White adolescents than Black or African American adolescents, Hispanic/Latino adolescents, and multi-racial (non-Hispanic) adolescents.

Sexual identity questions were first included in the national YRBS questionnaire in 2015. While this limits our ability to visually assess for trends over time, adolescents who responded as “not sure” had the strongest associations of depressive symptoms with both alcohol use (Appendix Figure 3.5) and cannabis use (Appendix Figure 3.6) in 2017 and 2019.

Exploratory Analysis Using TVEM

In exploratory weighted, unadjusted TVEM analyses, associations between past 12 month depressive symptoms and past 30 day ever use of alcohol (Appendix Figure 3.7) and cannabis (Appendix Figure 3.8) both indicated an increase in strength of associations from 1999 to 2019. However, while the association for alcohol use increased steadily over time, the association for cannabis use decreased from the early to late 2000s before increasing again.

3.5 Discussion

Using 2019 YRBS national combined data from 1991 to 2019, we assessed for changes over time in the associations of depressive symptoms and suicidality indicators with substance use in a nationally representative sample of high school students in public and private schools in the United States. Overall, we found that for all past 12 month depressive symptom and suicidality indicators associations with past 30 day ever use of alcohol and cannabis have increased slightly over time. For the remaining substances evaluated in our analyses, comparisons across time indicated similarities in associations over time, though the lack of available data precludes our ability to comprehensively assess patterns in these associations. In analyses considering effect modification by demographic factors, stratified aORs generally followed similar patterns to unstratified aORs.

We are aware of few studies that assessed for change in cross-sectional associations between depressive symptoms and/or suicidality and substance use among adolescents over time. Our findings differ from those of the aforementioned Keyes et al. study, which found evidence for weakening of the association between depressive symptoms and past two week

ever binge drinking over time among twelfth graders using data from the nationally representative Monitoring the Future study from 1991 (aOR: 1.74; 95% CI: 1.54, 1.97) to 2018 (aOR: 1.46; 95% CI: 1.18, 1.82) (12). Most obviously, we were limited to two years of data in which comparable questions for past 30 day ever binge drinking were asked in YRBS questionnaires. With that said, aORs in our analyses were similar to one another in 2017 (aOR: 2.07) and 2019 (aOR: 1.99). Comparisons with our findings of past 30 day any use of alcohol, representing the same type of substance (i.e., alcohol) but potentially different patterns of use from binge drinking, also differ from the findings of Keyes et al. With that said, we note large methodological differences in our analyses from those of Keyes et al. While Keyes et al. adjusted for sex, race/ethnicity, and parental education (as a proxy for socioeconomic status), we adjusted for sex, race/ethnicity, and age. The 2019 YRBS does not contain any comparable socioeconomic indicators. Depressive symptoms are measured differently in Monitoring the Future surveys with a four Likert scale items and are measured at the time of the survey. Keyes et al. operationalized higher than average depressive symptoms as those who were in the 75th percentile of the quantitative score for current depressive symptoms. Compared to our binary measure of having experienced two or more weeks of sadness or hopelessness that impacted usual activities in the past 12 months from the YRBS, it is possible that the operationalization of depressive symptoms by Keyes et al. may represent more severe experience of depressive symptoms. Key differences in temporality are also of note: Keyes et al. assessed associations for current depressive symptoms and past two week binge drinking while we assessed associations for past 12 month depressive symptoms and past 30 day binge drinking.

A similar, albeit less recent, study of Norwegian adolescents observed decreases in ORs for the associations between past 12 month depressive symptoms and past four week alcohol use from 1992 to 2010 for both more than a few sips of alcohol (1992: aOR: 1.41; 95% CI: 1.23, 1.62; 2010: aOR: 1.11, 95% CI: 0.99, 1.24) and binge drinking (1992: aOR: 1.47; 95% CI: 1.29, 1.67; 2010: aOR: 1.22; 95% CI: 1.10, 1.35) after adjusting for sex, age, and country of birth (20). Our analyses adjusting for analogous covariates identified stronger associations for past 12 month depressive symptoms and past 30 day ever alcohol use in 2009 (aOR: 2.02; 95% CI: 1.84, 2.22) and 2011 (aOR: 2.22; 95% CI: 2.04, 2.43), which may be due to different measurements of depressive symptoms and/or differences in sociocultural context. However, we observed evidence for similar associations for past 30 day alcohol use over time, apart from an increase from 1999 to 2001, which differs from the trends observed in Norwegian adolescents.

The aforementioned Keyes et al. analysis also conducted stratified analyses for the association between adolescent depressive symptoms and binge drinking. For sex, the authors report evidence of interaction for some time periods and an overall similar decrease in the association over time for both males and females (12). Further, the authors report limited evidence for interaction by race/ethnicity, but some qualitative differences by racial/ethnic identity over time. Due to limited time points at which the current iteration of the question for binge drinking was administered, we did not conduct stratified analyses for binge drinking. Our findings for past 30 day any alcohol use however indicate an overall increase in the association between depressive symptoms and alcohol use for both males and females, which differs from those of Keyes et al., but some variation over time by race/ethnicity, which is qualitatively similar to the findings of Keyes et al.

Our findings should be considered within the strengths and limitations of our analyses. Because our analyses were completed using a weighted, nationally representative sample of high school students in the United States, they are highly generalizable. However, youth who are not present in the classroom setting may not be well represented and therefore generalizations of our findings for this potentially highly vulnerable group of adolescents should be made cautiously. All associations that we modeled are cross-sectional and there is potential for the dependent variables (substance use) to have occurred before the independent variables (depressive symptoms and suicidality). As such, we have not established a clear sequence of temporality and no causal inferences can be made. YRBS participants self-report on the potentially sensitive topics of mental health and substance use. Therefore, responses may be subject to social desirability bias resulting in misclassification of mental health status or substance use. Adolescents participate in the YRBS anonymously in an attempt to mitigate this source of bias. Our analyses for trends in associations over time are substantially limited for binge drinking, electronic vapor product use, prescription pain medicine misuse due to the limited time points in which these questions were asked. Lastly, the most recent YRBS data available at the time of writing are from 2019. Thus, we are not able to assess the impact of the COVID-19 pandemic.

The results of our analyses suggest that adolescents who experience depressive symptoms and suicidality may be more likely to engage in substance, and that these patterns have persisted over time for both alcohol use and cannabis use. Those with prominent roles in adolescent lives should be aware that depressive symptoms and suicidality may increase the likelihood of substance use among youth, and vice versa. Adolescents who report depressive

symptoms and/or suicidality to healthcare providers should be additionally screened for substance use, and those who report substance use should be screened for depressive symptoms and suicidality regardless of substance reported. Our findings also highlight potential methodological issues in assessing for time trends in associations for more recent substance use behaviors (e.g., electronic vapor product use) and for comparing conclusions across analyses of similar trends. Funding agencies and other groups who are in the process of designing new studies should consider that these types of assessments require long-standing data collection efforts and consistent questions over time. Future research is needed to elucidate potential reasons for differences between our findings and similar analyses in the literature and to assess for trends in more recent substance use behaviors (e.g., electronic vapor product use). In addition, our collective understanding of these associations over time, and thus our ability to best tailor current resources and programming to the current needs of adolescents, would be greatly improved by additional large, ongoing studies of adolescent mental health and substance use designed to assess for additional nuance.

3.6 References

1. Substance Abuse and Mental Health Services Administration. Key substance use and mental health indicators in the United States: Results from the 2020 National Survey on Drug Use and Health. Center for Behavioral Health Statistics and Quality, Substance Abuse and Mental Health Services Administration; 2021 (Accessed January 13, 2022).(https://www.samhsa.gov/data/sites/default/files/reports/rpt35325/NSDUHFFRPDFWHTMLFiles2020/2020NSDUHFFR1PDFW102121.pdf). (Accessed January 13, 2022)

2. Johnston LD, Miech RA, O'Malley PM, et al. Monitoring the Future national survey results on drug use 1975-2021: Overview, key findings on adolescent drug use. Ann Arbor: University of Michigan Institute for Social Research; 2022 (Accessed May 17, 2022).(http://www.monitoringthefuture.org//pubs/monographs/mtf-overview2021.pdf). (Accessed May 17, 2022)

3. National Conference of State Legislatures. Marijuana Overview. 2019;(http://www.ncsl.org/research/civil-and-criminal-justice/marijuana-overview.aspx). (Accessed December 9, 2019)

4. Sarvet AL, Wall MM, Fink DS, et al. Medical marijuana laws and adolescent marijuana use in the United States: a systematic review and meta-analysis. *Addiction*. 2018;113(6):1003–1016.

5. Pacula RL, Powell D, Heaton P, et al. Assessing the Effects of Medical Marijuana Laws on Marijuana Use: The Devil is in the Details. *Journal of Policy Analysis and Management* [electronic article]. 2015;34(1):7–31. (http://doi.wiley.com/10.1002/pam.21804)

6. Becker TD, Rice TR. Youth vaping: a review and update on global epidemiology, physical and behavioral health risks, and clinical considerations. *Eur J Pediatr* [electronic article]. 2022;181(2):453–462. (https://link.springer.com/10.1007/s00431-021-04220-x). (Accessed May 17, 2022)

7. Patrick ME, Evans-Polce RJ, Kloska DD, et al. Reasons High School Students Use Marijuana: Prevalence and Correlations With Use Across Four Decades. *Journal of Studies on Alcohol and Drugs* [electronic article]. 2019;80(1):15–25. (https://www.jsad.com/doi/10.15288/jsad.2019.80.15)

8. Edlund MJ, Forman-Hoffman VL, Winder CR, et al. Opioid abuse and depression in adolescents: Results from the National Survey on Drug Use and Health. *Drug and Alcohol Dependence* [electronic article]. 2015;152:131–138. (http://dx.doi.org/10.1016/j.drugalcdep.2015.04.010)

9. Scholes-Balog KE, Hemphill SA, Patton GC, et al. Relationships Between Substance Use and Depressive Symptoms: A Longitudinal Study of Australian Adolescents. *The Journal of Early Adolescence* [electronic article]. 2015;35(4):538–561. (http://journals.sagepub.com/doi/10.1177/0272431614540526). (Accessed April 14, 2022)

10. Cioffredi L-A, Kamon J, Turner W. Effects of depression, anxiety and screen use on adolescent substance use. *Preventive Medicine Reports* [electronic article]. 2021;22:101362. (https://linkinghub.elsevier.com/retrieve/pii/S221133552100053X). (Accessed April 14, 2022)

11. Wang P-W, Lin H-C, Yeh Y-C, et al. The relation of substance use with different levels of depressive symptoms and the moderating effect of sex and age in Taiwanese adolescents. *Comprehensive Psychiatry* [electronic article]. 2012;53(7):1013–1020. (https://linkinghub.elsevier.com/retrieve/pii/S0010440X12000314). (Accessed April 14, 2022)

12. Keyes KM, Hamilton A, Patrick ME, et al. Diverging Trends in the Relationship Between Binge Drinking and Depressive Symptoms Among Adolescents in the U.S. From 1991 Through 2018. *Journal of Adolescent Health* [electronic article]. 2020;66(5):529–535. (https://doi.org/10.1016/j.jadohealth.2019.08.026)

13. Centers for Disease Control and Prevention. 2019 YRBS National, State, and District Combined Datasets User's Guide. 2020;(August). (https://www.cdc.gov/healthyyouth/data/yrbs/pdf/2019/2019_YRBS_SADC_Documentation.pdf)

14. Brener ND, Kann L, Shanklin S, et al. Methodology of the Youth Risk Behavior Surveillance System - 2013. *MMWR Recommendations and Reports*. 2013;62(1):1–23.

15. YRBS Questionnaire Content - 1991-2019. Centers for Disease Control and Prevention; 2018 (Accessed May 17, 2022).(https://www.cdc.gov/healthyyouth/data/yrbs/pdf/2019/YRBS_questionnaire_content_1991-2019.pdf). (Accessed May 17, 2022)

16. YRBSS Data & Documentation. *Centers for Disease Control and Prevention*. 2022;(https://www.cdc.gov/healthyyouth/data/yrbs/data.htm). (Accessed May 17, 2022)

17. Lanza ST, Vasilenko SA, Liu X, et al. Advancing the understanding of craving during smoking cessation attempts: A demonstration of the time-varying effect model. *Nicotine and Tobacco Research*. 2014;16(SUPPL2):127–134.

18. Lumley T. Package 'survey.' 2021;(https://cran.r-project.org/web/packages/survey/survey.pdf). (Accessed April 14, 2022)

19. Dziak JJ, Coffman DL, Li R, et al. Package 'tvem.' 2021 (Accessed May 17, 2021).(https://cran.r-project.org/web/packages/tvem/tvem.pdf). (Accessed May 17, 2021)

20. Pedersen W, Von soest T. Adolescent alcohol use and binge drinking: An 18-year trend study of prevalence and correlates. *Alcohol and Alcoholism*. 2015;50(2):219–225.

3.7 Tables and Figures

Table 3.1: Demographics of the Weighted 1991 and 2019 YRBS Weighted Samples

	1991	2019
Characteristic	**Percent (%)***	**Percent (%)***
Sex		
Male	51.1	50.2
Female	48.9	48.9
Missing	0.03	0.9
Race/Ethnicity		
American Indian/Alaska Native	0.8	0.6
Asian	3.3	4.9
Black or African American	14.3	11.8
Hispanic/Latino	8.8	25.3
Native Hawaiian/Other Pacific Islander	NA	0.3
White	69.9	49.6
Multiple Races (Non-Hispanic)	NA	4.3
Missing	2.9	3.1
Sexual Identity		
Straight	NA	79.2
Gay or Lesbian	NA	2.3
Bisexual	NA	8.2
Not Sure	NA	4.2
Missing	NA	6.1
Age		
12 years old or younger	0.06	0.3
13 years old	0.03	0.1
14 years old	9.2	11.8
15 years old	23.2	24.6
16 years old	26.2	25.4
17 years old	23.8	23.5
18 years old or older	17.5	13.6
Missing	0.01	0.6

*Note: Percentages may not sum to 100 due to rounding.
Abbreviations: NA = not asked

Table 3.2: Prevalence of Past 12 Month Depressive Symptoms and Suicidality Indicators (Independent Variables) in 1991 and 2019 YRBS Weighted Samples

	1991	2019
	Percent (%)*	**Percent (%)***
Depressive Symptoms		
Yes	NA	36.2
No	NA	62.4
Missing	NA	1.4
Seriously Considered Attempting Suicide		
Yes	26.7	18.5
No	65.6	80.1
Missing	7.7	1.5
Made a Suicide Plan		
Yes	16.8	15.5
No	73.4	83.1
Missing	9.9	1.5
Suicide Attempts		
0	85.2	76.1
1	3.5	4.1
2-3	2.3	2.3
4-5	0.4	0.5
6+	0.5	0.6
Missing	8.1	16.4
Injurious Suicide Attempts		
Yes	1.6	2.0
No	5.1	5.0
Missing or Did Not Attempt Suicide	93.3	93.0

*Note: Percentages may not sum to 100 due to rounding.
Abbreviations: NA = not asked

Table 3.3: Prevalence of Substance Use Behaviors (Dependent Variables) in 1991 and 2019 YRBS Weighted Samples

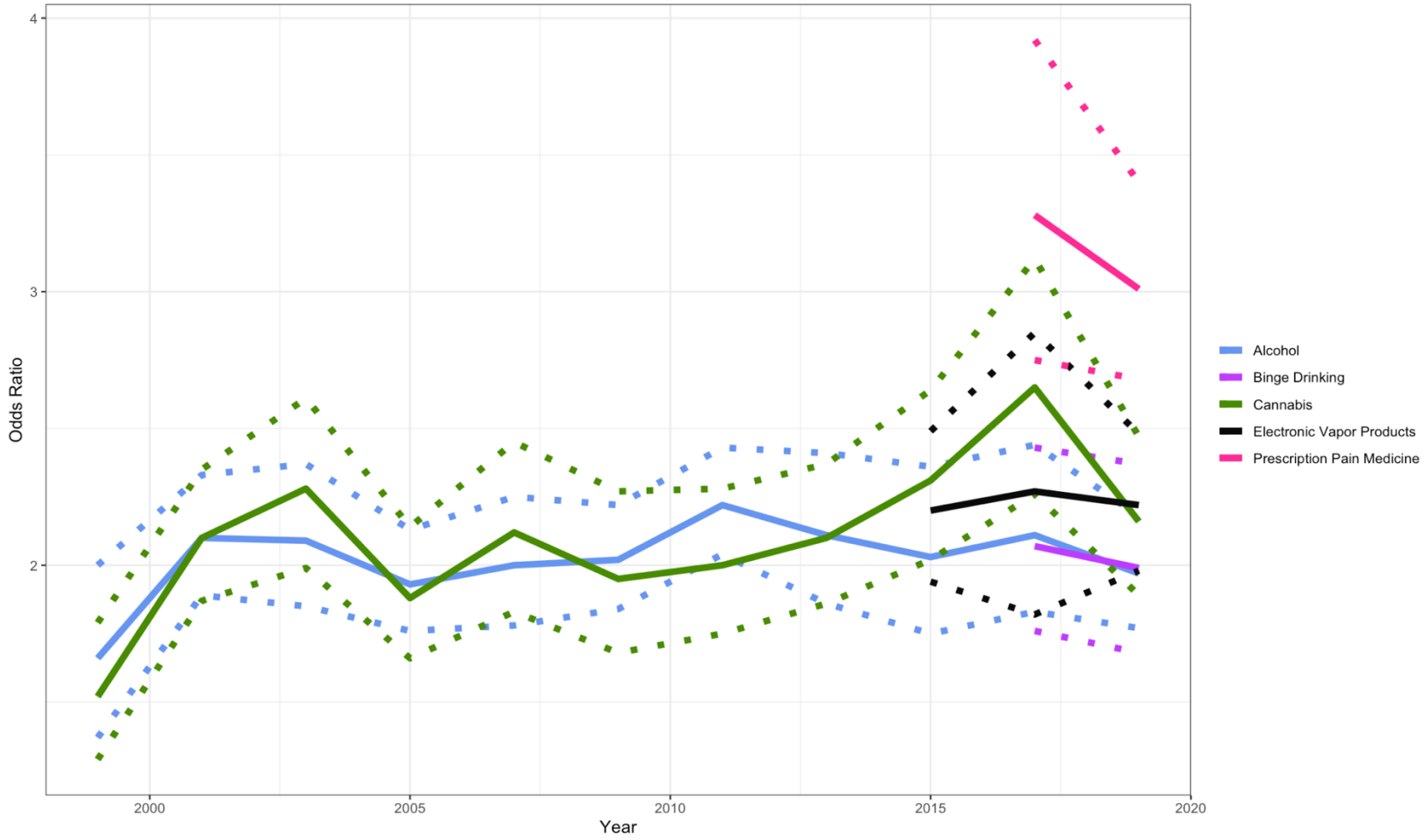
	1991	2019
Substance Use	**Percent (%)***	**Percent (%)***
Past 30 Day Alcohol Use		
0 days	47.3	65.7
1 or 2 days	20.7	14.9
3 to 5 days	11.8	6.6
6 to 9 days	8.1	3.3
10 to 19 days	6.5	1.4
20 to 29 days	1.2	0.4
All 30 days	0.7	0.6
Missing	3.8	7.2
Past 30 Day Binge Drinking		
0 days	NA	77.8
1 day	NA	4.3
2 days	NA	3.3
3 to 5 days	NA	2.6
6 to 9 days	NA	1.3
10 to 19 days	NA	0.5
20 or more days	NA	0.4
Missing	NA	9.8
Past 30 Day Cannabis Use		
0 times	85.0	76.4
1 or 2 times	5.7	7.8
3 to 9 times	4.3	4.6
10 to 19 times	2.0	2.7
20 to 39 times	1.2	2.3
40 or more times	1.4	3.8
Missing	0.4	2.4
Past 30 Day Electronic Vapor Product Use		
0 days	NA	63.1
1 or 2 days	NA	9.1
3 to 5 days	NA	4.8
6 to 9 days	NA	3.0
10 to 19 days	NA	4.0
20 to 29 days	NA	3.3
All 30 days	NA	6.7
Missing	NA	6.1
Lifetime Prescription Pain Medicine Use		
0 times	NA	81.3
1 or 2 times	NA	6.6

3 to 9 times	NA	3.3
10 to 19 times	NA	1.4
20 to 39 times	NA	0.8
40 or more times	NA	1.4
Missing	NA	5.2

*Note: Percentages may not sum to 100 due to rounding.

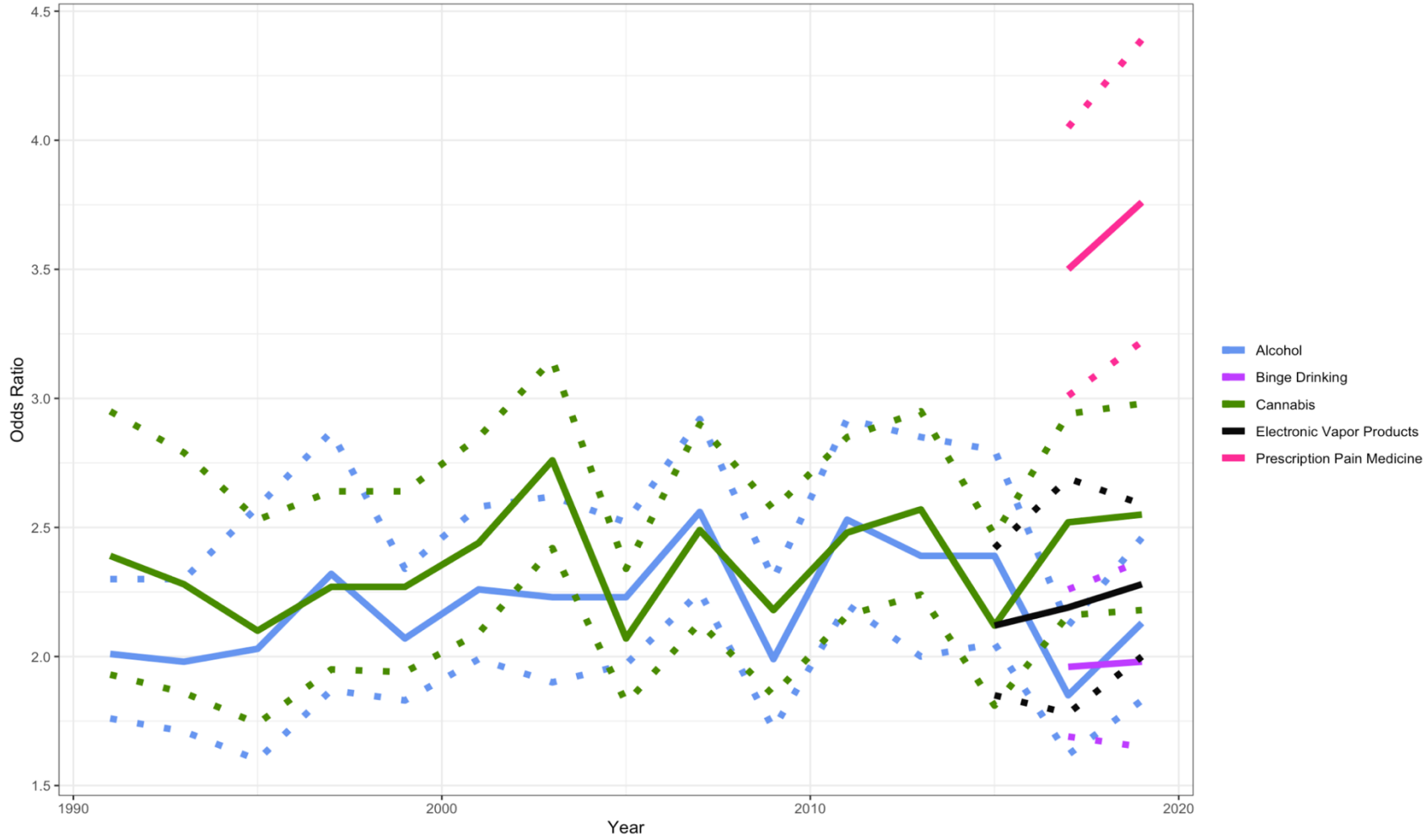
Abbreviations: NA = not asked

Figure 3.1: Adjusted Odds Ratios for the Association Between Past 12 Month Depressive Symptoms and Substance Use Over Time



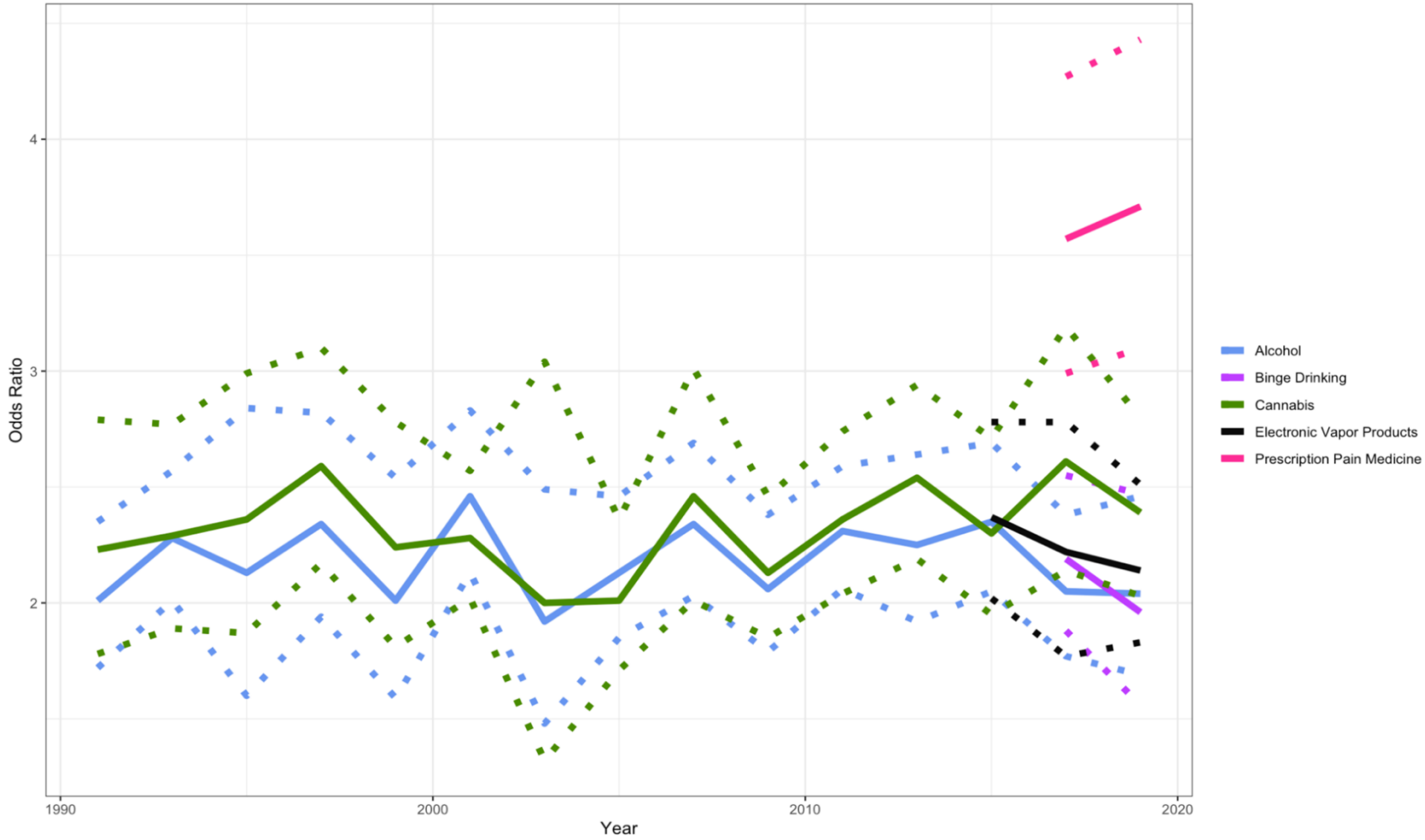
Notes: Weighted logistic regression models adjusted for sex, age, and race/ethnicity. All substance use measures are for past 30 day ever use, except prescription pain medicine which is lifetime ever use. Solid lines represent adjusted odds ratios and dotted lines represent 95% confidence intervals.

Figure 3.2: Adjusted Odds Ratios for the Association Between Past 12 Month Having Seriously Considered Suicide and Substance Use Over Time



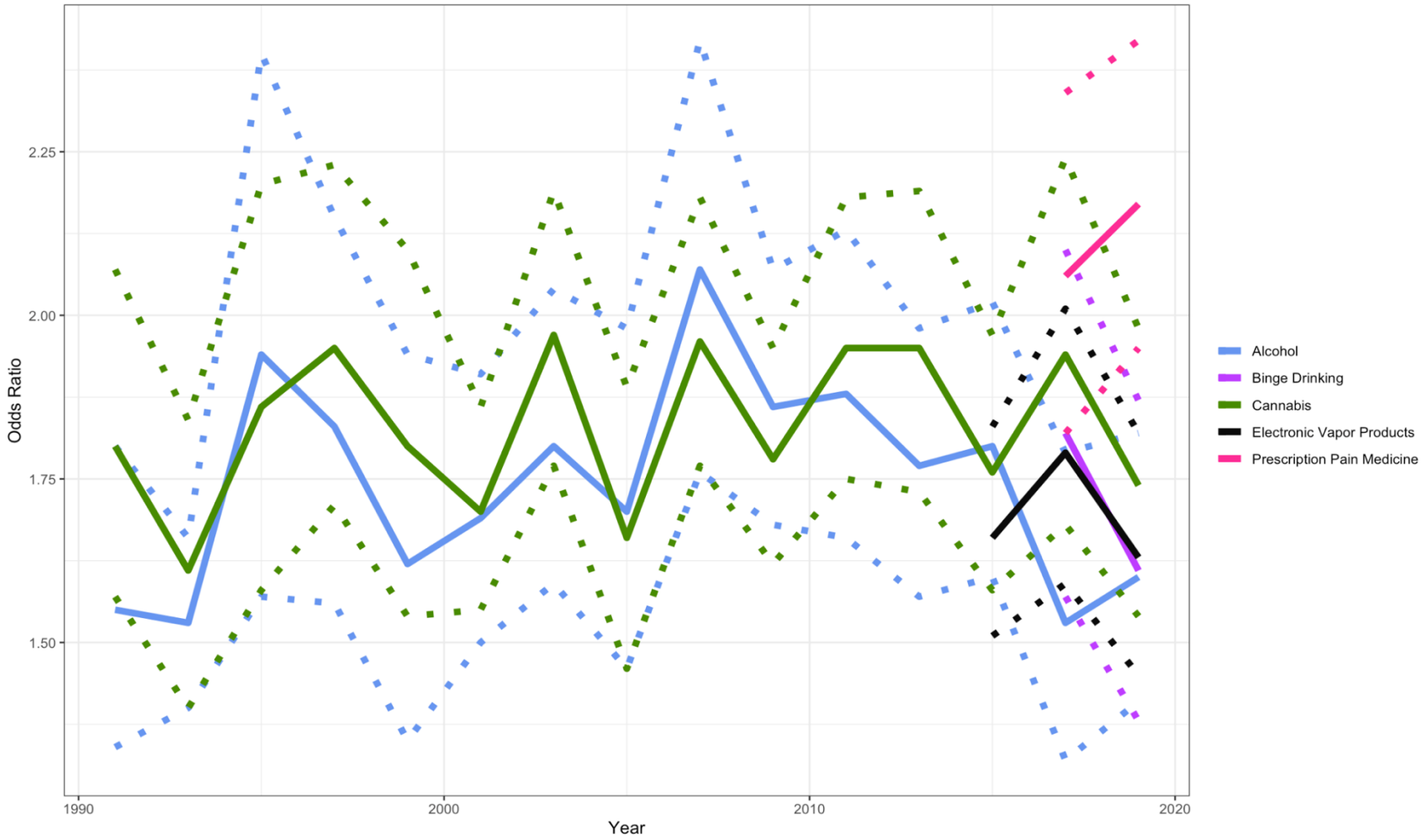
Notes: Weighted logistic regression models adjusted for sex, age, and race/ethnicity. All substance use measures are for past 30 day ever use, except prescription pain medicine which is lifetime ever use. Solid lines represent adjusted odds ratios and dotted lines represent 95% confidence intervals.

Figure 3.3: Adjusted Odds Ratios for the Association Between Past 12 Month Having Made a Suicide Plan and Substance Use Over Time



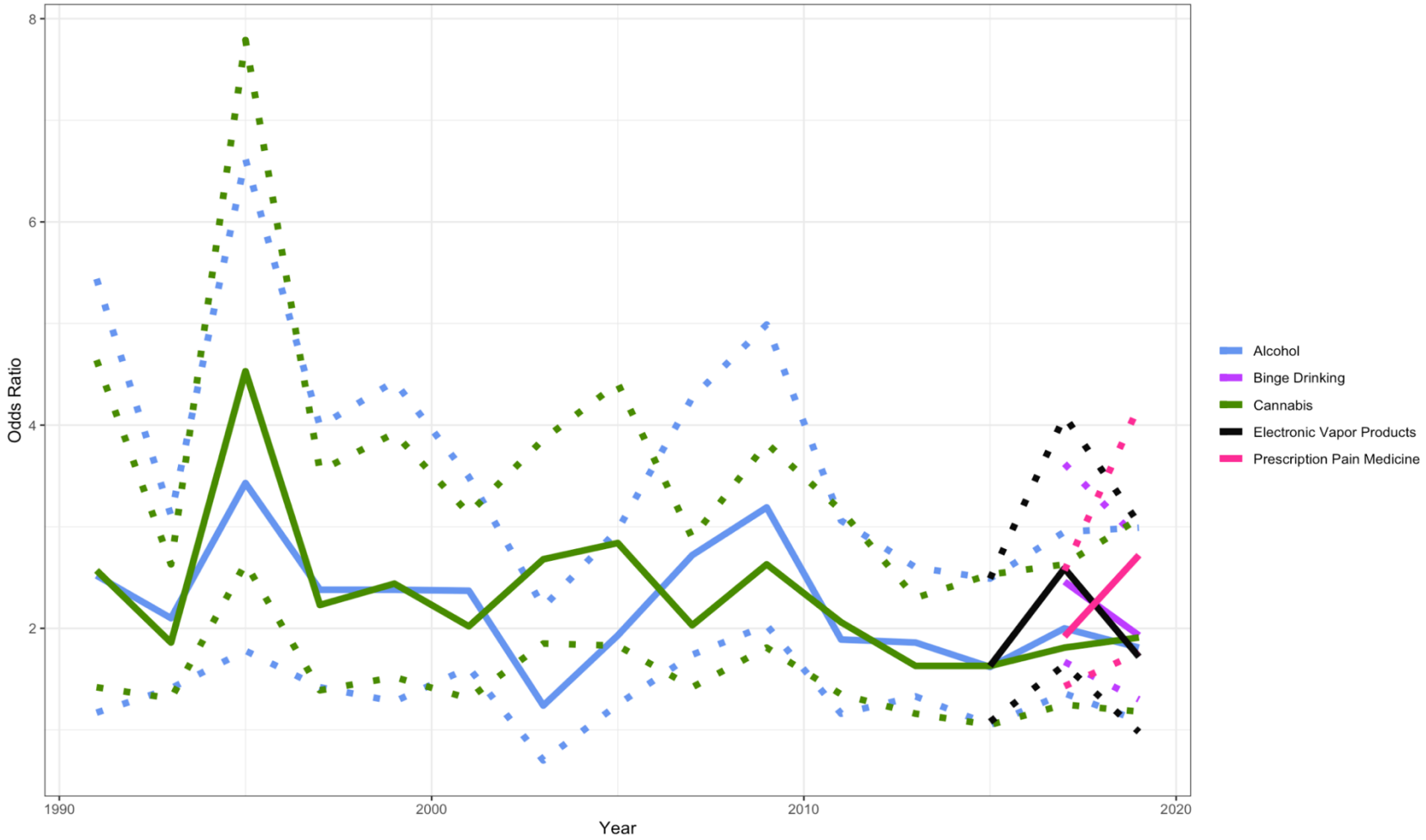
Notes: Weighted logistic regression models adjusted for sex, age, and race/ethnicity. All substance use measures are for past 30 day ever use, except prescription pain medicine which is lifetime ever use. Solid lines represent adjusted odds ratios and dotted lines represent 95% confidence intervals.

Figure 3.4: Adjusted Odds Ratios for the Association Between Past 12 Month Suicide Attempts and Substance Use Over Time



Notes: Weighted logistic regression models adjusted for sex, age, and race/ethnicity. All substance use measures are for past 30 day ever use, except prescription pain medicine which is lifetime ever use. Solid lines represent adjusted odds ratios and dotted lines represent 95% confidence intervals. Suicide attempts coded as 0 = 0, 1 = 1, 2 = 2-3, 3 = 4-5, 4 = 6+.

Figure 3.5: Adjusted Odds Ratios for the Association Between Past 12 Month Injurious Suicide Attempts and Substance Use Over Time



Notes: Weighted logistic regression models adjusted for sex, age, and race/ethnicity. All substance use measures are for past 30 day ever use, except prescription pain medicine which is lifetime ever use. Solid lines represent adjusted odds ratios and dotted lines represent 95% confidence intervals.

3.8 Appendix

Appendix Table 3.1: Analytic Constructs and Corresponding Youth Risk Behavior Survey 2019 Survey Questions

	First Year Asked With Current Question Form	Survey Question	Response Options
Depressive Symptom and Suicidality			
Past 12 Month Depressive Symptoms	1999	During the past 12 months, did you ever feel so sad or hopeless almost every day for two weeks or more in a row that you stopped doing some usual activities?	Binary: Yes/No
Past 12 Month Considered Suicide Attempt	1991	During the past 12 months, did you ever seriously consider attempting suicide?	Binary: Yes/No
Past 12 Month Suicide Plan	1991	During the past 12 months, did you make a plan about how you would attempt suicide?	Binary: Yes/No
Past 12 Month Suicide Attempts	1991	During the past 12 months, how many times did you actually attempt suicide?	Categorical: 0 times, 1 time, 2 or 3 times, 4 or 5 times, 6 or more times
Past 12 Month Injurious Suicide Attempts	1991	If you attempted suicide during the past 12 months, did any attempt result in an injury, poisoning, or overdose that had to be treated by a doctor or nurse?	Categorical: I did not attempt suicide during the past 12 months, Yes, No
Substance Use			
Past 30 Day Alcohol Use	1991	During the past 30 days, on how many days did you have at least one drink of alcohol?	Categorical: 0 days, 1 or 2 days, 3 to 5 days, 6 to 9 days, 10 to 19 days, 20 to 29 days, all 30 days
Past 30 Day Binge Drinking	2017	During the past 30 days, on how many days did you have 4 or more drinks of alcohol in a row, that is,	Categorical: 0 days, 1 day, 2 days, 3 to 5 days, 6 to 9 days, 10 to 19 days, 20 or more days

		within a couple of hours (if you are female) or 5 or more drinks of alcohol in a row, that is, within a couple of hours (if you are male)?	
Past 30 Day Cannabis Use	1991	During the past 30 days, how many times did you use marijuana?	Categorical: 0 times, 1 or 2 times, 3 to 9 times, 10 to 19 times, 20 to 39 times, 40 or more times
Past 30 Day Electronic Vapor Product Use	2015	During the past 30 days, on how many days did you use an electronic vapor product?	Categorical: 0 days, 1 or 2 days, 3 to 5 days, 6 to 9 days, 10 to 19 days, 20 to 29 days, all 30 days
Lifetime Prescription Pain Medicine Misuse	2017	During your life, how many times have you taken prescription pain medicine without a doctor's prescription or differently than how a doctor told you to use it?	Categorical: 0 times, 1 or 2 times, 3 to 9 times, 10 to 19 times, 20 to 39 times, 40 or more times
Covariates			
Race/Ethnicity (7 level indicator from 2019 YRBS combined national dataset)	1991	Are you Hispanic or Latino? AND What is your race? (Select one or more responses.)	Categorical: American Indian/Alaska Native, Asian, Black or African American, Hispanic/Latino, Native Hawaiian/Other Pacific Islander, White, Multiple Races (Non-Hispanic)
Sex	1991	What is your sex?	Categorical: Male, Female
Sexual Identity	2015	Which of the following best describes you?	Categorical: Heterosexual (straight), Gay or Lesbian, Bisexual, Not Sure
Age	1991	How old are you?	Categorical: 12 years old or younger, 13 years old, 14 years old, 15 years old, 16 years

	old, 17 years old, 18 years old or older

Appendix Table 3.2: Adjusted Odds Ratios for Associations Between Past 12 Month Depressive Symptoms and Substance Use Over Time

Year	aOR	Lower 95% CI	Upper 95% CI	p value
Any Past 30 Day Alcohol Use				
1999	1.66	1.37	2.00	<0.001
2001	2.10	1.89	2.33	<0.001
2003	2.09	1.85	2.37	<0.001
2005	1.93	1.76	2.13	<0.001
2007	2.00	1.78	2.25	<0.001
2009	2.02	1.84	2.22	<0.001
2011	2.22	2.04	2.43	<0.001
2013	2.11	1.86	2.41	<0.001
2015	2.03	1.75	2.36	<0.001
2017	2.11	1.83	2.44	<0.001
2019	1.97	1.77	2.18	<0.001
Any Past 30 Day Binge Drinking				
2017	2.07	1.76	2.43	<0.001
2019	1.99	1.68	2.37	<0.001
Any Past 30 Day Cannabis Use				
1999	1.52	1.29	1.79	<0.001
2001	2.10	1.87	2.35	<0.001
2003	2.28	1.99	2.61	<0.001
2005	1.88	1.66	2.14	<0.001
2007	2.12	1.83	2.45	<0.001
2009	1.95	1.68	2.27	<0.001
2011	2.00	1.75	2.28	<0.001
2013	2.10	1.86	2.37	<0.001
2015	2.31	2.02	2.64	<0.001

2017	2.65	2.26	3.12	<0.001
2019	2.16	1.89	2.47	<0.001
Any Past 30 Day Electronic Vapor Product Use				
2015	2.20	1.94	2.49	<0.001
2017	2.27	1.82	2.85	<0.001
2019	2.22	1.98	2.48	<0.001
Any Lifetime Prescription Pain Medicine Misuse				
2017	3.28	2.75	3.92	<0.001
2019	3.01	2.68	3.40	<0.001

Notes: Weighted logistic regression models adjusted for sex, age, and race/ethnicity. All substance use measures are for past 30 day ever use, except prescription pain medicine which is lifetime ever use.
Abbreviations: aOR = adjusted odds ratio, CI = confidence interval

Appendix Table 3.3: Adjusted Odds Ratios for Associations Between Past 12 Month Having Seriously Considered Suicide and Substance Use Over Time

Year	aOR	Lower 95% CI	Upper 95% CI	p value
Any Past 30 Day Alcohol Use				
1991	2.01	1.76	2.30	<0.001
1993	1.98	1.71	2.30	<0.001
1995	2.03	1.60	2.58	<0.001
1997	2.32	1.87	2.87	<0.001
1999	2.07	1.83	2.34	<0.001
2001	2.26	1.99	2.58	<0.001
2003	2.23	1.90	2.62	<0.001
2005	2.23	1.97	2.52	<0.001
2007	2.56	2.25	2.92	<0.001
2009	1.99	1.72	2.30	<0.001
2011	2.53	2.20	2.92	<0.001
2013	2.39	2.00	2.85	<0.001
2015	2.39	2.05	2.8	<0.001
2017	1.85	1.62	2.12	<0.001
2019	2.13	1.83	2.46	<0.001
Past 30 Day Any Binge Drinking				
2017	1.96	1.69	2.26	<0.001
2019	1.98	1.65	2.37	<0.001
Past 30 Day Any Cannabis Use				
1991	2.39	1.93	2.95	<0.001
1993	2.28	1.86	2.79	<0.001
1995	2.10	1.74	2.53	<0.001
1997	2.27	1.95	2.64	<0.001
1999	2.27	1.94	2.64	<0.001

2001	2.44	2.09	2.85	<0.001
2003	2.76	2.42	3.15	<0.001
2005	2.07	1.82	2.34	<0.001
2007	2.49	2.13	2.90	<0.001
2009	2.18	1.85	2.57	<0.001
2011	2.48	2.16	2.85	<0.001
2013	2.57	2.24	2.95	<0.001
2015	2.12	1.81	2.47	<0.001
2017	2.52	2.16	2.94	<0.001
2019	2.55	2.18	2.98	<0.001
Past 30 Day Any Electronic Vapor Product Use				
2015	2.12	1.85	2.42	<0.001
2017	2.19	1.78	2.69	<0.001
2019	2.28	2.00	2.59	<0.001
Lifetime Any Prescription Pain Medicine Misuse				
2017	3.50	3.01	4.05	<0.001
2019	3.76	3.22	4.39	<0.001

Notes: Weighted logistic regression models adjusted for sex, age, and race/ethnicity. All substance use measures are for past 30 day ever use, except prescription pain medicine which is lifetime ever use.
Abbreviations: aOR = adjusted odds ratio, CI = confidence interval

Appendix Table 3.4: Adjusted Odds Ratios for Associations Between Past 12 Month Having Made a Suicide Plan and Substance Use Over Time

Year	aOR	Lower 95% CI	Upper 95% CI	p value
Any Past 30 Day Alcohol Use				
1991	2.01	1.72	2.35	<0.001
1993	2.28	2.01	2.57	<0.001
1995	2.13	1.60	2.84	<0.001
1997	2.34	1.94	2.82	<0.001
1999	2.01	1.59	2.54	<0.001
2001	2.46	2.13	2.83	<0.001
2003	1.92	1.48	2.49	<0.001
2005	2.13	1.85	2.46	<0.001
2007	2.34	2.03	2.69	<0.001
2009	2.06	1.79	2.38	<0.001
2011	2.31	2.06	2.59	<0.001
2013	2.25	1.92	2.64	<0.001
2015	2.35	2.05	2.69	<0.001
2017	2.05	1.77	2.38	<0.001
2019	2.04	1.69	2.46	<0.001
Past 30 Day Any Binge Drinking				
2017	2.19	1.88	2.55	<0.001
2019	1.96	1.56	2.47	<0.001
Past 30 Day Any Cannabis Use				
1991	2.23	1.78	2.79	<0.001
1993	2.29	1.89	2.77	<0.001
1995	2.36	1.87	2.99	<0.001
1997	2.59	2.17	3.10	<0.001
1999	2.24	1.81	2.78	<0.001

2001	2.28	2.02	2.57	<0.001
2003	2.00	1.32	3.04	0.002
2005	2.01	1.71	2.36	<0.001
2007	2.46	2.01	3.01	<0.001
2009	2.13	1.85	2.46	<0.001
2011	2.36	2.04	2.74	<0.001
2013	2.54	2.19	2.94	<0.001
2015	2.30	1.95	2.71	<0.001
2017	2.61	2.14	3.19	<0.001
2019	2.39	2.03	2.80	<0.001
Past 30 Day Any Electronic Vapor Product Use				
2015	2.37	2.02	2.78	<0.001
2017	2.22	1.77	2.78	<0.001
2019	2.14	1.83	2.51	<0.001
Lifetime Any Prescription Pain Medicine Misuse				
2017	3.57	2.99	4.27	<0.001
2019	3.71	3.10	4.43	<0.001

Notes: Weighted logistic regression models adjusted for sex, age, and race/ethnicity. All substance use measures are for past 30 day ever use, except prescription pain medicine which is lifetime ever use.
Abbreviations: aOR = adjusted odds ratio, CI = confidence interval

Appendix Table 3.5: Adjusted Odds Ratios for Associations Between Past 12 Month Suicide Attempts and Substance Use Over Time

Year	aOR	Lower 95% CI	Upper 95% CI	p value
Any Past 30 Day Alcohol Use				
1991	1.55	1.34	1.80	<0.001
1993	1.53	1.40	1.66	<0.001
1995	1.94	1.57	2.40	<0.001
1997	1.83	1.56	2.15	<0.001
1999	1.62	1.35	1.94	<0.001
2001	1.69	1.50	1.91	<0.001
2003	1.80	1.59	2.04	<0.001
2005	1.70	1.46	1.98	<0.001
2007	2.07	1.76	2.42	<0.001
2009	1.86	1.68	2.07	<0.001
2011	1.88	1.66	2.13	<0.001
2013	1.77	1.57	1.98	<0.001
2015	1.80	1.6	2.02	<0.001
2017	1.53	1.32	1.79	<0.001
2019	1.60	1.41	1.82	<0.001
Past 30 Day Any Binge Drinking				
2017	1.82	1.57	2.10	<0.001
2019	1.61	1.38	1.87	<0.001
Past 30 Day Any Cannabis Use				
1991	1.80	1.57	2.07	<0.001
1993	1.61	1.40	1.84	<0.001
1995	1.86	1.58	2.20	<0.001
1997	1.95	1.71	2.23	<0.001
1999	1.80	1.54	2.10	<0.001

2001	1.70	1.55	1.86	<0.001
2003	1.97	1.77	2.19	<0.001
2005	1.66	1.46	1.89	<0.001
2007	1.96	1.77	2.18	<0.001
2009	1.78	1.62	1.95	<0.001
2011	1.95	1.75	2.18	<0.001
2013	1.95	1.73	2.19	<0.001
2015	1.76	1.58	1.97	<0.001
2017	1.94	1.68	2.24	<0.001
2019	1.74	1.54	1.98	<0.001
Past 30 Day Any Electronic Vapor Product Use				
2015	1.66	1.51	1.83	<0.001
2017	1.79	1.59	2.01	<0.001
2019	1.63	1.45	1.82	<0.001
Lifetime Any Prescription Pain Medicine Misuse				
2017	2.06	1.82	2.34	<0.001
2019	2.17	1.95	2.42	<0.001

Notes: Weighted logistic regression models adjusted for sex, age, and race/ethnicity. All substance use measures are for past 30 day ever use, except prescription pain medicine which is lifetime ever use. Suicide attempts coded as 0 = 0, 1 = 1, 2 = 2-3, 3 = 4-5, 4 = 6+.
Abbreviations: aOR = adjusted odds ratio, CI = confidence interval

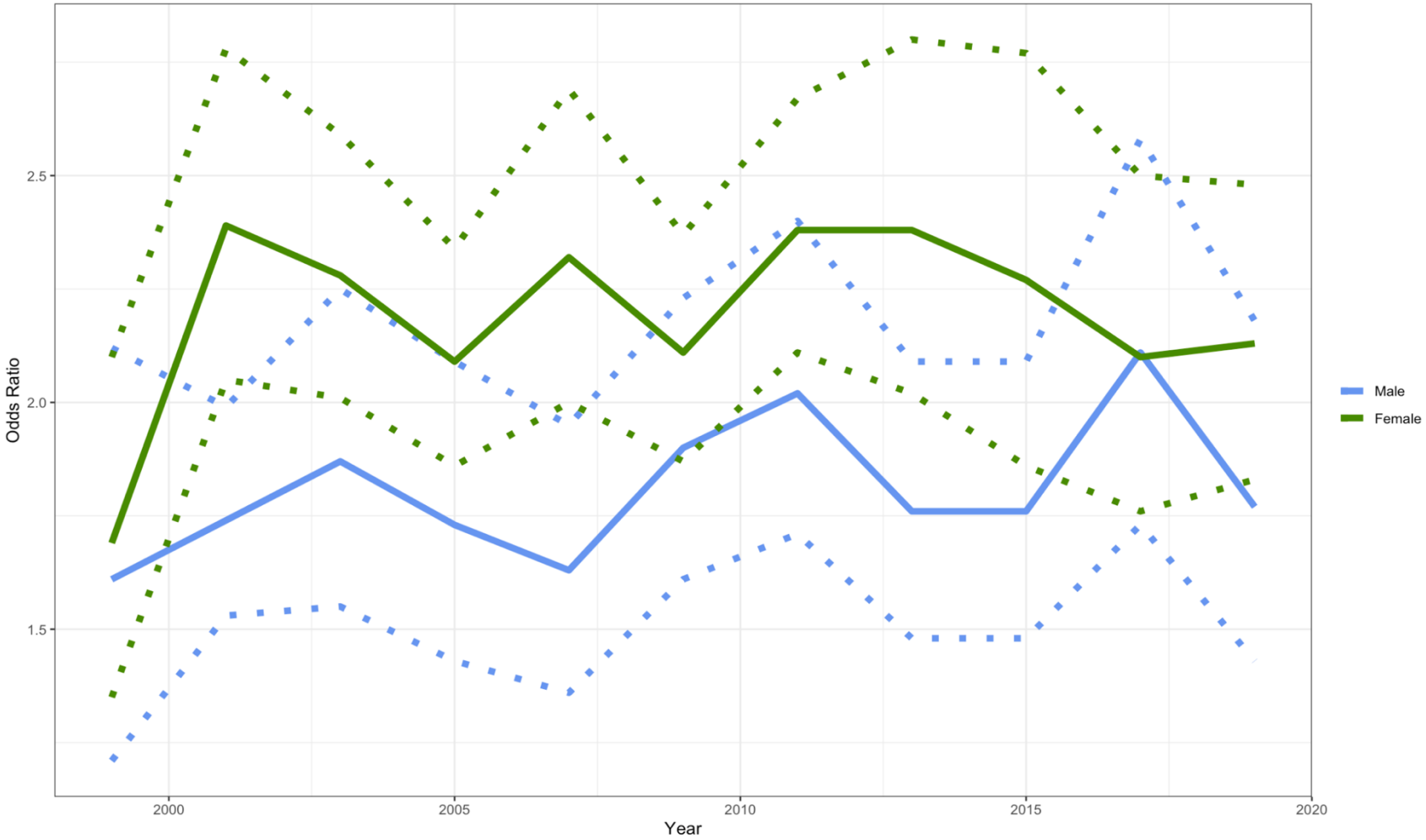
Appendix Table 3.6: Adjusted Odds Ratios for Associations Between Past 12 Month Injurious Suicide Attempts and Substance Use Over Time

Year	aOR	Lower 95% CI	Upper 95% CI	p value
Any Past 30 Day Alcohol Use				
1991	2.52	1.17	5.44	0.02
1993	2.10	1.41	3.11	<0.001
1995	3.43	1.78	6.62	<0.001
1997	2.38	1.42	3.99	0.001
1999	2.38	1.28	4.43	0.007
2001	2.37	1.61	3.49	<0.001
2003	1.24	0.70	2.21	0.4
2005	1.93	1.25	2.97	0.004
2007	2.72	1.74	4.27	<0.001
2009	3.19	2.03	4.99	<0.001
2011	1.89	1.16	3.06	0.011
2013	1.86	1.33	2.6	<0.001
2015	1.62	1.05	2.49	0.029
2017	2.00	1.36	2.95	<0.001
2019	1.81	1.09	2.99	0.023
Past 30 Day Any Binge Drinking				
2017	2.46	1.67	3.62	<0.001
2019	1.93	1.30	2.87	0.002
Past 30 Day Any Cannabis Use				
1991	2.57	1.42	4.64	0.003
1993	1.86	1.31	2.63	<0.001
1995	4.53	2.64	7.79	<0.001
1997	2.23	1.39	3.55	0.001
1999	2.44	1.52	3.92	<0.001

2001	2.02	1.31	3.13	0.002
2003	2.68	1.85	3.86	<0.001
2005	2.84	1.83	4.41	<0.001
2007	2.03	1.42	2.89	<0.001
2009	2.63	1.81	3.82	<0.001
2011	2.06	1.35	3.16	0.001
2013	1.63	1.16	2.30	0.006
2015	1.63	1.05	2.53	0.031
2017	1.81	1.25	2.63	0.003
2019	1.91	1.18	3.08	0.01
Past 30 Day Any Electronic Vapor Product Use				
2015	1.63	1.08	2.49	0.023
2017	2.59	1.64	4.09	<0.001
2019	1.72	0.98	3.03	0.058
Lifetime Any Prescription Pain Medicine Misuse				
2017	1.92	1.43	2.57	<0.001
2019	2.72	1.76	4.19	<0.001

Notes: Weighted logistic regression models adjusted for sex, age, and race/ethnicity. All substance use measures are for past 30 day ever use, except prescription pain medicine which is lifetime ever use.
Abbreviations: aOR = adjusted odds ratio, CI = confidence interval

Appendix Figure 3.1: Sex-Stratified Adjusted Odds Ratios for the Association Between Past 12 Month Depressive Symptoms and Past 30 Day Ever Alcohol Use Over Time

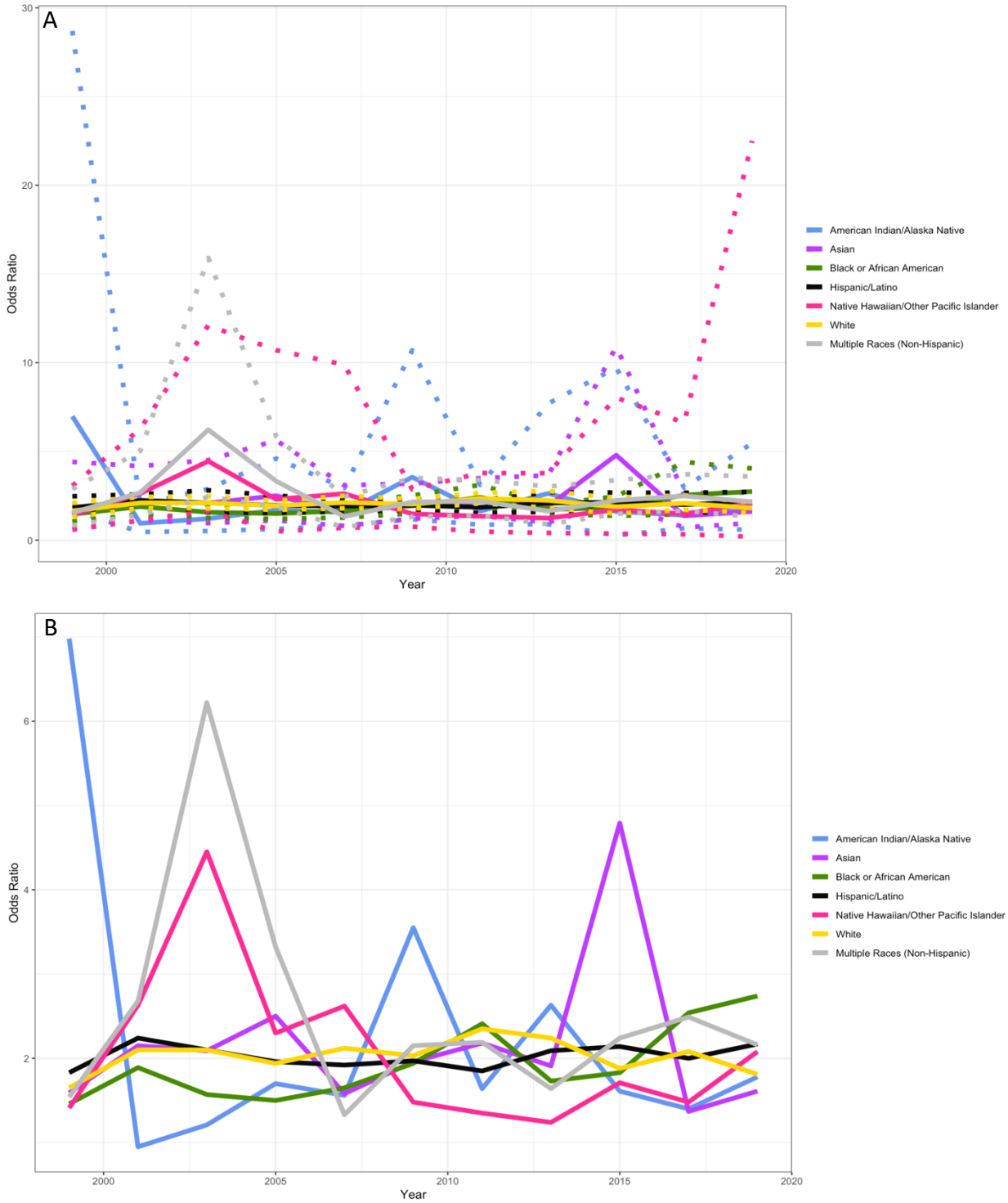


Notes: Weighted logistic regression models adjusted for age and race/ethnicity. Solid lines represent adjusted odds ratios and dotted lines represent 95% confidence intervals.

Appendix Figure 3.2: Sex-Stratified Adjusted Odds Ratios for the Association Between Past 12 Month Depressive Symptoms and Past 30 Day Ever Cannabis Use Over Time

Notes: Weighted logistic regression models adjusted for age and race/ethnicity. Solid lines represent adjusted odds ratios and dotted lines represent 95% confidence intervals.

Appendix Figure 3.3: Race/Ethnicity-Stratified Adjusted Odds Ratios for the Association Between Past 12 Month Depressive Symptoms and Past 30 Day Ever Alcohol Use Over Time

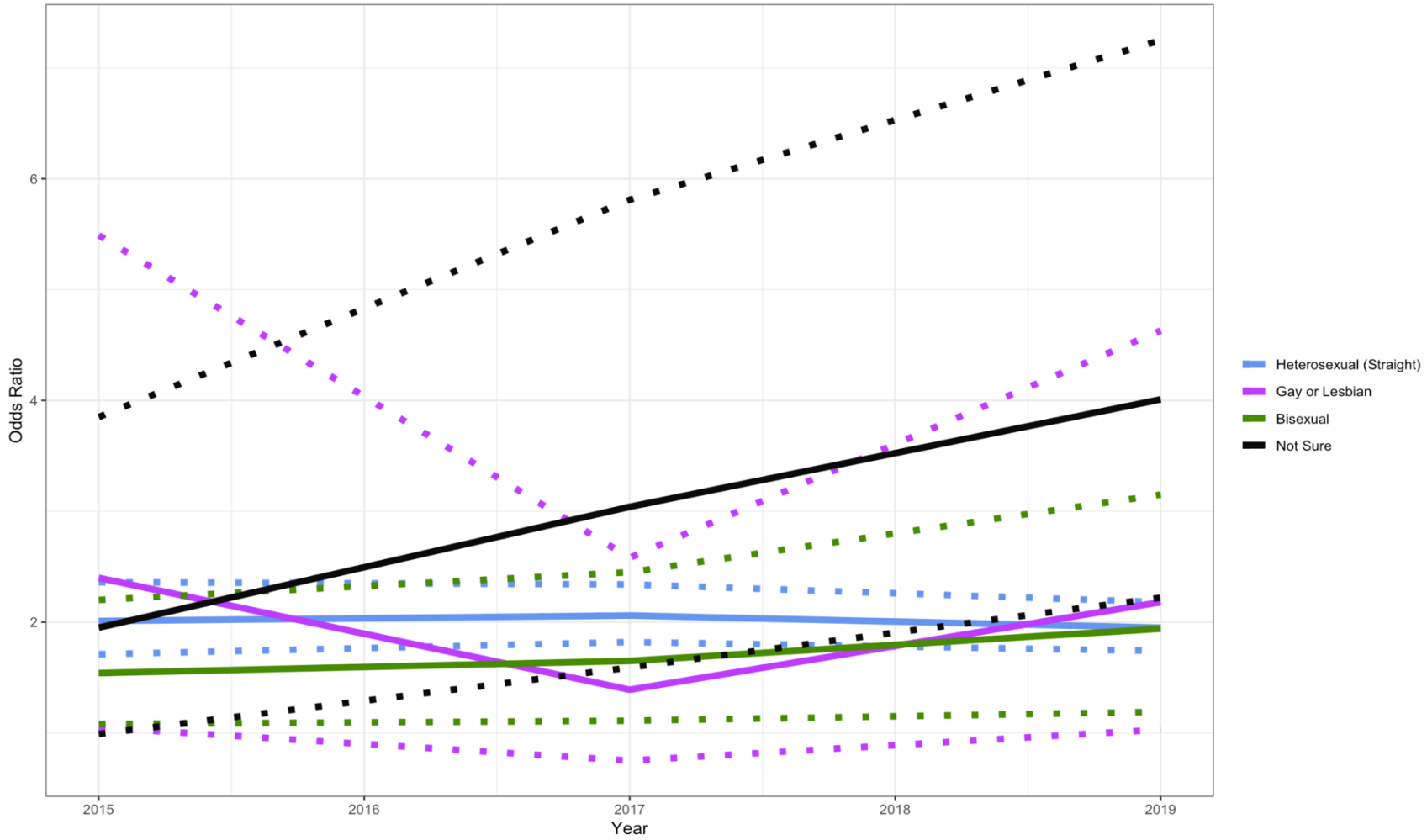


Notes: Weighted logistic regression models adjusted for age and sex. Solid lines represent adjusted odds ratios and dotted lines represent 95% confidence intervals. Panel A presents adjusted odds ratios and 95% confidence intervals. Panel B presents only adjusted odds ratios to better visualize effect size given the wide range in 95% confidence intervals.

Appendix Figure 3.4: Race/Ethnicity-Stratified Adjusted Odds Ratios for the Association Between Past 12 Month Depressive Symptoms and Past 30 Day Ever Cannabis Use Over Time

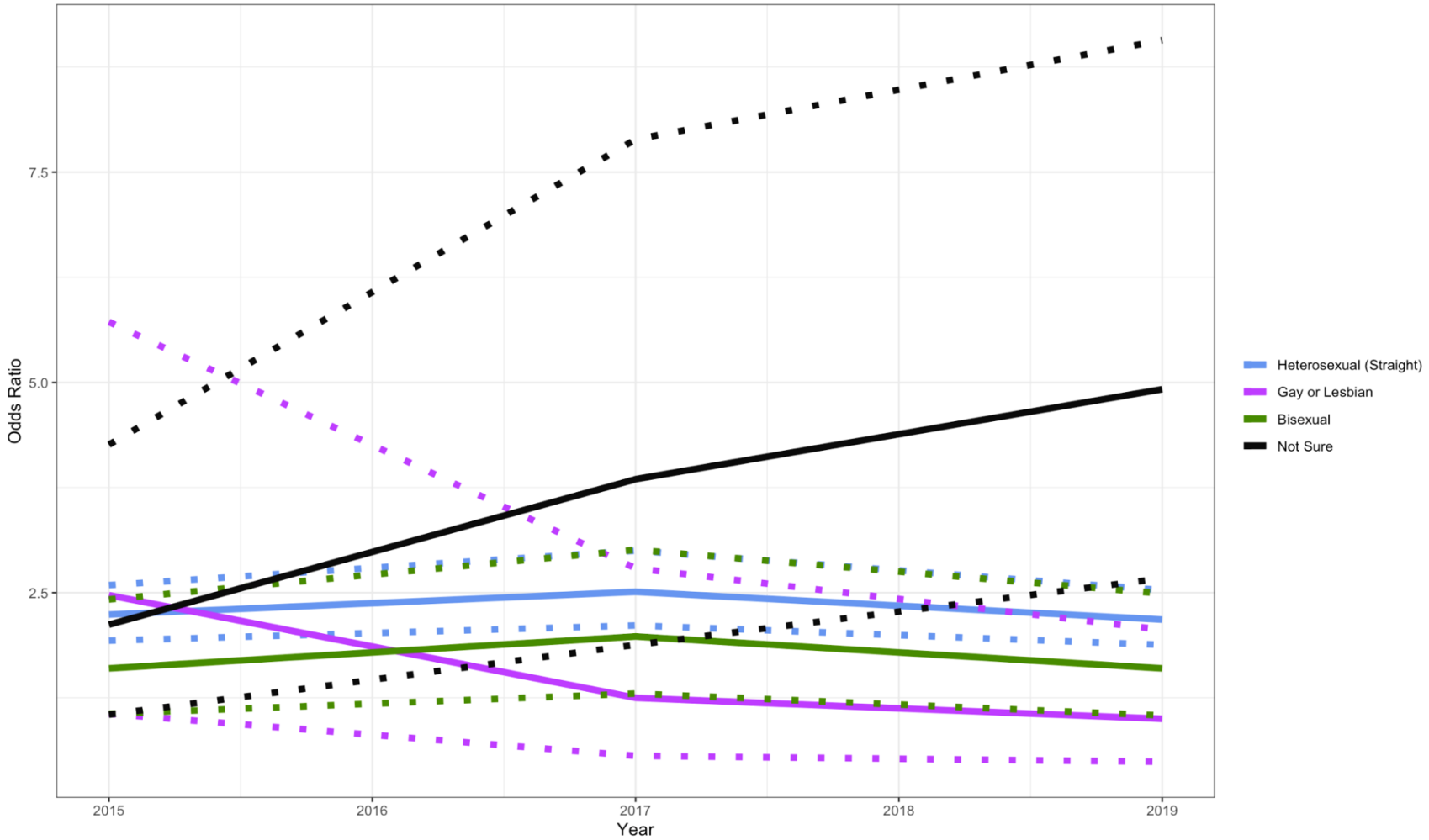
Notes: Weighted logistic regression models adjusted for age and sex. Solid lines represent adjusted odds ratios and dotted lines represent 95% confidence intervals. Panel A presents adjusted odds ratios and 95% confidence intervals. Panel B presents only adjusted odds ratios to better visualize effect size given the wide range in 95% confidence intervals.

Appendix Figure 3.5: Sexual Identity-Stratified Adjusted Odds Ratios for the Association Between Past 12 Month Depressive Symptoms and Past 30 Day Ever Alcohol Use Over Time



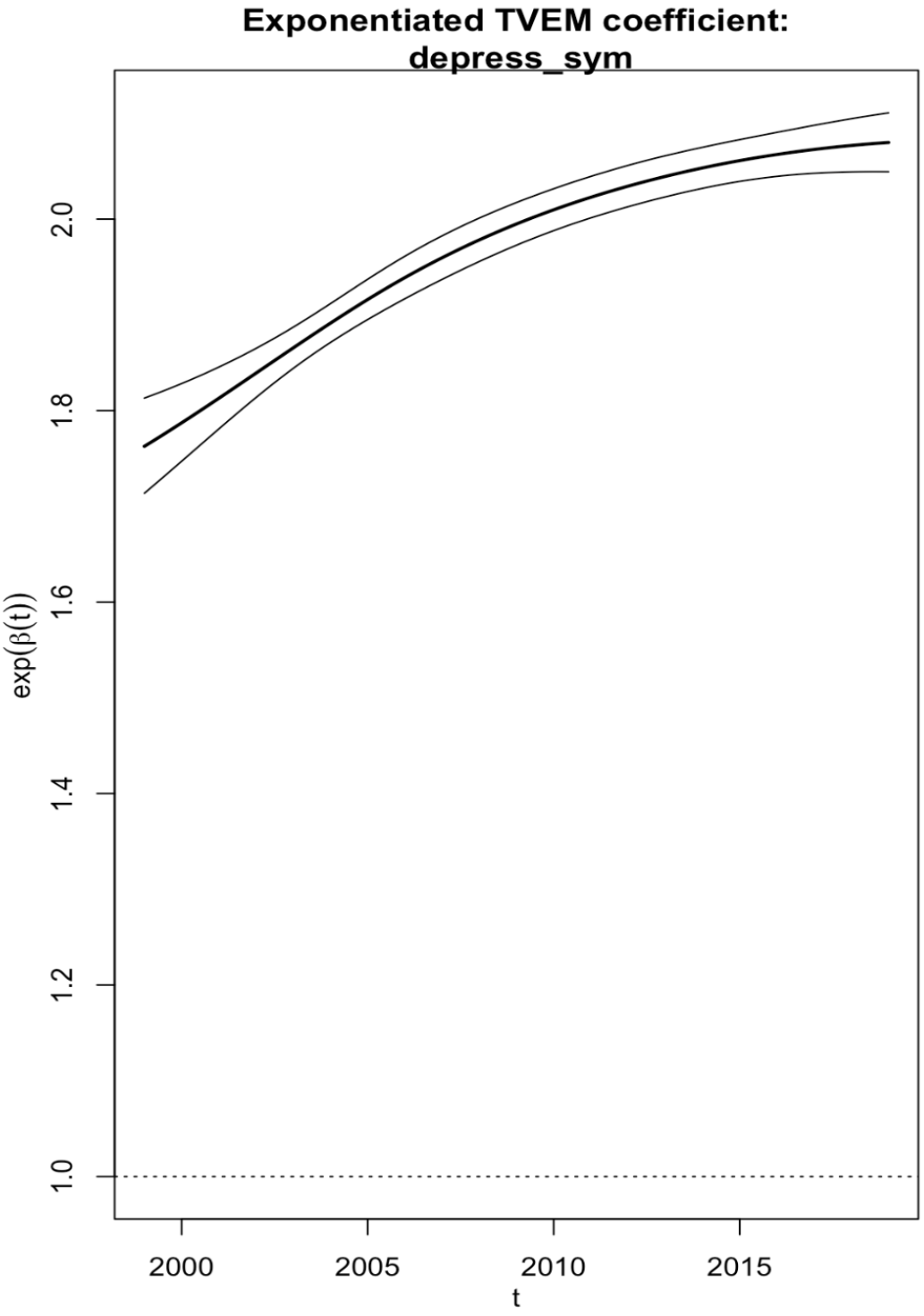
Notes: Weighted logistic regression models adjusted for sex, age, and race/ethnicity. Solid lines represent adjusted odds ratios and dotted lines represent 95% confidence intervals.

Appendix Figure 3.6: Sexual Identity-Stratified Adjusted Odds Ratios for the Association Between Past 12 Month Depressive Symptoms and Past 30 Day Ever Cannabis Use Over Time

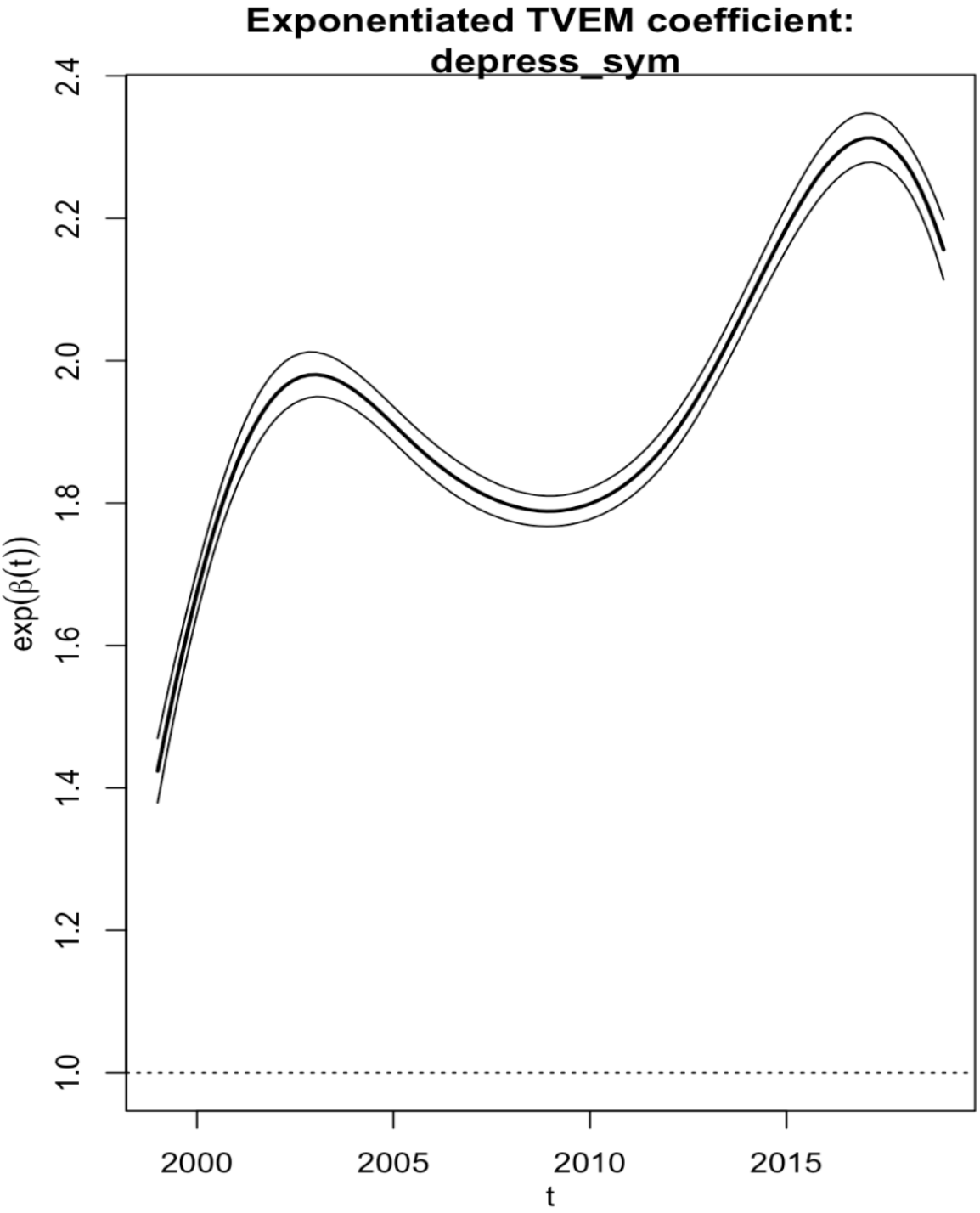


Notes: Weighted logistic regression models adjusted for sex, age, and race/ethnicity. Solid lines represent adjusted odds ratios and dotted lines represent 95% confidence intervals.

Appendix Figure 3.7: Exploratory TVEM Displaying Unadjusted, Weighted Odds Ratios for the Association Between Past 12 Depressive Symptoms and Past 30 Day Ever Alcohol Use Over Time



Appendix Figure 3.8: Exploratory TVEM Displaying Unadjusted, Weighted Odds Ratios for the Association Between Past 12 Depressive Symptoms and Past 30 Day Ever Cannabis Use Over Time



Chapter 4. Cross-sectional Relationships between the Experience of Being Bullied, Depressive Symptoms, and Substance Use in 2019

4.1 Abstract

Purpose: The experience of having been bullied and substance use are common among adolescents in the United States. Existing evidence indicates that adolescents who report that they have been bullied are more likely to engage in substance use. Depressive symptoms may mediate this association. Given contemporary increases in adolescent internet use representing potential new venues for bullying, increases in depressive symptoms, and changes in adolescent substance use, examining relationships between the experience of having been bullied, depressive symptoms, and substance use is warranted.

Methods: We utilized 2019 Youth Risk Behavior Survey Data (from 13,677 participants) to assess the cross-sectional associations between having been bullied (at school or electronically) in the past 12 months and ever substance use (alcohol, binge drinking, cannabis, electronic vapor product, and prescription pain medicine) in the past 30 days. We ran unadjusted, partially adjusted (including sex, race/ethnicity, sexual identity, and age), and fully adjusted (additionally including other substance use) multivariable logistic regression models and applied appropriate survey weights. We assessed for interaction between the experience of being bullied and demographic factors (racial/ethnic identity, sex, and sexual identity) using Rao-Scott likelihood ratio tests. In addition, we assessed the role of depressive symptoms as mediators of these associations using Poisson structural equation models. We assessed for statistical significance at a two-sided p-value < 0.01.

Results: Among respondents, 19.3% and 15.5% (of the weighted sample) reported being bullied at school and electronically, respectively. The most prevalent form of substance use was electronic vapor product use (30.9%), followed by alcohol use (27.0%), cannabis use (21.1%), binge drinking (12.4%), and prescription pain medicine misuse (5.5%). In fully adjusted models, we observed statistically significant associations of being bullied at school in the past 12 months with any past 30 day use of electronic vapor products (aOR: 1.49; 95% CI: 1.21, 1.84; $p < 0.001$) and prescription pain medicine misuse (aOR: 2.10; 95% CI: 1.72, 2.55; $p < 0.001$). We did not find associations of being bullied at school in the past 12 months with alcohol use (aOR: 1.03; 95% CI: 0.86, 1.24; $p = 0.7$), binge drinking (aOR: 0.89; 95% CI: 0.73, 1.09; $p = 0.2$), or cannabis use (aOR: 0.97; 95% CI: 0.82, 1.15; $p = 0.7$). Similar patterns in results were observed when considering being bullied electronically. Associations between past 12 month experience of being bullied electronically and any past 30 day any electronic vapor product use (aOR: 1.89; 95% CI: 1.55, 2.31; $p < 0.001$) and prescription pain medicine misuse (aOR: 1.99; 95% CI: 1.48, 2.67; $p < 0.001$) were statistically significant after full adjustment, while no statistically significant associations were present for alcohol use (aOR: 1.27; 95% CI: 1.03, 1.55; $p = 0.025$), binge drinking (aOR: 1.16; 95% CI: 0.94, 1.44; $p = 0.2$), or cannabis use (aOR: 1.07; 95% CI: 0.88, 1.28; $p = 0.5$). We did not observe statistically significant evidence for effect modification for any of these associations by demographic factors. In mediation analyses, statistically significant indirect effects for the association of the experience of being bullied with substance use through depressive symptoms were observed for all types of experience of being bullied and substance use combinations (p-value range: < 0.001 to 0.006) except for having been bullied electronically in the past 12 months and any binge drinking in the past 30 days ($p = 0.031$).

Conclusions: We identified that the experience of having been bullied in the past 12 months at school was associated with any use of electronic vapor product use in the past 30 days and prescription pain medicine misuse in the past 30 days in fully adjusted models. Similarly, the experience of having been bullied at school in the past 12 months was associated with any use of electronic vapor product use in the past 30 days and prescription pain medicine misuse in the past 30 days. Our findings may inform priority areas for intervention following bullying victimization.

4.2 Introduction

The experience of having been bullied is common among adolescents in the United States. In 2019, 15.7% of adolescents reported being bullied electronically and 19.5% of adolescents reported being bullied on school property in the past year (1). Experiencing bullying is associated with a number of undesirable outcomes including poor mental health, sexual behavior problems, and somatic health symptoms (2). Additionally, adolescents who report that they have been bullied are more likely to engage in substance use (3–5). These observed associations seem to translate to electronic vapor product use, which is a relatively new public health issue for adolescents (6–9). Adolescent substance use is also a substantial public health issue. Estimates from the 2021 Monitoring the Future survey indicate that that more than half (54.1%) of twelfth graders have used alcohol in their lifetime, and nearly half have used cannabis (38.6%) or tried some form of vaping (40.5%) (10).

Associations between the experience of having been bullied and substance use among adolescents can be explained through stress (precipitated by being bullied) (11) and subsequent

maladaptive coping via the self-medication hypothesis (12) and the reformulated negative reinforcement model (13,14). As delineated by Hong et al., the association between the experience of being bullied and substance use can be mediated by a variety of factors including stress, internalizing problems, poor academic performance, and school absenteeism (15). The conceptualization of depressive symptoms as a mediator for this association is supported in the literature (4,15,16).

For adolescents, the context of both bullying and substance use are changing. Internet use, social media use, and texting have increased rapidly in the past few decades (17). Per 2018 estimates from Pew Research Center, 95% of adolescents have access to a smartphone and 45% of adolescents use the internet "almost constantly" (18). This represents a seismic change in the landscape of adolescent social lives, including avenues for bullying. The legal and societal contexts for substance use are also shifting. Cannabis use state laws are changing (19) and new products are entering the market and becoming increasingly popular (e.g., electronic vapor products) (20). Further, there is evidence of potential changes in the associations between binge drinking and depressive symptoms among adolescents over time (21) as well as increases over time in coping as an adolescent-reported reason for cannabis use (22). With these ongoing changes in mind, the current study was motivated to assess associations in the present adolescent context of media use, bullying, and mood disorders.

We analyzed associations of having been bullied in school and electronically with substance use (i.e., alcohol use, binge drinking, cannabis use, electronic vapor product use, and prescription pain medicine misuse) in a recent, nationally representative sample of adolescents. Given the known differences in prevalence of bullying victimization (23–25) and substance use

(26) by demographic factors, we also assessed the role of race/ethnicity, sex, and sexual identity in these associations. Finally, we assessed for mediation of these associations by depressive symptoms. Our hope is that study findings can inform design and implementation of adolescent health programs and policies, as well as prioritization of resources.

4.3 Methods

Study Setting

We used the 2019 National Youth Risk Behavior Survey (YRBS) data to assess the associations between the experience of having been bullied and substance use (27). The YRBS samples high school students with a three-stage cluster sampling scheme using systematic equal probability sampling with a random start (27), with primary sampling units (i.e., counties and groups of counties), secondary sampling units (i.e., schools with grades nine through 12), and a third sampling stage (i.e. classrooms for a required subject or class period) (28). All of the students in a selected class could participate and there was no replacement of sampling units for refusal to participate. In total, 181 schools were sampled and 136 schools ultimately participated; 17,025 students were sampled, 13,872 submitted questionnaires, and 13,677 questionnaires were usable after data quality check for consistency and plausibility (27). The overall response percentage, calculated as school response rate multiplied by the student response rate, was 60.3%.

Sampling weights were generated for each participant which accounted for student and school nonresponse and oversampling of Black and Hispanic students (27). Weights were scaled to the total sample size and the weighted proportions of students within grades nine through

12 were matched to that of the projected proportions for grades nine through 12. The weighted national 2019 YRBS sample was intended to be a nationally representative sample of public and private high school students in grades nine to 12 in the United States.

Protocol and procedures for the 2019 YRBS was approved by the Center for Disease Control and Prevention's Institutional Review Board (28). Prior to administration of the survey to students, local parental permission guidelines were followed. Students participated anonymously. National 2019 YRBS data are publicly available for download (29). These analysis activities were reviewed by the University of Washington Human Subjects Division and deemed to not involve human subjects.

Analytic Variables

We assessed the associations between the experience of being bullied in the past 12 months (independent variables) and substance use (i.e., alcohol use, binge drinking, cannabis use, electronic vapor product use, and prescription pain medicine misuse) in the past 30 days (dependent variables). The experience of being bullied (binary variable) was assessed in the past 12 months with questions specifying two locations: on school property and electronically. Past 30 day substance use was assessed for either the number of times (cannabis use and prescription pain medicine misuse) or number of days (alcohol use, binge drinking, and electronic vapor product misuse) in the 2019 YRBS questionnaire. We transformed these substance use variables for analysis to be binary (e.g., did not use cannabis in the past 30 days versus did use cannabis in the past 30 days).

Our analyses also considered demographic characteristics for confounding and/or effect modification. Demographic characteristics included race/ethnicity (with mutually exclusive

categories of American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, White, Hispanic/Latino, Multiple—Hispanic/Latino, Multiple—Non-Hispanic/Latino), age (with categories of 12 years old or younger, 13 years old, 14 years old, 15 years old, 16 years old, 17 years old, 18 years old or older), sex (with categories of male and female), and sexual identity (with categories of heterosexual or straight, gay or lesbian, bisexual, and not sure). We additionally considered depressive symptoms in the past 12 months as a potential mediator. Depressive symptoms were assessed with binary response options to the question "During the past 12 months, did you ever feel so sad or hopeless almost every day for two weeks or more in a row that you stopped doing some usual activities?".

In our fully adjusted analyses, we adjusted for demographic factors and other substance use, which was a combined variable for use of other substances besides the primary substance use outcome that was modeled (e.g., for models with cannabis use outcomes, ever lifetime use of cocaine, inhalants, heroin, methamphetamines, ecstasy, synthetic marijuana, steroid pills and shots, hallucinogens and injection drugs and past 30 day use of alcohol, binge drinking, electronic vapor products, and prescription pain medication misuse). See Appendix Table 4.1 for full details on the 2019 YRBS questions utilized for these analyses.

Statistical Analysis

We calculated descriptive statistics (i.e., percentages) summarizing selected characteristics of the weighted survey sample. In order to estimate the associations between past 12 month experience of being bullied and past 30 day substance use, we fit binary logistic regression models for each independent variable and dependent variable combination (e.g., past 12 month experienced being bullied at school and past 30 day binge drinking, etc.). We fit

unadjusted, partially adjusted (including race/ethnicity, sex, sexual orientation, and age), and fully adjusted (additionally including a combined variable for use of substances besides the modeled dependent variable) models. Fully adjusted models represent assessing the modeled substance use outcome above and beyond the impact of adolescent-reported use of other substances. Model results are presented as unadjusted odds ratios (ORs) and adjusted odds ratios (aORs), 95% confidence intervals (95% CIs), and p-values. We assessed for statistical significance at a two-sided p-value < 0.01 ($\alpha = 0.05/5 = 0.01$) to account for multiple hypothesis testing.

We examined interaction between the experience of being bullied and demographic factors (i.e., race/ethnicity, sex, and sexual identity) on substance use using interaction terms (e.g., having experienced being bullied electronically X sexual identity) in fully adjusted models. We assessed for statistical significance of interactions using Rao-Scott likelihood ratio tests with a two-sided p-value < 0.01 as the level of significance. As an exploratory analysis, we present the results of stratified models for independent variable and demographic factor combinations where the Rao-Scott likelihood ratio test p values were less than 0.10.

To assess for potential mediation of the association between the past 12 month experience of having been bullied and past 30 day any substance use by past 12 month depressive symptoms (Appendix Figure 4.1), we utilized Poisson generalized structural equation models. Models were adjusted for race/ethnicity, sex, sexual orientation, age, and a combined measure of any other substance use (as described above). We calculated direct effects (i.e., reflecting the pathways between the experience of having been bullied and substance use *not* through depressive symptoms), indirect effects (i.e., reflecting the pathways between the

experience of having been bullied and substance use through depressive symptoms), and total effects (i.e., the sum of the direct and indirect effects), as well as proportion mediated (i.e., indirect effect divided by total effect) (30,31) for the unexponentiated regression coefficients. We selected Poisson models as opposed to logistic regression models for mediation analyses in consideration of the limitations in computations for direct and indirect effects when logistic regression models for mediation analyses (32). Analyses were conducted in R version 3.6.2 with survey weights applied with the R *survey* package (33) for logistic regression models and in STATA/SE version 16.1 with the svy prefix to apply survey weights and using the gsem command (34,35) for mediation analyses.

4.4 Results

In the weighted sample of 13,677 participants, slightly more reported male sex (50.2%) than female (48.9%) (Table 4.1). The most common racial/ethnic group reported was White (49.6%), followed by multiple races Hispanic/Latino (16.4%), Black or African American (11.8%), Hispanic/Latino (8.9%), Asian (4.9%), multiple races non-Hispanic/Latino (4.3%), American Indian/Alaska Native (0.6%), and Native Hawaiian/Other Pacific Islander (0.3%). An additional 3.1% were missing racial/ethnic information. The sample primarily identified as heterosexual or straight (79.1%), followed by bisexual (8.2%), missing information on sexual identity (6.1%), not sure (4.2%), and gay or lesbian (2.3%). Corresponding with the high school survey setting, the vast majority of the sample was between ages 14 to 18 or older (99.0%) and in ninth through twelfth grades (99.1%).

Prevalence of the Experience of Being Bullied and Substance Use

Nearly one-fifth (19.3%) of respondents indicated that they had been bullied at school in the past 12 months (Table 4.2). Having been electronically bullied in the past 12 months was slightly less common (15.5%). The most prevalent substance use behavior in the weighted sample was electronic vapor product use with 30.9% reporting use in the past 30 days (Table 4.3). A slightly lower but similar proportion of adolescents reported any use of alcohol (27.0%), while any binge drinking in the past 30 days was less common (12.4%). Approximately one-fifth (21.1%) of adolescents indicated any use of cannabis. Finally, any use of prescription pain medicine in the past 30 days was the least prevalent (5.5%).

Associations of Being Bullied at School with Substance Use

All associations between the experience of being bullied at school and any use of substances in the past 30 days were statistically significant in unadjusted models (p-range: < 0.001 to 0.002) (Table 4.4). In partially adjusted models including race/ethnicity, sex, and sexual identity, all associations remained statistically significant (alcohol: aOR: 1.45; 95% CI: 1.25, 1.69; $p < 0.001$; cannabis: aOR: 1.38; 95% CI: 1.17, 1.63; $p < 0.001$; electronic vapor product: aOR: 1.83; 95% CI: 1.53, 2.18; $p < 0.001$; prescription pain medicine: aOR: 2.51; 95% CI: 2.04, 3.09; $p < 0.001$) with the exception of any binge drinking in the past 30 days (aOR: 1.28; 95% CI: 1.05, 1.55; $p = 0.016$), based on the multiple testing adjusted *a priori* set cutoff.

In fully adjusted models, additionally adjusting for other substance use, associations were not statistically significant for past 30 day any use of alcohol (aOR: 1.03; 95% CI: 0.86, 1.24; $p = 0.7$), binge drinking (aOR: 0.89; 95% CI: 0.73, 1.09; $p = 0.2$), and cannabis use (aOR: 0.97; 95% CI: 0.82, 1.15; $p = 0.7$). However, we observed statistically significant associations of being bullied at school in the past 12 months with past 30 day ever use of electronic vapor

products (aOR: 1.49; 95% CI: 1.21, 1.84; p < 0.001) and prescription pain medicine misuse (aOR: 2.10; 95% CI: 1.72, 2.55; p < 0.001).

Associations of Being Bullied Electronically with Substance Use

Patterns of findings were similar when being bullied electronically was the independent variable of interest. Associations between past 12 month of being bullied electronically and past 30 month substance use were all statistically significant in unadjusted models (all p-values < 0.001) and in partially adjusted models (all p-values < 0.001) (Table 4.4). After fully adjusting for covariates including race/ethnicity, sex, age, sexual identity, and other substance use, associations were no longer statistically significant for any alcohol use (aOR: 1.27; 95% CI: 1.03, 1.55; p = 0.025), any binge drinking (aOR: 1.16; 95% CI: 0.94, 1.44; p = 0.2), and any cannabis use (aOR: 1.07; 95% CI: 0.88, 1.28; p = 0.5) in the past 30 days. However, associations between past 12 month experience of being bullied electronically and past 30 day ever electronic vapor product use (aOR: 1.89; 95% CI: 1.55, 2.31; p < 0.001) and past 30 day ever prescription pain medicine misuse (aOR: 1.99; 95% CI: 1.48, 2.67; p < 0.001) were statistically significant after full adjustment.

Experience of Being Bullied and Demographic Factor Interactions

At the $\alpha = 0.01$ level, we identified no statistically significant interactions between the experience of being bullied either at school or electronically in the past 12 months and demographic factors (i.e., sex, race/ethnicity, and sexual identity) for past 30 day any use of substances outcomes (Table 4.5). In exploratory analyses of stratified models for which Rao-Scott likelihood ratio test p values were less than 0.1, some differences across groups were observed. We observed sex-specific differences in associations of past 12 month being bullied

at school with past 30 day ever binge drinking (females: aOR: 0.75; 95% CI: 0.60, 0.94; p = 0.017; males: aOR: 1.18; 95% CI: 0.80, 1.75; p = 0.4), past 12 month being bullied at school and past 30 day ever cannabis use (females: aOR: 1.12, 95% CI: 0.84, 1.48; p = 0.4; males: aOR: 0.83; 95% CI: 0.67, 1.03; p = 0.090), and past 12 month being bullied electronically and past 30 day ever cannabis use (females: aOR: 1.23, 95% CI: 0.95, 1.95; p = 0.11; males: aOR: 0.89; 95% CI: 0.69, 1.14; p = 0.3) (Appendix Table 4.2).

While stratified analyses for the association between past 12 month being bullied electronically and past 30 day ever binge drinking by race/ethnicity were limited substantially by small group sizes, our findings suggested particularly strong positive associations for American Indian/Alaska Native adolescents (aOR: 5.98, 95% CI: 0.78, 46.0; p = 0.079), Black or African American adolescents (aOR: 3.15; 95% CI: 1.29, 7.68; p = 0.014), Asian adolescents (aOR: 2.62; 95% CI: 0.81, 9.45; p = 0.10), and non-Hispanic multiracial adolescents (aOR: 2.48; 95% CI: 0.89, 6.92; p = 0.080) (Appendix Table 4.3). In contrast, associations appeared to be inverse for Hispanic/Latino adolescents (aOR: 0.81; 95% CI: 0.25, 2.67; p = 0.7) and White adolescents (aOR: 0.95; 95% CI: 0.69, 1.31; p = 0.7).

Assessment of Mediation of Associations of Being Bullied with Substance Use by Depressive Symptoms

Past 12 month depressive symptoms, considered as a mediator in our analyses, were endorsed by more than one-third of the weighted sample (36.2%) (Table 4.6). Mediation analyses using fully adjusted Poisson structural equation models indicated that the indirect effect mediated through depressive symptoms was statistically significant for the pathway leading from being bullied at school in the past 12 months to past 30 day any alcohol use (p =

0.001), binge drinking (p = 0.005), cannabis use (p < 0.001), electronic vapor product use (p < 0.001), and prescription pain medicine misuse (p < 0.001) (Table 4.7). For the experience of having been bullied at school, the absolute value of the proportion mediated by depressive symptoms was larger than one for past 30 day any alcohol use (proportion mediated = 1.25), binge drinking (proportion mediated = -3.83), and cannabis use (proportion mediated = 2.65). Notably, for these proportion mediated values for which the absolute value was greater than one, the absolute value of the indirect effect was greater than the absolute value of the total effect, and the direct effects were negative and not statistically significant while the indirect effects were positive and statistically significant, suggesting inconsistent mediation (36). For past 30 day any electronic vapor product use and prescription pain medicine misuse, the proportion mediated was less than half (electronic vapor product = 0.42; prescription pain medicine = 0.46).

Assessment of mediation by past 12 month depressive symptoms of the association between past 12 month being bullied electronically and past 30 day substance use indicated significant indirect effects for any alcohol use (p = 0.006), cannabis use (p < 0.001), electronic vapor product use (p < 0.001), and prescription pain medicine misuse (p < 0.001), but not for binge drinking (p = 0.031). Proportions mediated were less than one for alcohol use (proportion mediated = 0.40), binge drinking (proportion mediated = 0.55), electronic vapor product use (proportion mediated = 0.42), and prescription pain medicine misuse (0.46), while the proportion mediated was greater than one for cannabis use (proportion mediated = 1.13).

4.5 Discussion

We sought to characterize associations between the experience of having been bullied and substance use in a recent and representative sample of adolescents. We identified that the experience of having been bullied in the past 12 months at school was associated with any use of electronic vapor product use in the past 30 days (aOR: 1.49; 95% CI: 1.21, 1.84; $p < 0.001$) and prescription pain medicine misuse in the past 30 days (aOR: 2.10; 95% CI: 1.72, 2.55; $p < 0.001$) in fully adjusted models including adjustment for sex, race/ethnicity, sexual identity, age, and other forms of substance use. Similarly, the experience of having been bullied at school in the past 12 months was associated with any use of electronic vapor product use in the past 30 days (aOR: 1.89; 95% CI: 1.55, 2.31; $p < 0.001$) and prescription pain medicine misuse in the past 30 days (aOR: 1.99; 95% CI: 1.48, 2.67; $p < 0.001$). Notably, both forms of bullying were statistically significantly associated with all examined substance use behaviors in partially adjusted models (including sex, race/ethnicity, sexual identity, and age, but not other substance use), except for the association of being bullied at school and binge drinking. While we found no evidence of statistically significant interactions by race/ethnicity, sex, and sexual identity in fully adjusted models, exploratory analyses suggested some differences by sex. In mediation analyses, nearly one half of the associations of past 12 month experience of having been bullied at school (proportion mediated = 0.46) and having been bullied electronically (proportion mediated = 0.48) with past 30 day any prescription pain medicine misuse were mediated through past 12 month depressive symptoms. For electronic vapor products, the proportions mediated were somewhat smaller with 0.42 for having been bullied at school and 0.27 for having been bullied electronically.

Our findings of no statistically significant associations between the experience of having been bullied and alcohol use, binge drinking, and cannabis use in fully adjusted models differ from previous reports which indicate that bullying victimization is associated with substance use (3,4,24) which may be the result of differences in analytic methods. In particular, our findings differ from those of Pontes et al. which found evidence of significant associations between the experience of having been bullied and alcohol use, binge drinking, cannabis use, and electronic vapor product use using YRBS 2011 to 2017 data (24). However, some differences in methods used in previous studies and the current study should be noted. Pontes et al. considered an aggregate variable for bullying victimization (i.e., respondents would be classified has having been bullied by answering yes to either being bullied at school and/or electronically) and did not adjust for use of other substances. Of note, our partially adjusted models, adjusting for race/ethnicity, sex, age, and sexual identity, but not other substance use, are qualitatively similar to the findings of Pontes et al. Our findings indicating no significant interaction by sex are also different from those of Pontes et al., where observed associations were stronger for female students than male students, though the comparability may again be limited.

The statistically significant associations of being bullied with electronic vapor product use and prescription pain medicine misuse (but not with alcohol use, binge drinking, or cannabis use) may be reflective of changing trends in adolescent-reported reasons for substance use. However, current trends in cannabis use among adolescents suggest that the prevalence of social and/or recreational reasons for cannabis use (i.e. boredom, feeling good or getting high, having a good time, experimentation, and fitting in) have decreased or remained

the same over time, while the prevalence of coping reasons for cannabis use (i.e. anger and/or frustration, relaxation, escape from problems, and getting through the day) have increased (22). This would be suggestive of a stronger association between the experience of having been bullied and cannabis use, as opposed to our observations of non-significant results. That said, our findings are potentially consistent with the observed decoupling between depressive symptoms and binge drinking (21) in that binge drinking may be less likely to be used by adolescents to cope with negative emotions and experiences. Finally, adolescent-reported motivations for electronic vapor product use in 2015 and 2016 are most commonly related to entertainment and experimentation (37,38), which differs from potential coping suggested by our observation of significant associations between having been bullied. More recent reports from 2019 found that nearly 40% of adolescents report using e-cigarettes to relax or relieve tension, which increased by more than one-third from 2018 measures, an observation that supports our findings (39). These findings may suggest that the substances that adolescents are vaping are changing, which is reflected in 2020 Monitoring the Future survey results indicating that before the COVID-19 pandemic that the prevalence of lifetime nicotine vaping (2017: 25.0%; 2020: 44.3%) and lifetime cannabis vaping (2017: 11.9%; 2020: 27.9%) among twelfth graders increased substantially, while the prevalence of vaping just flavoring remained relatively unchanged (2017: 30.7%; 2020: 29.8%) (10). Notably, the prevalence of all types of vaping decreased in 2021, possibly reflecting the impact of the COVID-19 pandemic.

Our mediation analyses indicated statistically significant indirect effects for mediation by depressive symptoms of all experience of being bullied types and substance use combinations except for having been bullied electronically in the past 12 months and any binge

drinking in the past 30 days. The observation of significant mediation by depressive symptoms is consistent with other studies assessing mediation by depressive symptoms of the association between being bullied and substance use among adolescents (4,15,16). With that being said, because of our use of cross-sectional data, our findings should be considered within the context of its limitations. The questions for exposure to bullying and depressive symptoms query about the past 12 month period and the questions for substance use query for the past 30 days. Therefore, it is possible that the modeled temporal sequence of being bullied, depressive symptoms, and substance use did not actually occur in that order.

The key strengths of our analyses are the use of a large, representative, and recent data source. Because the YRBS is nationally representative of students in high schools in the United States, our findings are highly generalizable. Use of 2019 data, which are the most recent YRBS data available at the time of these analyses, allows for the assessment of recent trends and associations in bullying, depressive symptoms, and substance use, including more recent substance use behaviors like electronic vapor product use. We additionally assessed for differences in the association between the experience of being bullied and substance use by demographic factors in order to assess for the potential role of the stress that individuals with marginalized identities experience.

Limitations of our analyses are primarily rooted in the cross-sectional nature of the YRBS data. Because of the time frames assessed for the experience of being bullied (12 months), depressive symptoms (12 months), and substance use (30 days), we are not able to establish temporality of exposures and outcomes, and therefore we cannot infer causation. Because the YRBS is weighted to be generalizable to adolescents in schools, our findings may not generalize

to adolescents not in school, who may be at higher risk for substance use. Notably, in 2019, 5.1% of 16 to 24 year olds were not enrolled in school and had not earned a high school credential (40). Generalizability is also limited due to the fact that the data were collected before the start of the COVID-19 pandemic, and therefore may not reflect changes in adolescent life and behaviors that resulted from the pandemic.

The experience of being bullied either at school or electronically may vary widely in terms of content and emotional impact. This heterogeneity in the independent variable in our models could result in attenuation of observed associations if adolescents who reported having been bullied experienced a wide range in types of bullying and emotional impact due to bullying. An additional issue in the classification of independent variables (i.e., having been bullied), the mediator (i.e., depressive symptoms), and dependent variables (i.e., substance use) may be social desirability bias due to self-reporting by adolescents. The sample size of the 2019 YRBS was large which may have resulted in power to detect small differences that may not be important. We have aimed to address this issue, in addition to multiple testing, through the use of a more stringent significance level of $\alpha = 0.01$. While the sample size was large, some demographic groups were small which may have limited our statistical power to assess for differences in associations, especially for race/ethnicity.

Our findings suggest that adolescents who experience being bullied either at school or electronically may be at higher risk for electronic vapor product use and prescription pain medicine misuse. Teachers, clinicians, and caregivers for adolescents should aim to provide additional support to adolescents who are being bullied and encourage healthy coping skills. Further, efforts to prevent bullying among adolescents may additionally serve to reduce

adolescent electronic vapor product use and prescription pain medicine misuse. Future studies should aim to assess longitudinal associations in recent adolescent cohorts. Further, additional work in this area should actively recruit adolescents with marginalized identities to ensure adequate sample size and power to comprehensively assess for differences by demographic factors.

4.6 References

1. Basile KC, Clayton HB, DeGue S, et al. Interpersonal Violence Victimization Among High School Students — Youth Risk Behavior Survey, United States, 2019. *MMWR Suppl.* [electronic article]. 2020;69(1):28–37. (http://www.cdc.gov/mmwr/volumes/69/su/SU6901a4.htm?s_cid=SU6901a4_w). (Accessed January 19, 2022)

2. Moore SE, Norman RE, Suetani S, et al. Consequences of bullying victimization in childhood and adolescence: A systematic review and meta-analysis. *WJP* [electronic article]. 2017;7(1):60. (http://www.wjgnet.com/2220-3206/full/v7/i1/60.htm). (Accessed April 28, 2022)

3. Radliff KM, Wheaton JE, Robinson K, et al. Illuminating the relationship between bullying and substance use among middle and high school youth. *Addictive Behaviors* [electronic article]. 2012;37(4):569–572. (http://dx.doi.org/10.1016/j.addbeh.2012.01.001)

4. Luk JW, Wang J, Simons-Morton BG. Bullying Victimization and Substance Use Among U.S. Adolescents: Mediation by Depression. *Prevention Science*. 2010;11(4):355–359.

5. Kim MJ, Catalano RF, Haggerty KP, et al. Bullying at elementary school and problem behaviour in young adulthood: A study of bullying, violence and substance use from age 11 to age 21. *Criminal Behav. Ment. Health* [electronic article]. 2011;21(2):136–144. (https://onlinelibrary.wiley.com/doi/10.1002/cbm.804). (Accessed April 28, 2022)

6. Orr M, Rajotte J, Jackson T, et al. E-cigarette Use and Rhode Island High School Students: What Providers Need to Know about the Characteristics of Initiation of E-cigarettes and Related Risk Behaviors. *Rhode Island Medical Journal* [electronic article]. 2020;103(1):51–54. (http://www.ncbi.nlm.nih.gov/pubmed/32013307)

7. Doxbeck CR. Up in Smoke: Exploring the Relationship between Bullying Victimization and E-Cigarette Use in Sexual Minority Youths. *Substance Use & Misuse* [electronic article]. 2020;55(13):2221–2229.

(https://www.tandfonline.com/doi/full/10.1080/10826084.2020.1797809). (Accessed April 28, 2022)

8. Hansen J, Morgenstern M, Isensee B, et al. Association between bullying victimization and e-cigarette use among German students. *Aggressive Behavior.* [electronic article]. 2021;47(4):421–429. (https://onlinelibrary.wiley.com/doi/10.1002/ab.21951). (Accessed April 28, 2022)

9. Azagba S, Mensah NA, Shan L, et al. Bullying Victimization and e-Cigarette Use among Middle and High School Students. *J School Health* [electronic article]. 2020;90(7):545–553. (https://onlinelibrary.wiley.com/doi/10.1111/josh.12902). (Accessed April 28, 2022)

10. Johnston LD, Miech RA, O'Malley PM, et al. Monitoring the Future national survey results on drug use 1975-2021: Overview, key findings on adolescent drug use. Ann Arbor: University of Michigan Institute for Social Research; 2022 (Accessed May 17, 2022).(http://www.monitoringthefuture.org//pubs/monographs/mtf-overview2021.pdf). (Accessed May 17, 2022)

11. Mc Guckin C. Experiences of school bullying, psychological well-being and stress in Northern Ireland: Findings from the young life and times survey, 2005. *Research in Education*. 2010;(83):54–66.

12. Khantzian EJ. The self-medication hypothesis of substance use disorders: A reconsideration and recent applications. *Harvard Review of Psychiatry*. 1997;4(5):231–244.

13. Baker TB, Piper ME, McCarthy DE, et al. Addiction Motivation Reformulated: An Affective Processing Model of Negative Reinforcement. *Psychological Review*. 2004;111(1):33–51.

14. McCarthy DE, Curtin JJ, Piper ME, et al. Negative reinforcement: Possible clinical implications of an integrative model. *Substance abuse and emotion.* 2010;(2009):15–42.

15. Hong JS, Davis JP, Sterzing PR, et al. A conceptual framework for understanding the association between school bullying victimization and substance misuse. *American Journal of Orthopsychiatry*. 2014;84(6):696–710.

16. Earnshaw VA, Elliott MN, Reisner SL, et al. Peer victimization, depressive symptoms, and substance use: A longitudinal analysis. *Pediatrics*. 2017;139(6).

17. Twenge JM, Martin GN, Spitzberg BH. Trends in U.S. Adolescents' media use, 1976–2016: The rise of digital media, the decline of TV, and the (near) demise of print. *Psychology of Popular Media Culture* [electronic article]. 2019;8(4):329–345. (http://doi.apa.org/getdoi.cfm?doi=10.1037/ppm0000203). (Accessed April 28, 2022)

18. Anderson M, Jiang J. Teens, Social Media & Technology 2018. Pew Research Center; 2018.(https://www.pewresearch.org/internet/2018/05/31/teens-social-media-technology-2018/)

19. National Conference of State Legislatures. State Medical Marijuana Laws. (https://www.ncsl.org/research/health/state-medical-marijuana-laws.aspx). (Accessed November 15, 2020)

20. Miech R, Johnston L, O'Malley PM, et al. Trends in Adolescent Vaping, 2017–2019. *New England Journal of Medicine*. 2019;2018–2019.

21. Keyes KM, Hamilton A, Patrick ME, et al. Diverging Trends in the Relationship Between Binge Drinking and Depressive Symptoms Among Adolescents in the U.S. From 1991 Through 2018. *Journal of Adolescent Health* [electronic article]. 2020;66(5):529–535. (https://doi.org/10.1016/j.jadohealth.2019.08.026)

22. Patrick ME, Evans-Polce RJ, Kloska DD, et al. Reasons High School Students Use Marijuana: Prevalence and Correlations With Use Across Four Decades. *Journal of Studies on Alcohol and Drugs* [electronic article]. 2019;80(1):15–25. (https://www.jsad.com/doi/10.15288/jsad.2019.80.15)

23. Goodenow C, Watson RJ, Adjei J, et al. Sexual Orientation Trends and Disparities in School Bullying and Violence-Related Experiences, 1999-2013. *Psychology of Sexual Orientation and Gender Diversity*. 2016;3(4):386–396.

24. Pontes NMH, Ayres CG, Lewandowski C, et al. Trends in bullying victimization by gender among U.S. high school students. *Res Nurs Health* [electronic article]. 2018;41(3):243–251. (https://onlinelibrary.wiley.com/doi/10.1002/nur.21868). (Accessed April 29, 2022)

25. Salmon S, Turner S, Taillieu T, et al. Bullying victimization experiences among middle and high school adolescents: Traditional bullying, discriminatory harassment, and cybervictimization. *Journal of Adolescence* [electronic article]. 2018;63(1):29–40. (https://onlinelibrary.wiley.com/doi/10.1016/j.adolescence.2017.12.005). (Accessed April 29, 2022)

26. Jones CM, Clayton HB, Deputy NP, et al. Prescription Opioid Misuse and Use of Alcohol and Other Substances Among High School Students — Youth Risk Behavior Survey, United States, 2019. *MMWR Suppl.* [electronic article]. 2020;69(1):38–46. (http://www.cdc.gov/mmwr/volumes/69/su/su6901a5.htm?s_cid=su6901a5_w). (Accessed April 29, 2022)

27. Centers for Disease Control and Prevention. 2019 YRBS Data User's Guide. 2020.(https://www.cdc.gov/healthyyouth/data/yrbs/pdf/2019/2019_National_YRBS_Data_Users_Guide.pdf)

28. Underwood JM, Brener N, Thornton J, et al. Overview and Methods for the Youth Risk Behavior Surveillance System — United States, 2019. *MMWR Supplements*. 2020;69(1):1–10.

29. YRBSS Data & Documentation. *Centers for Disease Control and Prevention*. 2022;(https://www.cdc.gov/healthyyouth/data/yrbs/data.htm). (Accessed May 17, 2022)

30. Hafeman DM, Schwartz S. Opening the Black Box: a motivation for the assessment of mediation. *International Journal of Epidemiology* [electronic article]. 2009;38(3):838–845. (https://academic.oup.com/ije/article-lookup/doi/10.1093/ije/dyn372). (Accessed May 7, 2022)

31. Gunzler D, Chen T, Wu P, et al. Introduction to mediation analysis with structural equation modeling. *Shanghai Archives of Psychiatry*. 2013;25(6):390–394.

32. VanderWeele TJ. Mediation Analysis: A Practitioner's Guide. *Annu. Rev. Public Health* [electronic article]. 2016;37(1):17–32. (https://www.annualreviews.org/doi/10.1146/annurev-publhealth-032315-021402). (Accessed May 7, 2022)

33. Lumley T. Package 'survey.' 2021;(https://cran.r-project.org/web/packages/survey/survey.pdf). (Accessed April 14, 2022)

34. gsem — Generalized structural equation model estimation command. (https://www.stata.com/manuals/semgsem.pdf). (Accessed May 7, 2022)

35. Example 42g — One- and two-level mediation models (multilevel). (https://www.stata.com/manuals/semexample42g.pdf). (Accessed May 7, 2022)

36. MacKinnon DP, Fairchild AJ, Fritz MS. Mediation Analysis. *Annu. Rev. Psychol.* [electronic article]. 2007;58(1):593–614. (https://www.annualreviews.org/doi/10.1146/annurev.psych.58.110405.085542). (Accessed May 8, 2022)

37. Patrick ME, Miech RA, Carlier C, et al. Self-reported reasons for vaping among 8th, 10th, and 12th graders in the US: Nationally-representative results. *Drug and Alcohol Dependence* [electronic article]. 2016;165:275–278. (http://dx.doi.org/10.1016/j.drugalcdep.2016.05.017)

38. Evans-Polce RJ, Patrick ME, Lanza ST, et al. Reasons for Vaping Among U.S. 12th Graders. *Journal of Adolescent Health* [electronic article]. 2018;62(4):457–462. (https://doi.org/10.1016/j.jadohealth.2017.10.009)

39. Monitoring the Future 2019 Survey Results: Vaping. U.S. Department of Health and Human Services National Institutes of Health National Institute on Drug Abuse; 2019 (Accessed May 8, 2022).(https://nida.nih.gov/drug-topics/trends-statistics/infographics/monitoring-future-2019-survey-results-vaping). (Accessed May 8, 2022)

40. National Center for Education Statistics. Status Dropout Rates. Condition of Education. U.S. Department of Education, Institute of Education Sciences; 2021 (Accessed April 14, 2022).(https://nces.ed.gov/programs/coe/indicator/coj). (Accessed April 14, 2022)

4.7 Tables

Table 4.1: Demographics of the Weighted 2019 YRBS Weighted Sample

Characteristic	Percent (%)*
Sex	
Male	50.2
Female	48.9
Missing	0.9
Race/Ethnicity	
American Indian/Alaska Native	0.6
Asian	4.9
Black or African American	11.8
Native Hawaiian/Other Pacific Islander	0.3
White	49.6
Hispanic/Latino	8.9
Multiple Races – Hispanic/Latino	16.4
Multiple Races – Non-Hispanic/Latino	4.3
Missing	3.1
Sexual Identity	
Straight	79.1
Gay or Lesbian	2.3
Bisexual	8.2
Not Sure	4.2
Missing	6.1
Age	
12 years old or younger	0.3
13 years old	0.1
14 years old	11.8
15 years old	24.6
16 years old	25.4
17 years old	23.5
18 years old or older	13.6
Missing	0.6
Grade in School	
9th grade	26.4
10th grade	25.3
11th grade	24.1
12th grade	23.4
Ungraded or other grade	0.2
Missing	0.7

*Note: Percentages may not sum to 100 due to rounding. All racial/ethnic groups are non-Hispanic/Latino unless otherwise specified.

Table 4.2: Prevalence of Past 12 Month Experience of Being Bullied in the 2019 YRBS Weighted Sample (Independent Variables)

	Percent (%)*
Bullied at School	
Yes	19.3%
No	78.5%
Missing	1.2%
Electronically Bullied	
Yes	15.5%
No	83.4%
Missing	1.1%

*Note: Percentages may not sum to 100 due to rounding.

Table 4.3: Prevalence of Past 30 Day Substance Use Behaviors (Outcomes) in 2019 YRBS Weighted Sample

Substance Use	Percent (%)*
Alcohol Use	
0 days	65.7
1 or 2 days	14.9
3 to 5 days	6.6
6 to 9 days	3.3
10 to 19 days	1.4
20 to 29 days	0.3
All 30 days	0.5
Missing	7.2
Binge Drinking	
0 days	77.8
1 day	4.3
2 days	3.3
3 to 5 days	2.6
6 to 9 days	1.3
10 to 19 days	0.5
20 or more days	0.4
Missing	9.8
Cannabis Use	
0 times	76.4
1 or 2 times	7.8
3 to 9 times	4.6
10 to 19 times	2.7
20 to 39 times	2.2
40 or more times	3.8
Missing	2.4
Electronic Vapor Product Use	
0 days	63.1
1 or 2 days	9.1
3 to 5 days	4.8
6 to 9 days	3.0
10 to 19 days	4.0
20 to 29 days	3.3
All 30 days	6.7
Missing	6.1
Prescription Pain Medicine Use	
0 times	72.5
1 or 2 times	3.0

3 to 9 times	1.3
10 to 19 times	0.5
20 to 39 times	0.2
40 or more times	0.5
Missing	21.9

*Note: Percentages may not sum to 100 due to rounding.

Table 4.4: Odds Ratios for the Associations Between Past 12 Month Experience of Being Bullied and Past 30 Day Ever Use of Substances

	Any Alcohol Use OR (95% CI) p-value			Any Binge Drinking OR (95% CI) p-value			Any Cannabis Use OR (95% CI) p-value			Any Electronic Vapor Product Use OR (95% CI) p-value			Any Prescription Pain Medicine Misuse OR (95% CI) p-value		
	U	**P**	**F**	**U**	**P**	**F**	**U**	**P**	**F**	**U**	**P**	**F**	**U**	**P**	**F**
Bullied at School	**1.51 (1.33, 1.71) <0.001**	**1.45 (1.25, 1.69) <0.001**	1.03 (0.86, 1.24) 0.7	**1.31 (1.12, 1.55) 0.002**	1.28 (1.05, 1.55) 0.016	0.89 (0.73, 1.09) 0.2	**1.38 (1.19, 1.61) <0.001**	**1.38 (1.17, 1.63) <0.001**	0.97 (0.82, 1.15) 0.7	**1.80 (1.52, 2.12) <0.001**	**1.83 (1.53, 2.18) <0.001**	**1.49 (1.21, 1.84) <0.001**	**2.51 (2.11, 2.97) <0.001**	**2.51 (2.04, 3.09) <0.001**	**2.10 (1.72, 2.55) <0.001**
Bullied Electronically	**2.01 (1.76, 2.30) <0.001**	**1.86 (1.59, 2.16) <0.001**	1.27 (1.03, 1.55) 0.025	**1.84 (1.57, 2.15) <0.001**	**1.71 (1.44, 2.04) <0.001**	1.16 (0.94, 1.44) 0.2	**1.65 (1.41, 1.94) <0.001**	**1.61 (1.35, 1.92) <0.001**	1.07 (0.88, 1.28) 0.5	**2.42 (2.12, 2.76) <0.001**	**2.43 (2.10, 2.82) <0.001**	**1.89 (1.55, 2.31) <0.001**	**2.58 (1.99, 3.35) <0.001**	**2.47 (1.87, 3.26) <0.001**	**1.99 (1.48, 2.67) <0.001**

Notes: Partially adjusted models are adjusted for race/ethnicity, sex, age, and sexual identity. Fully adjusted models are adjusted for race/ethnicity, sex, age, sexual identity, and other substance use (any past 30 day use of other substances included in the analysis or any lifetime use of cocaine, inhalants, heroin, methamphetamines, ecstasy, synthetic marijuana, steroid pills and shots, hallucinogens, and injection drugs). **Bolded** values are those that are statistically significant when assessed at $\alpha = 0.01$.
Abbreviations: CI = confidence interval, F = fully adjusted, P = partially adjusted, U = unadjusted

Table 4.5: Results of Likelihood Ratio Tests of Fully Adjusted Models Including Terms for Interaction Independent Variables and Demographic Factors

	Any Alcohol Use	Any Binge Drinking	Any Cannabis Use	Any Electronic Vapor Product Use	Any Prescription Pain Medication Misuse
	p-value	p-value	p-value	p-value	p-value
Bullied at School					
Sex	0.181	**0.076**	**0.093**	0.822	0.811
Race/ethnicity	0.204	0.128	0.343	0.210	0.813
Sexual identity	0.190	0.110	0.546	0.630	0.118
Electronically Bullied					
Sex	**0.019**	0.154	**0.030**	0.775	0.547
Race/ethnicity	0.163	**0.079**	0.462	0.471	0.570
Sexual identity	0.424	0.105	0.278	0.147	0.179

Notes: Fully adjusted models are adjusted for race/ethnicity, sex, age, sexual identity, and other substance use (any past 30 day use of other substances included in the analysis or any lifetime use of cocaine, inhalants, heroin, methamphetamines, ecstasy, synthetic marijuana, steroid pills and shots, hallucinogens, and injection drugs. **Bolded** values are those that are $p < 0.1$.

Table 4.6: Prevalence of Past 12 Month Depressive Symptoms and Suicidality Indicators (Mediator) in 2019 YRBS Weighted Sample

	Percent (%)*
Depressive Symptoms	
Yes	36.2
No	62.4
Missing	1.4

*Note: Percentages may not sum to 100 due to rounding.

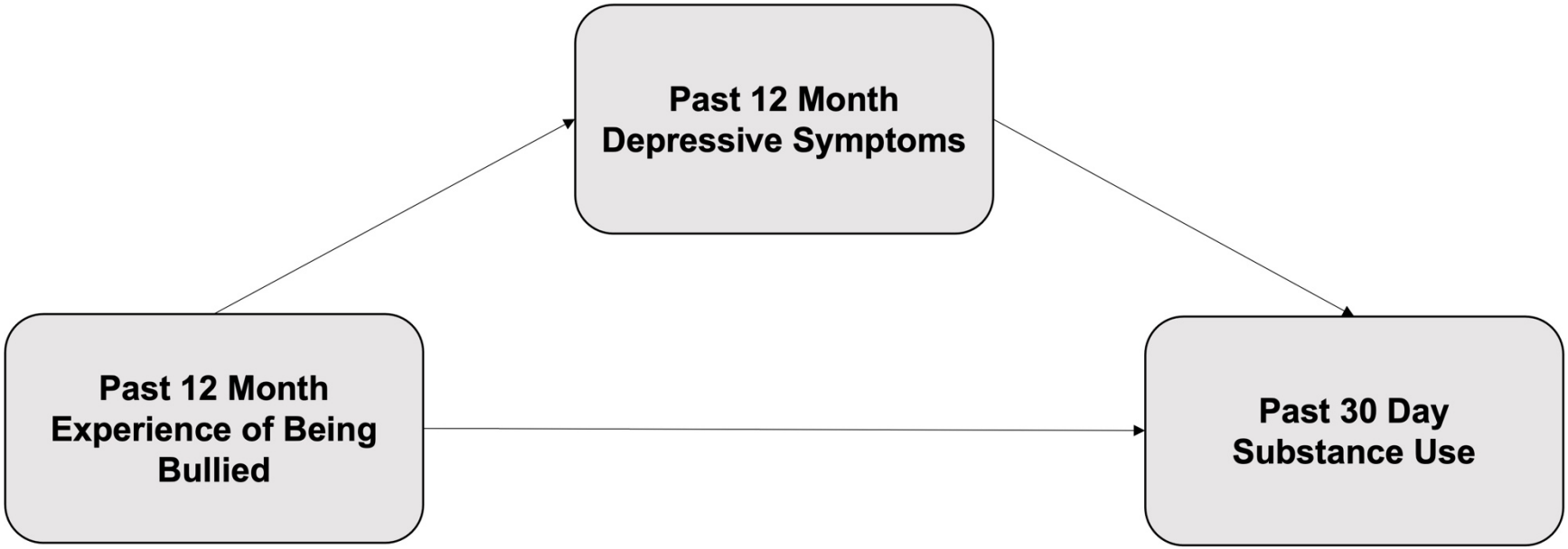
Table 4.7: Mediation Analysis for Mediation By Depressive Symptoms for the Association for the Past 12 Month Experience of Being Bullied and Past 30 Day Ever Use of Substances

	Any Alcohol Use Poisson Regression Coefficient (p-value) / Proportion Mediated	Any Binge Drinking Poisson Regression Coefficient (p-value) / Proportion Mediated	Any Cannabis Use Poisson Regression Coefficient (p-value) / Proportion Mediated	Any Electronic Vapor Product Use Poisson Regression Coefficient (p-value) / Proportion Mediated	Any Prescription Pain Medicine Misuse Poisson Regression Coefficient (p-value) / Proportion Mediated
Bullied at School					
Direct Effect	-0.01 (0.767)	-0.14 (0.057)	-0.07 (0.157)	**0.12 (0.002)**	**0.48 (<0.001)**
Indirect Effect	**0.06 (0.001)**	**0.11 (0.005)**	**0.12 (<0.001)**	**0.09 (<0.001)**	**0.40 (<0.001)**
Total Effect	0.05 (0.233)	-0.03 (0.692)	0.04 (0.336)	**0.21 (<0.001)**	**0.88 (<0.001)**
Proportion Mediated	1.25	-3.83	2.65	0.42	0.46
Bullied Electronically					
Direct Effect	0.08 (0.079)	0.07 (0.347)	-0.01 (0.839)	**0.21 (<0.001)**	**0.42 (0.001)**
Indirect Effect	**0.05 (0.006)**	0.08 (0.031)	**0.11 (<0.001)**	**0.08 (<0.001)**	**0.39 (<0.001)**
Total Effect	**0.13 (0.004)**	**0.15 (0.008)**	0.09 (0.083)	**0.29 (<0.001)**	**0.81 (<0.001)**
Proportion Mediated	0.40	0.55	1.13	0.27	0.48

Notes: Models were fully adjusted for race/ethnicity, sex, age, sexual identity, and other substance use (any past 30 day use of other substances included in the analysis or any lifetime use of cocaine, inhalants, heroin, methamphetamines, ecstasy, synthetic marijuana, steroid pills and shots, hallucinogens, and injection drugs. **Bolded** values are those that are $p < 0.1$.

4.8 Appendix

Appendix Figure 4.1: Conceptual Framework for Mediation Analyses



Appendix Table 4.1: Analytic Constructs and Corresponding Youth Risk Behavior Survey 2019 Survey Questions

	Survey Question	Response Options
Experience of Being Bullied		
School Property Bullying	During the past 12 months, have you ever been bullied on school property?	Binary: Yes/No
Electronic Bullying	During the past 12 months, have you ever been electronically bullied? (Count being bullied through texting, Instagram, Facebook, or other social media.)	Binary: Yes/No
Substance Use		
Past 30 Day Alcohol Use	During the past 30 days, on how many days did you have at least one drink of alcohol?	Categorical: 0 days, 1 or 2 days, 3 to 5 days, 6 to 9 days, 10 to 19 days, 20 to 29 days, all 30 days
Past 30 Day Binge Drinking	During the past 30 days, on how many days did you have 4 or more drinks of alcohol in a row, that is, within a couple of hours (if you are female) or 5 or more drinks of alcohol in a row, that is, within a couple of hours (if you are male)?	Categorical: 0 days, 1 day, 2 days, 3 to 5 days, 6 to 9 days, 10 to 19 days, 20 or more days
Past 30 Day Cannabis Use	During the past 30 days, how many times did you use marijuana?	Categorical: 0 times, 1 or 2 times, 3 to 9 times, 10 to 19 times, 20 to 39 times, 40 or more times
Past 30 Day Electronic Vapor Product Use	During the past 30 days, on how many days did you use an electronic vapor product?	Categorical: 0 days, 1 or 2 days, 3 to 5 days, 6 to 9 days, 10 to 19 days, 20 to 29 days, all 30 days
Past 30 Day Prescription Pain Medicine Misuse	During the past 30 days, how many times have you taken prescription pain medicine without a doctor's prescription or differently than how a doctor told you to use it?	Categorical: 0 times, 1 or 2 times, 3 to 9 times, 10 to 19 times, 20 to 39 times, 40 or more times
Depressive Symptoms		
Past 12 Month Depressive Symptoms	During the past 12 months, did you ever feel so sad or hopeless almost every day for two weeks or more in a row that you stopped doing some usual activities?	Binary: Yes/No

Covariates		
Race/Ethnicity	Are you Hispanic or Latino? AND What is your race? (Select one or more responses.)	Categorical: American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, White, Hispanic/Latino, Multiple—Hispanic/Latino, Multiple—Non-Hispanic/Latino
Sex	What is your sex?	Categorical: Male, Female
Sexual Identity	Which of the following best describes you?	Categorical: Heterosexual (straight), Gay or Lesbian, Bisexual, Not Sure
Ever Other Illicit Drug Use	Combination of questions about lifetime use of cigarette cocaine, inhalants, heroin, methamphetamines, ecstasy, synthetic marijuana, steroid pills and shots, and injection drugs and past 30 day use of other analytic substance except for the specific modeled outcome	Binary: Yes/No
Age	How old are you?	Categorical: 12 years old or younger, 13 years old, 14 years old, 15 years old, 16 years old, 17 years old, 18 years old or older

Appendix Table 4.2: Sex-Stratified Odds Ratios for Fully Adjusted Interaction Models with Rao-Scott Likelihood Ratio Test p < 0.10

	Past 12 Month Bullied at School and Past 30 Day Ever Binge Drinking OR (95% CI) p-value	Past 12 Bullied at School and Past 30 Day Ever Cannabis Use OR (95% CI) p-value	Past 12 Month Electronically Bullied and Past 30 Day Ever Alcohol Use OR (95% CI) p-value	Past 12 Electronically Bullied and Past 30 Day Ever Cannabis Use OR (95% CI) p-value
Female	0.75 (0.60, 0.94) 0.017	1.12 (0.84, 1.48) 0.4	1.10 (0.87, 1.39) 0.4	1.23 (0.95, 1.95) 0.11
Male	1.18 (0.80, 1.75) 0.4	0.83 (0.67, 1.03) 0.090	**1.69** **(1.21, 2.36)** **0.003**	0.89 (0.69, 1.14) 0.3

Notes: Fully adjusted models are adjusted for race/ethnicity, sex, age, sexual identity, and other substance use (any past 30 day use of other substances included in the analysis or any lifetime use of cocaine, inhalants, heroin, methamphetamines, ecstasy, synthetic marijuana, steroid pills and shots, hallucinogens, and injection drugs). **Bolded** values are those that are statistically significant when assessed at $\alpha = 0.01$.

Abbreviations: CI = confidence interval

Appendix Table 4.3: Race/Ethnicity-Stratified Odds Ratios for Fully Adjusted Interaction Models with Rao-Scott Likelihood Ratio Test p < 0.10

	Past 12 Month Electronically Bullied and Past 30 Day Ever Binge Drinking OR (95% CI) p-value
American Indian/Alaska Native	5.98 (0.78, 46.0) 0.079
Asian	2.62 (0.81, 9.45) 0.10
Black or African American	3.15 (1.29. 7.68) 0.014
Native Hawaiian/Other Pacific Islander	*
White	0.95 (0.69, 1.31) 0.7
Hispanic/Latino	0.81 (0.25, 2.67) 0.7
Multiple Races – Hispanic/Latino	1.25 (0.85, 1.82) 0.2
Multiple Races – Non-Hispanic/Latino	2.48 (0.89, 6.92) 0.080

Notes: Fully adjusted models are adjusted for race/ethnicity, sex, age, sexual identity, and other substance use (any past 30 day use of other substances included in the analysis or any lifetime use of cocaine, inhalants, heroin, methamphetamines, ecstasy, synthetic marijuana, steroid pills and shots, hallucinogens, and injection drugs).
Abbreviations: CI = confidence interval
* Zero or negative residual degrees of freedom

Chapter 5. The Impact of COVID-19 on Adolescent Social Media Use, Substance Use, and Mental Health: A Scoping Review

5.1 Abstract

Purpose: We conducted a scoping review of published, peer-reviewed literature in order to characterize and synthesize the existing literature on the impact of COVID-19 on adolescent social media use, substance use (i.e., alcohol, cannabis, electronic vapor products, and prescription medication misuse), and depressive symptoms in the United States.

Methods: We utilized the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines for the review. We searched PubMed, PsycINFO, and Embase and completed dual screening of title, abstract, and full text. Extraction of articles that passed through the full text screen was completed in two stages, with a primary extraction completed by a single reviewer followed by a review of the primary extraction by a second reviewer. We included quantitative or qualitative studies among 12 to 17 year-olds or their caregivers and provided results that were specific to adolescents (age 10 to 19 years or middle school to high school) in the United States and included data collected at least at one time point since March 1, 2020 (reflecting the beginning of the impact of the pandemic on daily life for the public).

Results: We identified 29 studies that met the criteria for inclusion, a majority of which reported on depressive symptoms and/or suicidality among adolescents (n = 22). Relatively fewer studies reported on social media use (n = 7) and substance use (n = 4). Cross-sectional assessments with varied depressive symptom measurement techniques indicated high

prevalence of depressive symptoms during the pandemic. However, studies that reported on the trajectory of depressive symptoms and suicidality suggest a possible decrease in the first few months following the beginning of the pandemic. In addition, prevalence of depressive symptoms and/or suicidality during the pandemic differed by youth characteristics. For example, multiple studies indicated girls reported more depressive symptoms than boys. The available literature on reasons for social media use was heterogenous with respect to the ways in which social media use behaviors were being queried, but broadly, included studies suggest high levels of social media use and that adolescents used social media for connection and coping during the pandemic. Findings for substance use were also varied in types of results reported and findings. However, two studies suggested lower e-cigarette use during the pandemic.

Conclusions: Additional mental health support and continued monitoring of mental and behavioral outcomes are needed for adolescents and their caregivers in clinical and school settings both during the pandemic and beyond. Further, adults with key roles in adolescent lives should discuss and model healthy social media use and substance use habits. Future research of the pandemic period should further characterize adolescent substance use and identify facilitators to positive mental health and healthy social media use during periods of physical distancing.

Sources of Support and Acknowledgements: This work was supported in part by a student project stipend from the Northwest Public Health Training Center at the Northwest Center for Public Health Practice (sponsored by the Health Resources and Services Administration (HRSA) of the U.S. Department of Health and Human Services (HHS) (grant # 6 UB6HP31690-04-01))

and by the Health Resources and Services Administration (HRSA) of the U.S. Department of Health and Human Services (HHS) under grant #T76MC00011. REDCap at ITHS is supported by the National Center For Advancing Translational Sciences of the National Institutes of Health under Award Number UL1 TR002319. Ruchi Tiwari was the second reviewer for this scoping review.

5.2 Introduction

Substance use and depressive symptoms are substantial public health problems among adolescents in the United States. Responses from twelfth graders in the 2019 Monitoring the Future survey indicated that the lifetime prevalence of use of alcohol was 58.5% (1). Lifetime prevalence estimates for other substances were also high, including 45.6% for any type of vaping, 43.7% for cannabis and 18.4% for illicit drugs other than cannabis. Both depressive symptoms and suicidality are also prevalent mental health problems for adolescents; 2019 estimates from the National Survey on Drug Use and Health indicate that 15.7% of adolescents had a major depressive episode in the past year (2). Accumulating evidence suggests evidence of an association of depression and suicidality with adolescent substance use (3–5). As communities negotiate the impact of marijuana legalization, rise in electronic vapor products, and the opioid crisis, priority must be placed on understanding substance use among adolescent populations in the current societal and cultural context.

Social media use is a key feature of modern adolescent life, which can support identity formation, connection with friends, and self-exploration (6). Notably, according to 2018 Pew Research estimates, almost all (95%) adolescents have access to a smartphone and nearly half

(45%) of adolescents use social media “almost constantly” (7). However, due to the negative consequences that can occur with social media use, such as depressive symptoms, poor sleep quality, and being a victim of cyberbullying (6), it is important to characterize and understand adolescent social media use as new social media venues and trends emerge.

Globally, the COVID-19 pandemic has resulted in an unprecedented impact on adolescent daily life, including limitations on in-person attendance for school and extracurricular activities, access to mental healthcare, and in person social interactions (8,9). Furthermore, in the United States, people have faced the stressors, grief, loss, and collective trauma resulting from both the pandemic and highly publicized acts of racism (10). These experiences may result in changes in adolescent health and lifestyle, such as increased use of maladaptive and harmful coping strategies (e.g., substance use), heightened depressive symptoms, and shifts in social media use. Given the potentially deleterious impacts of the COVID-19 pandemic, it is of the utmost importance to assess the impact of the current crisis on adolescent social media use, mental health, and substance use. Information on potentially changing trends in depressive symptoms, use of key prevalent substances (including electronic vapor products, alcohol, and cannabis), and social media use during the COVID-19 pandemic have the potential to inform design and implementation of interventions to improve adolescent social, emotional, and physical health in both the immediate future and in the event of future crises that result in similar mass disruption to daily life.

In order to characterize and synthesize the existing literature available on the impact of COVID-19 on adolescent social media use, substance use, and depressive symptoms among

adolescents in the United States, we conducted a scoping review with the intention of identifying key priorities for future research, practice, and policy.

5.3 Methods

The current scoping review of the impact of the COVID-19 pandemic on adolescent substance use, social media use, and depressive symptoms in the United States was conducted using the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines (11). Utilizing search terms designed to capture COVID-19 pandemic, adolescence, social media use, substance use, and depressive symptoms, we conducted searches for publications in PubMed using MEDLINE, PsycINFO using EBSCOhost, and Embase using Elsevier on April 18, 2021 and completed updated searches on June 20, 2021 (see Appendices 5.1 – 5.3 for the full search terms).

Inclusion Criteria

The inclusion criteria were as follows: (1) publication written in English; (2) peer reviewed article (e.g., records that were dissertations or conference abstracts were excluded); (3) reported the results of a quantitative or qualitative study (e.g., not reviews, commentaries, case studies, etc.) conducted with a minimum of five participants and the unit of analyses is individual people (e.g., not individual Twitter tweets); (4) included adolescents (ages 12 to 17 years); (5) some or all participants lived in the United States; (6) study reports on the constructs of interest (i.e., depressive symptoms, suicide, substance use, and/or social media use); (7) data collected during the COVID-19 pandemic (beginning in March 2020); (8) some or all findings stratified to report only on participants in the United States; (9) some or all findings stratified to

report only on the COVID-19 period (beginning in March 2020); (10) some or all findings stratified to report only on adolescents ages 10 to 19 years (range selected recognizing that some studies may select participants on grade level, early adolescence, etc.).

Of note, given that depressive symptoms are a form of internalizing distress (12) and the prevalent comorbidity of anxiety disorders among youth with depressive symptoms (13), we considered studies that reported on internalizing symptoms to meet the inclusion criteria and reported relevant findings with depressive symptoms. We also extracted information on suicidality from included articles. With the intent to manage the scope of this review and thus number of records to review, we did not consider tobacco use (with the exception of electronic vapor product use of tobacco) to be within the scope of our review as our review scope was centered on electronic vapor product use, cannabis use, and alcohol use.

Screening and Extraction

Title and abstract screening and full text screening were completed with dual reviewers (MD, RT) using Research Electronic Data Capture (REDCap) tools hosted at the University of Washington (14,15) using a REDCap project created for this scoping review. Extraction of articles that passed through the full text screen was completed in two stages, with a primary extraction (MD) and a review of the primary extraction (RT) also using REDCap. For each included publication, we extracted the following: age range of participants, sample characteristics, sample size, data collection date range, geographic location, study design, details on substance use (i.e., measurement, effect measures, qualitative results reported, etc.), details on social media use, and details on depressive symptoms. Extraction results were collated to tables and findings were qualitatively synthesized following review of extraction

results. When it was unclear if the eligibility criteria were met (e.g., mean age reported, but not range) by articles, we reviewed online study resources and/or contacted authors for further information.

5.4 Results

The Embase, PubMed, and PsycINFO searches resulted in 301, 1,093, and 156 records, respectively (Figure 5.1). After removal of duplicate records, 1,403 results remained. In title/abstract screening, 1,131 records were excluded. Of the 272 records for which the full text was reviewed, 245 records were excluded, most commonly for not including adolescents ages 12 to 17 years (n = 65), the study location(s) not including the United States (n = 59), and not reporting results that were stratified to adolescents (n = 42). In total, we identified 27 studies that met inclusion criteria. The studies were geographically diverse, were conducted in a variety of settings (e.g., schools, hospitals) and among varying populations (e.g., school-based populations, ongoing longitudinal studies), and had adolescent sample sizes ranging from 85 to 23,615 (Table 5.1).

Social Media Use

We identified seven studies that described social media use during the COVID-19 pandemic among adolescents in the United States (Table 5.2). We identified three included studies that reported on frequency and/or duration of social media use. In a national online survey, adolescents reported spending an average of 4.6 (standard deviation: 3.6) hours per day using social media since COVID-19 (16). In a study of predominantly Hispanic/Latinx students in fifth through eighth grade in a large city in the Southwestern United States, participants

reported their frequency of contact with friends through video or social media in mid-April 2020 (17). There was a range of frequency, with 20.0% of adolescents reporting not at all, 30.8% reporting a little, 28.1% reporting a lot, and 21.1% reporting a whole lot. When parents of adolescents (n = 61) in a nationwide study were asked if their child had increased their use of technology to connect with others outside the home, 44.3% reported "yes, a lot" and 27.9% reported "yes, some" (18).

Social media use was important for adolescent communication and connection during the pandemic. In a national sample of parents, factor analyses of 11 items for the question "Since social distancing began, how frequently does YOUR CHILD do the following things on technology TO CONNECT with others outside your home?" with responses of 0 (never) to 5 (multiple times a day) indicated that the mean score for adolescent social media/technology use was 3.51 (SD: 1.08) which was significantly higher than younger age groups (18). In a study of gay and bisexual cisgender male adolescents, participants reported messaging on men-seeking-men websites and/or phone applications at about the same amount since COVID-19 (on a scale of 0 less often to 100 more often; mean = 44.3, 95% CI: 35.2, 53.4) (19).

Two studies reported qualitative findings. In written open ended responses to a query about caring oneself in the pandemic, sexual minority adolescents noted social media as a communication venue during the COVID-19 pandemic (20). In the aforementioned study of gay and bisexual cisgender male youth, 10% of participants noted an increase in virtual connections with sexual partners, such the use of Skype and Snapchat for virtual sex, in qualitative responses when asked about changes in their sexual lives (19).

In addition to connection, social media use served other purposes in adolescent life. Among diverse public school students in north central Georgia, 57.7% of respondents indicated social media as a news source (21). In the same study, approximately half (50.8%) of participants reported using social media to cope with stress, fear, or anxiety during the pandemic (22). There was no statistically significant difference by racial/ethnic identity ($p = 0.0939$), free and reduced lunch eligibility ($p = 0.10$), or grade level ($p = 0.51$); however, more girls (56.6%) than boys (40.8%) reported using social media to cope ($p < 0.001$). Similarly, social media was reported as a method of caring for oneself through connection with friends and distraction by sexual minority adolescents in qualitative findings (20).

Substance Use

Adolescent substance use during the COVID-19 pandemic in the United States was reported in four studies, which most frequently examined e-cigarette use (Table 5.3). A nationally representative study examined the prevalence of pandemic related experiences among e-cigarette users and never users (23). As compared to adolescents who were never-users, adolescents who had ever used e-cigarettes more frequently reported COVID-19-related symptoms (25.5% vs. 16.1%), a COVID-19 test (16.3% vs. 2.8%), and a COVID-19-positive diagnosis (1.2% vs. 0.1%). A different national, cross-sectional study reporting estimates for 15 to 17 year-olds found that the prevalence of past-30 day e-cigarette use decreased from January 2020 (20.6%) to June 2020 (13.6%) and that the odds of e-cigarette use (OR = 0.72; 95% CI: 0.54, 0.96) and non-JUUL e-cigarette use (OR = 0.71, 95% CI: 0.52, 0.97) were significantly lower during the COVID-19 pandemic period compared to the pre-COVID-19 pandemic period (24). The authors additionally found demographic variation in the odds of e-cigarette use.

Compared to non-Hispanic White or other non-Hispanic respondents, non-Hispanic Black respondents had lower odds of past-30 day e-cigarette use (OR: 0.45, 95% CI: 0.26, 0.78) and non-JUUL e-cigarette use (OR: 0.37, 95% CI: 0.19, 0.73) during the COVID-19 pandemic. Furthermore, individuals with low perceived financial circumstances had higher odds of past-30 day e-cigarette use during the COVID-19 pandemic (OR 1.44, 95% CI: 1.06, 1.96) compared to adolescents with higher perceived financial circumstances (i.e., meet basic needs with at least a little left over). Analyses among a subsample of current e-cigarette users indicated that age did not modify the likelihood of decreasing use of e-cigarettes during the COVID-19 pandemic, with findings showing that 15 to 17 year-olds were not more likely (aOR: 1.00, 95% CI: 0.64, 1.55) to report that they were using e-cigarettes less than before the COVID-19 pandemic when compared to 21 to 24 year-olds.

Considering e-cigarette use longitudinally, in a prospective cohort study of 1,423 tenth and eleventh grade students in Northern California with baseline data collected prior to the pandemic and following the stay-at-home order, past 30-day use of e-cigarettes was significantly lower after the stay at home order (March 19, 2020 or later; before: 16.1%, after: 10.7%, $p < 0.001$) and remained significantly lower when looking specifically at responses after 30 or more days following the stay-at-home order (April 18 or later; before: 17.9%, after: 10.2%, $p < 0.001$) (25). However, after adjustment for demographic factors, academic performance, other substance use, and depression, there was no significant difference between e-cigarette use before and after the stay-at-home-order.

In addition, this study of students in Northern California presented findings related to alcohol use and cannabis use (25). Cannabis ($p = 0.24$) and alcohol ($p = 0.57$) use were not

significantly different following the stay-at-home order or in analyses of only responses after 30 or more days following the stay-at-home order (cannabis p = 0.10; alcohol use p = 0.60).

Finally, one study reported qualitative experiences of sexual minority adolescents related to substance use. A small proportion of participants indicated vaping, alcohol use, and cannabis as a way of caring for themselves during the pandemic (20).

Depressive Symptoms

Our scoping review identified 22 studies reporting on depressive symptoms and suicidality among adolescents in the United States during the COVID-19 pandemic (Table 5.4).

Cross-sectional Assessment of Depressive Symptoms

Of the 22 studies reporting on depressive symptoms and sucidality, eight studies reported cross-sectional assessments of depressive symptoms; all suggested high prevalence. Depressive symptom measurement was heterogenous, as were factors considered in analyses (e.g., stratified analyses by gender, etc.). However, four studies reported depressive symptoms using the Patient Health Questionnaire-9 Item measure. In a national sample of high school athletes in May 2020 which compared cross-sectional measurements of depressive symptoms by demographic factors, more females than males had moderate (female: 22.0%; 95% CI: 21.9, 22.2; male: 15.7; 95% CI: 15.6, 15.9) and moderately severe (female: 15.7%; 95% CI: 15.6, 15.9; male: 9.0; 95% CI: 8.8, 9.1) depression (26). Further, more females (7%; 95% CI: 6.8, 7.1) than males (3.5%; 95% CI: 3.4, 3.6) had severe depression. In addition, depressive symptoms were higher for students in higher grade levels (minimal or no depression: 9th: 37.6%, 95% CI: 37.2, 38.0; 12th: 22.0%, 95% CI: 21.7, 22.3; severe depression: 9th: 4.0%, 95% CI: 3.9, 4.1; 12th: 8.1%, 8.0, 8.3). Similar findings were observed in an online survey of individuals ages 13 years and

older which identified that 55% of adolescent participants had 9-item Patient Health Questionnaire scores indicative of elevated depressive symptoms at the time of the survey (16). Predictors of elevated depressive symptoms included higher loneliness since the COVID-19 pandemic (ß = 0.38, 98% CI: 0.24, 0.52, $p < 0.001$), lower rating of overall health (ß = -0.53, 98% CI: -0.92, -0.15, $p = 0.01$), greater than moderate severity sleep problems (ß = 1.67, 98% CI: 1.04, 2.34, $p < 0.001$), higher perceived stress (ß = 0.27, 98% CI: 0.13, 0.42, $p < 0.001$), and higher hours per day of social media use since COVID-19 (ß = 0.12, 98% CI: 0.03, 0.21, $p = 0.02$).

In another study of high school athletes in October 2020 found that high school athletes who reported playing a fall sport (57.7%) more frequently reported minimal or no depression as compared to participants who did not play a fall sport (31.3%) (27). Correspondingly, they were less likely to report moderate, moderately severe, or severe depression (18.2% vs. 40.1%), though prevalence of mild depression was similar (played fall sport: 23.9%; did not play fall sport: 28.5%). Finally, a study of adolescent athletes in Wisconsin utilizing the Patient Health Questionnaire-9 Item measure compared results to a comparison group of adolescents who participated in 2015 to 2018 (28). 35% of females had a mild level of depression, which was significantly different from the comparison group before COVID-19 (24%, $p < 0.001$). This was similar among males (during COVID-19 = 35%, before COVID-19 = 15%, $p < 0.001$). The difference was greater for moderate, moderately severe, or severe levels of depression (females: during COVID-19 = 37%, before COVID-19 = 11%, $p < 0.001$; males: during COVID-19 = 27%, before COVID-19 = 6%, $p < 0.001$).

Other studies used disparate measures of depressive symptoms, but indicated similar findings. Assessing prevalence of depressive symptoms, 29.6% of high school students in rural

Georgia reported "3 or more days" of feeling down, depressed, or hopeless in the past 7 days (22). Similarly, 30.6% of North Central Florida high school students were "at risk" and 8.1% were "high risk" for depressive symptoms and 37.8% middle school students were "at risk" and 4.9% were "high risk" for depressive symptoms in a scale developed by school psychologists (29). The odds for depressive symptoms risk did not differ by high school versus middle school status. In a study of gay or bisexual adolescent boys, 32% of participants reported a negative mental health impact (depression, anxiety, stress, etc.) as a change with the COVID-19 pandemic, with similar rates by outness (out: 34%, not out: 30%) (19).

The study of high school students in rural Georgia also assessed for differences by demographic factors (22). More students (46%) in the "other" racial category (including multiracial, Asian, Native Hawaiian/Other Pacific Islander, and American Indian/Alaska Native students) indicated 3 or more days than other racial/ethnic groups (ranging from 26% to 29%; chi-squared = 15.02, $p = 0.02$). More girls (35.4%) than boys (19.3%) reported 3 or more days ($p < 0.0001$). Students in older grade levels reported feeling more depressed/hopeless than students in younger grade levels ($p = 0.01$), but there was no difference by free and reduced lunch eligibility ($p = 0.56$). In stratified tables, social media use (increased vs. no increase) did not appear to have an impact on feeling down, depressed, or hopeless.

The remaining cross-sectional study consisted of assessments of adolescent depressive symptoms as reported by caregivers (30). In a qualitative analyses from caregivers, problems with depression were more commonly reported among adolescents compared with younger children ($t=7.02$, $p < 0.01$, 95% CI: 4.28, 7.72) (30). For 13 to 19 year-olds, depression (55%) was the most commonly reported problem, compared to 18% among the 6 to 12 year-old group.

Longitudinal Assessments of Depressive Symptoms Beginning During the Pandemic

We identified two longitudinal studies in which the first time point in the analyses was after the beginning of the COVID-19 pandemic (31,32). Both indicated a decrease in depressive symptoms from the beginning of the pandemic to later periods in the pandemic. In a study of adolescents in a large metropolitan city in the Mid-Atlantic region, at the first time point (T1) (April 20, 2020 – May 15, 2020), 30% of participants reported clinically significant depressive symptoms compared to 25% at the second time point (T2) approximately one month later (31). There was a decrease in internalizing (depressive symptoms and anxiety) symptoms from T1 to T2 ($p = 0.001$). The study also showed an interaction between parent internalizing and adolescent coping at T1 (standardized ß = 0.13, $p = 0.004$) such that when adolescent avoidant coping was moderate (moderate-stratified $p = 0.006$) or high (high-stratified $p < 0.001$) (but not low (low-stratified $p = 0.91$)), higher parent internalizing symptoms at T1 were predictive of higher adolescent T2 internalizing symptoms. In a cross-lagged moderation model which also controlled for parent and adolescent anxiety symptoms at T2, a direct effect of T1 adolescent avoidant coping was observed on T2 adolescent depressive symptoms (standardized ß = 0.36, $p = 0.007$). Additional associations with adolescent depressive symptoms at T2 were observed for adolescent depressive symptoms at T1 (standardized ß = 0.36, $p < 0.001$), adolescent anxiety at T2 (standardized ß = 0.40, $p < 0.001$), and an interaction between parent depressive symptoms at T1 and adolescent coping at T1 (standardized ß = 0.12, $p =0.023$) such that there was a positive association between parent depressive symptoms at T1 and adolescent depressive symptoms at T2 when adolescent avoidant coping was high ($p = 0.003$) (but not when moderate ($p = 0.402$) or low ($p = 0.063$)).

Another study in Long Island, New York reported age-specific estimates from growth models using fixed curve effects for quadratic changes in depression and found an estimated positive slope for change in depression as measured by the Children's Depression Inventory (with 27 items rated on three-point scales) from April 2020 to July 2020 for 16 year-olds (estimate = 2.45, SE = 0.49, t = 5.01, $p < .001$), 17 year-olds (estimate = 1.62, SE = 0.35, t = 4.61, $p < .001$), and 18 year-olds (estimate = 0.79, SE = 0.34, t = 2.32, p = .02), but there was non-significant slope for 19 year-olds (estimate = -0.04, SE = 0.47, t = -0.09, p = .93) (32). Negative curve effects, reflecting quadratic change, were observed 16 year-olds, 17 year-olds, and 18 year-olds, but not for 19 year-olds.

Longitudinal Assessments of Depressive Symptoms Beginning Before the Pandemic

There were five studies which were nested within ongoing longitudinal studies with the first point of data collection occurring before the pandemic. These studies assessed for variation in depressive symptoms by a wide assortment of demographic and developmental factors. In a study of adolescents with and without ADHD, depression symptoms measured via the Vanderbilt ADHD Diagnostic Rating Scale were highest in spring 2020 (mean: 50.95, SD: 15.01), and significantly different from pre-COVID-19 (September 2018 to February 2020; mean: 45.10, SD: 13.04) and summer 2020 (mean: 46.19, SD: 13.70) (33). Emotion regulation abilities pre-COVID-19 were significantly associated with changes in depression symptoms (repeated measures ANOVA $p < 0.001$) such that adolescents with poorer emotion regulation abilities reported more depression symptoms at all time points (paired sample t-tests $p < 0.006$), but no differences were observed for sex (repeated measures ANOVA p = 0.22), race/ethnicity (repeated measures ANOVA p = 0.31), income (repeated measures ANOVA p =

0.62), or ADHD status (repeated measures ANOVA p = 0.53). Further, there was no evidence of an interaction between pre-COVID-19 emotion regulation ability and ADHD status for depression symptoms (p = 0.52).

Another study assessed the impact of puberty, measured via participant-report on the Tanner Staging Questionnaire, on internalizing symptoms both before (T1; 2013 to 2016), in the three months before the pandemic (pre-COVID-19) and during (April 2020) the pandemic (34). Pubertal stage was positively associated with internalizing symptom severity at the COVID-19 time point ($p < 0.05$), but not at the pre-COVID-19 assessment ($p > 0.05$). Internalizing severity was greater among girls in the pre-COVID-19 period ($t(83)=2.37$, $p = 0.02$) and during COVID-19 ($t(83)=3.77$, $p < 0.01$), but not at T1 ($p=0.11$). Internalizing symptoms at T1 were correlated with the severity of internalizing symptoms in the pre-COVID-19 period ($r(83)=0.22$, $p = 0.04$) but not the peri-COVID-19 period ($r(83) = 0.21$, $p = 0.05$). The average increase in internalizing severity in the recent 2 weeks during the COVID-19 time period was 0.42 (range: -1.50, 2.00; from a mean of 2.33 in the 3 months before COVID-19), and this was statistically different from the pre-COVID-19 internalizing scores ($t84 = 6.00$, $p < 0.0001$). This increase from pre- to during COVID-19 was greater for participants who were at more advanced stages of puberty at T1 after controlling for age ($B = 0.21$, $t65 = 2.07$, $p = 0.04$).

In a study of students in fifth to eighth grade who were predominantly Hispanic/Latinx (72.7%), data on internalizing problems measured via the Brief Problem Monitor were collected from January 2020 to May 2020 and variation was assessed by baseline scores and trauma (17). Students in the highest 20% of scores (i.e., high endorsement of mental health problems) at baseline were considered to be "high scorers". The mean scores of the full sample (high and

low scorers) decreased from the first (January 2020) to second (mid-April 2020) time point and remained relatively stagnant through the third (early May 2020) and the fourth (late May 2020) time points. Similar patterns were observed within high and low scoring groups. In simple effects analysis with Bonferroni adjustments, internalizing scores significantly differed between baseline (January 2020) and 1st follow up (mid-April 2020) for both low scorers (mean difference = 0.58, $p = 0.003$) and high scorers (mean difference = 3.87, $p < 0.001$). Additional analyses considered the role of specific traumatic events. In post-hoc analyses of the impact of an immediate family member losing some or all hours of employment, there was no 3-way interaction between time, group, and job loss nor a 2-way interaction for time and job loss for internalizing problems.

The two remaining studies focused presented on variation by more "traditional" demographic factors. In a national sample based on quotas for representativeness with data from October 2019 (T1) and April 2020 (T2), there was a significant difference ($t(406) = 3.88$, $p < 0.001$; Cohen's $d = 0.19$) in depressive symptoms measured via the Children's Depression Inventory short version between T1 (mean = 1.75, SD = 0.52; range = 1.00 – 3.58) and T2 (mean = 1.84, SD = 0.56, range = 1.00 – 3.75) (35). There was no statistically significant effect modification by sex for depressive symptoms at T2 ($0.05 < p < 0.1$), race/ethnicity ($0.05 < p < 0.1$), or community type ($0.1 < p$; urban area, urban cluster, or rural). In hierarchical regression models, the T1 depressive symptoms were the strongest predictors of T2 depressive symptoms. Generally, adolescents with reported increases negative affect and family conflict and decreases in friend support during COVID-19 reported higher depressive symptoms at the April 2020 timepoint, above and beyond depressive symptoms in October 2019. This study also

reported on negative affect, including feeling nervous, irritable, upset, and distressed as measured by a Likert scale based on the Positive and Negative Affect Schedule, and found that perceived changes in negative affect at T2 were rated as mean 3.24 (0.80 SD; range: 1.00-5.00), indicating that the majority reported increases in negative affect.

The same study also completed qualitative analyses (35). In open ended responses, 28 participant responses (of 407 participants) were coded as "in a funk" including references to feeling "sad", "depressed", and that it is a "little harder to get through the day". When asked if any COVID-19 related changes have been good for the participant mentally or emotionally or for relationships with family and friends, 169 participant responses were coded as "there are no benefits" with one example response indicating feeling depressed due to missing out on high school experiences. However, notably some respondents reported positive changes for mental health.

Lastly, in a study of 157,213 users (23,615 adolescents) of an application for cognitive and behavioral interventions called Youper that included data from February 2020 to July 2020, the authors assessed the impact of age on the associations between time (pre- and acute pandemic periods) and acute negative emotions, including depression (36). There was no significant interaction effect with age and time that predicted depressive symptoms ($p > 0.05$).

Mental Healthcare for Depressive Symptoms

Two articles in which mental healthcare for depressive symptoms was discussed and/or analyzed were identified by our review. One study performed qualitative analyses of text and chat inquiries from May and June 2020 to The Childhelp National Child Abuse Hotline by youth ages 10 to 18 years that were classified by counselors as having a co-occurring COVID-19

concern (37). Their findings indicated that accessing mental healthcare was a reported concern. Broadly, some youth indicated that their parents did not let them seek out mental health services or did not take their mental health concerns seriously. One quote from an adolescent specifically indicated that their parent "acts like it never happened" in reference to a doctor telling the adolescent that they might have mild to severe depression and anxiety. Looking at service utilization for mental healthcare, an analysis of psychiatric service utilization via electronic health records from Kaiser Permanente Northern California found that among 13-17 year old patients with psychiatric diagnoses (including anxiety disorders, depressive disorders, bipolar disorder, psychotic disorder, intellectual disabilities, developmental disorders, and disorders seen in childhood, substance use disorder, adjustment disorder, and other disorders), there was a decrease in the number of visits in 2020 (n = 9,161) as compared to 2019 (n = 9,524; standardized change: -5.4, 95% CI: -8.2, -2.7) comparing March 9 to May 31 in each year (38).

Depressive Symptoms and Sexual Minority Adolescent Self Care

One study presented information on sexual minority adolescent self care in May 2020; in some responses, adolescents mentioned the role of depressive symptoms in their routines (20). Some participants noted keeping routines for the sake of mental health, as illustrated by the quote "I make sure to keep a schedule so I do not fall into a depression. Simple, like making sure I am awake around the same time every day and take care of myself.". In another quote, a participant noted "trying to bathe every other day or so (depression makes it hard for me to do it every day)".

Suicidality

Suicidality was examined in four studies. These studies generally suggested increased suicidality during the pandemic, with some exceptions. In an online survey, adolescents reported psychiatric outcomes since the COVID-19 pandemic with 37% reporting suicidal ideation, 1.7% suicide attempt, and 38% suicidal ideation or behavior (16). Predictors of suicidal ideation or behavior included lifetime suicidal ideation (ß = 6.69, 98% CI: 5.09, 9.60, $p < 0.001$) and higher hours per day exposure to media reporting on COVID-19 (ß = 0.13, 98% CI: 0.03, 0.25, $p = 0.02$).

In another study using data on visits to emergency departments for suicide attempts and nonsuicidal self-harm recorded in the National Syndromic Surveillance Program from January 1, 2019 to May 15, 2021, visits for adolescents (ages 12 to 17) were lower in spring (March 29 to April 25) 2020 than in spring 2019 by 26.5% (39). However, in summer (July 26-August 22,) 2020 and winter (February 21-March 20,) 2021, the number of visits was higher for both sexes than in the corresponding period in the 2019 reference periods (i.e., summer 2019, winter 2019) by 22.3% and 39.1%, respectively. Across the pandemic, the number of visits increased, which was largely driven by visits among females. In all periods, the ratio comparing the proportion of emergency department visits that were suspected suicide attempts comparing girls to boys was above 1 (range: 2.51 to 3.44). Comparing winter periods, the increase in visits in winter 2021 (compared to winter 2019) was larger for females (50.6%) than males (3.7%).

Among psychiatrically-hospitalized adolescents in Rhode Island, the past 7-day suicide attempts rate ((phi = 0.11): 24.6% versus 15.8%; $x^2 = 4.09$, $p = 0.043$) and past 30-day suicide attempt rate ((phi = 0.13): 31.0% versus 19.4%; $x^2 = 6.03$, $p = 0.014$) was significantly greater in

2020 compared to 2019 (40). Higher Suicidal Ideation Questionnaire-Junior (SIQ-Jr) scores (indicating higher risk) were reported in 2020 (m = 36.08, SD = 27.66) than in 2019 (m = 30.05, SD = 26.23; t(336) = −2.04, p = .042, Hedges' g = 0.22). In 2020, 47.2% of participants reported feeling suicidal in relation to COVID-19 to some extent (m = 2.57, SD = 1.16). Past 7-day and past 30-day suicide attempts did not differ by COVID-19 suicidal ideation status. However, SIQ-Jr scores were higher among those with COVID-19 suicidal ideation (m = 46.99, SD = 24.22) than those without ((m = 26.35, SD = 27.05; t(140) = -4.77, p < .001), Hedges' g = 0.80). The authors further evaluated the role of specific stressors in suicidality. Not being able to attend special events (p = 0.01) was the only significantly different stressor between adolescents with COVID-19 suicidality and those without. Though not statistically significant at p < 0.05, money problems, conflict at home, and changing living circumstances were endorsed more highly among adolescents with COVID-19 suicidality (0.10 > p > 0.05). For adolescents experiencing their first hospitalization, those with COVID-19 suicidal ideation had higher ratings for being cutoff from contact with others (t(65) = -2.16, p = .034; Hedges' g = 0.53), being unable to leave home (t(65) = - 2.34, p = .022; Hedges' g = 0.58), missing events (t(65) = -2.57, p = .013; Hedges' g = 0.63), and not being able to see people they care about (t(65) = −2.14, p = .036; Hedges' g = 0.52). For adolescents with a history of hospitalization, those with COVID-19 suicidal ideation were more worried about contracting COVID-19 themselves (t(71.33) = -2.22, p = .030, Hedges' g = 0.51). However, COVID-19 suicidal ideation did not differ comparing those with and without previous psychiatric hospitalizations.

Finally, in a prospective cohort study including 31 adolescents who were recruited from adolescent in patient psychiatry unit with suicidal thinking or a recent suicide attempt who

were participating in an ongoing ecological momentary assessment study in which suicidal urges and intent were assessed multiple times a day, there was no increase in suicidal thinking observed for adolescents from the pre-pandemic phase to the pandemic phase (OR: 0.84, 95% CI: 0.69, 1.01, p = 0.07; data collected October 8, 2019 to April 17, 2020), though there was for adults (OR: 4.01, 95% CI: 3.28, 4.90, p < .001) (41). Inspection of trends visually indicated a small increase in suicidal thinking for adolescents in January and then decreases in the period leading to the pandemic. Comparing the periods before the pandemic (before March 13, 2020) and after the pandemic (after March 13, 2020) among adolescents, average suicidal ideation scores (possible range: 0 to 20) increased for 35.48%, decreased for 58.06%, and did not change for 6.45%.

5.5 Discussion

In our scoping review of the impact of the COVID-19 pandemic on social media use, substance use, and depressive symptoms among adolescents in the United States, we identified differences in the number of studies reporting on these facets of adolescent health and risk behavior by topic area. Many studies (n = 22) reported on depressive symptoms. Cross-sectional assessments of depressive symptoms during the pandemic indicated a high prevalence and longitudinal studies with baseline data collected prior to the pandemic largely indicated increased depressive symptoms during the pandemic. However, studies that reported on the trajectory of symptoms from the first month of the pandemic to a few months into the pandemic suggest a possible decrease in depressive symptoms during that span of time. Studies of depressive symptoms also assessed for differences by a wide variety of demographic,

developmental, and social factors with varying results. With respect to suicidality which was assessed in four studies, high levels of suicidal ideation and behavior were reported during the pandemic in both the general population and among adolescents who were psychiatrically hospitalized.

The available literature on social media use (n = 7) was diverse with respect to the ways in which social media use behaviors were being queried, but broadly they suggest that adolescents used social media for connection and coping during the COVID-19 pandemic which may reflect positive adaptive behavior in the context of physical distancing. Regarding substance use, our review identified only four articles that reported on the impact of the pandemic on substance use with results stratified to specifically among adolescents only. There was substantial heterogeneity in the format in which these articles presented results on adolescent substance use, which limits our ability to assess for similarities and/or differences in findings across studies. However, two articles noted lower e-cigarette use during the pandemic than before the pandemic. This observation could be due in part to public health messaging early in the pandemic about lung health with COVID-19 and electronic vapor product use.

Key strengths of this scoping review include a comprehensive search strategy of three sources and the use of the PRISMA-ScR guidelines (11). We also conducted a double review for the title/abstract screening, full text review, and extraction stages which minimizes potential bias. Limitations include the inability to disentangle the impact of co-occurring national events during the pandemic (i.e., highly publicized acts of racism and subsequent protests) and the high heterogeneity in measurement (e.g., assessment of social media use, tools used to measure depressive symptoms, etc.) which may limit comparability of included studies.

We identified a few studies that reported on social media posts (42,43) or news articles (44) as the unit of analysis. While these articles provide context to the broader picture of social media use, they are outside the scope of this review. Similarly, articles detailing the results of trainings for providers (45) were beyond our scope, but may hold potential implications for the adolescent experience of mental health during the COVID-19 pandemic. Due to our exclusion criteria, we are not able to generalize our findings to locations outside of the United States or to young adults. Our exclusion criteria were designed to include only studies that reported adolescent-specific results due to the uniqueness of this developmental period, which resulted in the exclusion of a number of unstratified studies (e.g., ages 0 to 18 years, etc.) that may provide additional context.

Though limited by the scope of available information, the findings of this scoping review indicate a number of key areas of priority for adolescent health. Namely, adolescents may be experiencing increased depressive symptoms during the COVID-19 pandemic. While these symptoms may wane over time short term, it is of the utmost importance that adolescents have access to resources to ameliorate negative affective states. It is additionally possible that the exposure to extended stress and trauma related to the ongoing pandemic has the potential to negatively impact adolescent mental health beyond the first year of the pandemic (46). Furthermore, adolescents would benefit from intensified screening efforts to identify depressive symptoms in schools, which are the source of mental health services for many students (47,48). Thus, schools and communities should consider options for augmenting mental health resources for students given the potentially higher prevalence of depressive symptoms. Additionally, caregivers should be provided with resources to support skills

development for encouraging both adolescents and their caregivers to build resilience. Similarly, with respect to social media use, which is utilized for accessing news (49,50) and connection, parents, guardians, teachers, healthcare providers, and other adults with key roles in adolescent lives should seek to discuss and teach about healthy social media use habits, especially within the context of potentially increased use in the face of the pandemic.

Regarding substance use, resources on the risks associated with adolescent substance use should be provided to parents, guardians, and adolescents themselves. Further, while the pandemic may be associated with decreased electronic vapor product use, healthcare providers should seek opportunities to discuss continued diminished use or discontinued use with their adolescent patients and their families. Finally, given the paucity of information available on adolescent-specific substance use and social media use during the COVID-19 pandemic in the United States, more research is needed in these areas. As the impacts of the pandemic persist, both in terms of COVID-19 infections and other implications, research will be needed to delineate the potentially lasting impacts of the COVID-19 pandemic. Future adolescent research priorities related to the COVID-19 pandemic include characterizing adolescent substance use including both protective and risk factors, facilitators for positive mental health, and strategies to encourage healthy social media use during times of physical distancing.

5.6 References

1. Johnston LD, Miech RA, Malley PMO, Bachman JG, Schulenberg JE, Patrick MeganE. Monitoring the Future national survey results on drug use 1975-2019: Overview, key findings on adolescent drug use. Ann Arbor, Michigan: Institute for Social Research, University of Michigan; 2020.

2. Substance Abuse and Mental Health Services Administration. Key substance use and mental health indicators in the United States: Results from the 2019 National Survey on Drug Use and Health (HHS Publication No. PEP20-07-01-001, NSDUH Series H-55) [Internet]. Rockville, MD: Center for Behavioral Health Statistics and Quality, Substance Abuse and Mental Health Services Administration; 2020 [cited 2022 Jan 13]. Available from: https://www.samhsa.gov/data/sites/default/files/reports/rpt29393/2019NSDUHFFRPDFWHTML/2019NSDUHFFR1PDFW090120.pdf

3. Edlund MJ, Forman-Hoffman VL, Winder CR, Heller DC, Kroutil LA, Lipari RN, et al. Opioid abuse and depression in adolescents: Results from the National Survey on Drug Use and Health. Drug and Alcohol Dependence [Internet]. 2015;152:131–8. Available from: http://dx.doi.org/10.1016/j.drugalcdep.2015.04.010

4. Chadi N, Li G, Cerda N, Weitzman ER. Depressive Symptoms and Suicidality in Adolescents Using e-Cigarettes and Marijuana. Journal of Addiction Medicine. 2019;13(5):1.

5. Pirkola SP, Marttunen MJ, Henriksson MM, Isometsä ET, Heikkinen ME, Lönnqvist JK. Alcohol-related problems among adolescent suicides in Finland. Alcohol and Alcoholism. 1999;34(3):320–9.

6. Uhls YT, Ellison NB, Subrahmanyam K. Benefits and Costs of Social Media in Adolescence. Pediatrics [Internet]. 2017 Nov 1 [cited 2022 Mar 29];140(Supplement_2):S67–70. Available from: https://publications.aap.org/pediatrics/article/140/Supplement_2/S67/34168/Benefits-and-Costs-of-Social-Media-in-Adolescence

7. Anderson M, Jiang J. Teens, Social Media & Technology 2018 [Internet]. Pew Research Center; 2018. Report No.: May. Available from: https://www.pewresearch.org/internet/2018/05/31/teens-social-media-technology-2018/

8. Fegert JM, Vitiello B, Plener PL, Clemens V. Challenges and burden of the Coronavirus 2019 (COVID-19) pandemic for child and adolescent mental health: A narrative review to highlight clinical and research needs in the acute phase and the long return to normality. Child and Adolescent Psychiatry and Mental Health [Internet]. 2020;14(1):1–11. Available from: https://doi.org/10.1186/s13034-020-00329-3

9. Singh S, Roy D, Sinha K, Parveen S, Sharma G, Joshi G. Impact of COVID-19 and lockdown on mental health of children and adolescents: A narrative review with recommendations. Psychiatry Research [Internet]. 2020 Nov;293:113429. Available from: https://linkinghub.elsevier.com/retrieve/pii/S016517812031725X

10. Silver RC, Holman EA, Garfin DR. Coping with cascading collective traumas in the United States. Nature Human Behaviour [Internet]. 2020; Available from: http://dx.doi.org/10.1038/s41562-020-00981-x

11. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Annals of Internal Medicine [Internet]. 2018 Oct;169(7):467–73. Available from: https://www.acpjournals.org/doi/10.7326/M18-0850

12. Willner CJ, Gatzke-Kopp LM, Bray BC. The dynamics of internalizing and externalizing comorbidity across the early school years. Development and Psychopathology [Internet]. 2016 Nov;28(4pt1):1033–52. Available from: https://www.cambridge.org/core/product/identifier/S0954579416000687/type/journal_article

13. Cummings CM, Caporino NE, Kendall PC. Comorbidity of anxiety and depression in children and adolescents: 20 years after. Psychological Bulletin [Internet]. 2014 May;140(3):816–45. Available from: http://doi.apa.org/getdoi.cfm?doi=10.1037/a0034733

14. Harris PA, Taylor R, Minor BL, Elliott V, Fernandez M, O'Neal L, et al. The REDCap consortium: Building an international community of software platform partners. Journal of Biomedical Informatics [Internet]. 2019 Jul;95:103208. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1532046419301261

15. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. Journal of Biomedical Informatics [Internet]. 2009 Apr;42(2):377–81. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1532046408001226

16. Murata S, Rezeppa T, Thoma B, Marengo L, Krancevich K, Chiyka E, et al. The psychiatric sequelae of the COVID-19 pandemic in adolescents, adults, and health care workers. Depression and anxiety. 2021 Feb;38(2):233–46.

17. Penner F, Hernandez Ortiz J, Sharp C. Change in Youth Mental Health During the COVID-19 Pandemic in a Majority Hispanic/Latinx US Sample. Journal of the American Academy of Child & Adolescent Psychiatry [Internet]. 2021 Apr;60(4):513–23. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0890856720322127

18. Drouin M, McDaniel BT, Pater J, Toscos T. How Parents and Their Children Used Social Media and Technology at the Beginning of the COVID-19 Pandemic and Associations with Anxiety. Cyberpsychology, behavior and social networking. 2020 Nov;23(11):727–36.

19. Nelson KM, Gordon AR, John SA, Stout CD, Macapagal K. "Physical sex is over for now": Impact of COVID-19 on the well-being and sexual health of adolescent sexual minority males in the US. Journal of Adolescent Health [Internet]. 2020 Dec;67(6):756–62. Available from: http://offcampus.lib.washington.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2020-76182-001&site=ehost-live

20. O'Brien RP, Parra LA, Cederbaum JA. "Trying My Best": Sexual Minority Adolescents' Self-Care During the COVID-19 Pandemic. The Journal of adolescent health : official publication of the Society for Adolescent Medicine. 2021 Jun;68(6):1053–8.

21. Campbell K, Weingart R, Ashta J, Cronin T, Gazmararian J. COVID-19 Knowledge and Behavior Change among High School Students in Semi-Rural Georgia. The Journal of school health. 2021 Jul;91(7):526–34.

22. Gazmararian J, Weingart R, Campbell K, Cronin T, Ashta J. Impact of COVID-19 Pandemic on the Mental Health of Students From 2 Semi-Rural High Schools in Georgia. The Journal of school health. 2021 May;91(5):356–69.

23. Gaiha SM, Cheng J, Halpern-Felsher B. Association Between Youth Smoking, Electronic Cigarette Use, and COVID-19. The Journal of adolescent health : official publication of the Society for Adolescent Medicine. 2020 Oct;67(4):519–23.

24. Kreslake JM, Simard BJ, O'Connor KM, Patel M, Vallone DM, Hair EC. E-Cigarette Use Among Youths and Young Adults During the COVID-19 Pandemic: United States, 2020. American journal of public health. 2021 Apr;e1–9.

25. Chaffee BW, Cheng J, Couch ET, Hoeft KS, Halpern-Felsher B. Adolescents' Substance Use and Physical Activity Before and During the COVID-19 Pandemic. JAMA pediatrics. 2021 May;

26. McGuine TA, Biese KM, Petrovska L, Hetzel SJ, Reardon C, Kliethermes S, et al. Mental Health, Physical Activity, and Quality of Life of US Adolescent Athletes During COVID-19-Related School Closures and Sport Cancellations: A Study of 13 000 Athletes. Journal of athletic training. 2020 Dec;56(1):11–9.

27. McGuine TA, Biese K, Hetzel SJ, Schwarz A, Kliethermes S, Reardon CL, et al. High School Sports During the CoVID-19 Pandemic: The Impact of Sport Participation on the Health of Adolescents. Journal of athletic training. 2021 May;

28. McGuine TA, Biese K, Hetzel SJ, Petrovska L, Kliethermes S, Reardon CL, et al. Changes in the Health of Adolescent Athletes: A Comparison of Health Measures Collected Before and During the CoVID-19 Pandemic. Journal of athletic training. 2021 Apr;

29. McKune SL, Acosta D, Diaz N, Brittain K, Beaulieu DJ, Maurelli AT, et al. Psychosocial health of school-aged children during the initial COVID-19 safer-at-home school mandates in Florida: a cross-sectional study. BMC public health. 2021 Mar;21(1):603.

30. Fitzpatrick O, Carson A, Weisz JR. Using Mixed Methods to Identify the Primary Mental Health Problems and Needs of Children, Adolescents, and Their Caregivers during the Coronavirus (COVID-19) Pandemic. Child psychiatry and human development. 2020 Oct;1–12.

31. Lorenzo NE, Zeytinoglu S, Morales S, Listokin J, Almas AN, Degnan KA, et al. Transactional Associations Between Parent and Late Adolescent Internalizing Symptoms During the COVID-19 Pandemic: The Moderating Role of Avoidant Coping. Journal of youth and adolescence. 2021 Mar;50(3):459–69.

32. Hawes MT, Szenczy AK, Olino TM, Nelson BD, Klein DN. Trajectories of depression, anxiety and pandemic experiences; A longitudinal study of youth in New York during the Spring-Summer of 2020. Psychiatry research. 2021 Apr;298:113778.

33. Breaux R, Dvorsky MR, Marsh NP, Green CD, Cash AR, Shroff DM, et al. Prospective impact of COVID-19 on mental health functioning in adolescents with and without ADHD: protective role of emotion regulation abilities. Journal of child psychology and psychiatry, and allied disciplines. 2021 Feb;

34. Chahal R, Kirshenbaum JS, Miller JG, Ho TC, Gotlib IH. Higher Executive Control Network Coherence Buffers Against Puberty-Related Increases in Internalizing Symptoms During the COVID-19 Pandemic. Biological Psychiatry: Cognitive Neuroscience and Neuroimaging [Internet]. 2021;6(1):79–88. Available from: https://doi.org/10.1016/j.bpsc.2020.08.010

35. Rogers AA, Ha T, Ockey S. Adolescents' Perceived Socio-Emotional Impact of COVID-19 and Implications for Mental Health: Results From a U.S.-Based Mixed-Methods Study. The Journal of adolescent health : official publication of the Society for Adolescent Medicine. 2021 Jan;68(1):43–52.

36. Yarrington JS, Lasser J, Garcia D, Vargas JH, Couto DD, Marafon T, et al. Impact of the COVID-19 Pandemic on Mental Health among 157,213 Americans. Journal of affective disorders. 2021 May;286:64–70.

37. Sinko L, He Y, Kishton R, Ortiz R, Jacobs L, Fingerman M. "The Stay at Home Order is Causing Things to Get Heated Up": Family Conflict Dynamics During COVID-19 From The Perspectives of Youth Calling a National Child Abuse Hotline. Journal of family violence. 2021 Jun;1–10.

38. Ridout KK, Alavi M, Ridout SJ, Koshy MT, Harris B, Dhillon I, et al. Changes in Diagnostic and Demographic Characteristics of Patients Seeking Mental Health Care During the Early COVID-19 Pandemic in a Large, Community-Based Health Care System. The Journal of clinical psychiatry. 2021 Mar;82(2).

39. Yard E, Radhakrishnan L, Ballesteros MF, Sheppard M, Gates A, Stein Z, et al. Emergency Department Visits for Suspected Suicide Attempts Among Persons Aged 12-25 Years Before and During the COVID-19 Pandemic - United States, January 2019-May 2021. MMWR Morbidity and mortality weekly report. 2021 Jun;70(24):888–94.

40. Thompson EC, Thomas SA, Burke TA, Nesi J, MacPherson HA, Bettis AH, et al. Suicidal thoughts and behaviors in psychiatrically hospitalized adolescents pre- and post- COVID-19: A

historical chart review and examination of contextual correlates. Journal of affective disorders reports. 2021 Apr;4:100100.

41. Fortgang RG, Wang SB, Millner AJ, Reid-Russell A, Beukenhorst AL, Kleiman EM, et al. Increase in suicidal thinking during COVID-19. Clinical Psychological Science [Internet]. 2021 May;9(3):482–8. Available from: http://offcampus.lib.washington.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2021-46775-014&site=ehost-live

42. Unni Z, Weinstein E. Shelter in Place, Connect Online: Trending TikTok Content During the Early Days of the U.S. COVID-19 Pandemic. The Journal of adolescent health : official publication of the Society for Adolescent Medicine. 2021 Apr;

43. Zhang C, Xu S, Li Z, Hu S. Understanding Concerns, Sentiments, and Disparities Among Population Groups During the COVID-19 Pandemic Via Twitter Data Mining: Large-scale Cross-sectional Study. Journal of medical Internet research. 2021 Mar;23(3):e26482.

44. Manzar MD, Albougami A, Usman N, Mamun MA. Suicide among adolescents and youths during the COVID-19 pandemic lockdowns: A press media reports-based exploratory study. Journal of child and adolescent psychiatric nursing : official publication of the Association of Child and Adolescent Psychiatric Nurses, Inc. 2021 Apr;

45. Olson JR, Lucy M, Kellogg MA, Schmitz K, Berntson T, Stuber J, et al. What Happens When Training Goes Virtual? Adapting Training and Technical Assistance for the School Mental Health Workforce in Response to COVID-19. School mental health. 2021 Jan;1–14.

46. de Figueiredo CS, Sandre PC, Portugal LCL, Mázala-de-Oliveira T, da Silva Chagas L, Raony Í, et al. COVID-19 pandemic impact on children and adolescents' mental health: Biological, environmental, and social factors. Progress in Neuro-Psychopharmacology and Biological Psychiatry [Internet]. 2021 Mar [cited 2022 Feb 21];106:110171. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0278584620304875

47. Duong MT, Bruns EJ, Lee K, Cox S, Coifman J, Mayworm A, et al. Rates of Mental Health Service Utilization by Children and Adolescents in Schools and Other Common Service Settings: A Systematic Review and Meta-Analysis. Administration and Policy in Mental Health and Mental Health Services Research. 2020;(0123456789).

48. Ali MM, West K, Teich JL, Lynch S, Mutter R, Dubenitz J. Utilization of Mental Health Services in Educational Setting by Adolescents in the United States. Journal of School Health. 2019;89(5):393–401.

49. Tandoc EC, Johnson E. Most students get breaking news first from Twitter. Newspaper Research Journal. 2016;37(2):153–66.

50. Craft S, Ashley S, Maksl A. Elements of News Literacy. Electronic News. 2016;10(3):143–60.

5.7 Funding and Acknowledgements

This work was supported in part by a student project stipend from the Northwest Public Health Training Center at the Northwest Center for Public Health Practice (sponsored by the Health Resources and Services Administration (HRSA) of the U.S. Department of Health and Human Services (HHS) (grant # 6 UB6HP31690-04-01)) and by the Health Resources and Services Administration (HRSA) of the U.S. Department of Health and Human Services (HHS) under grant #T76MC00011. REDCap at ITHS is supported by the National Center For Advancing Translational Sciences of the National Institutes of Health under Award Number UL1 TR002319. Ruchi Tiwari was the second reviewer for this scoping review.

5.8 Tables and Figures

Figure 5.1: PRISMA Diagram

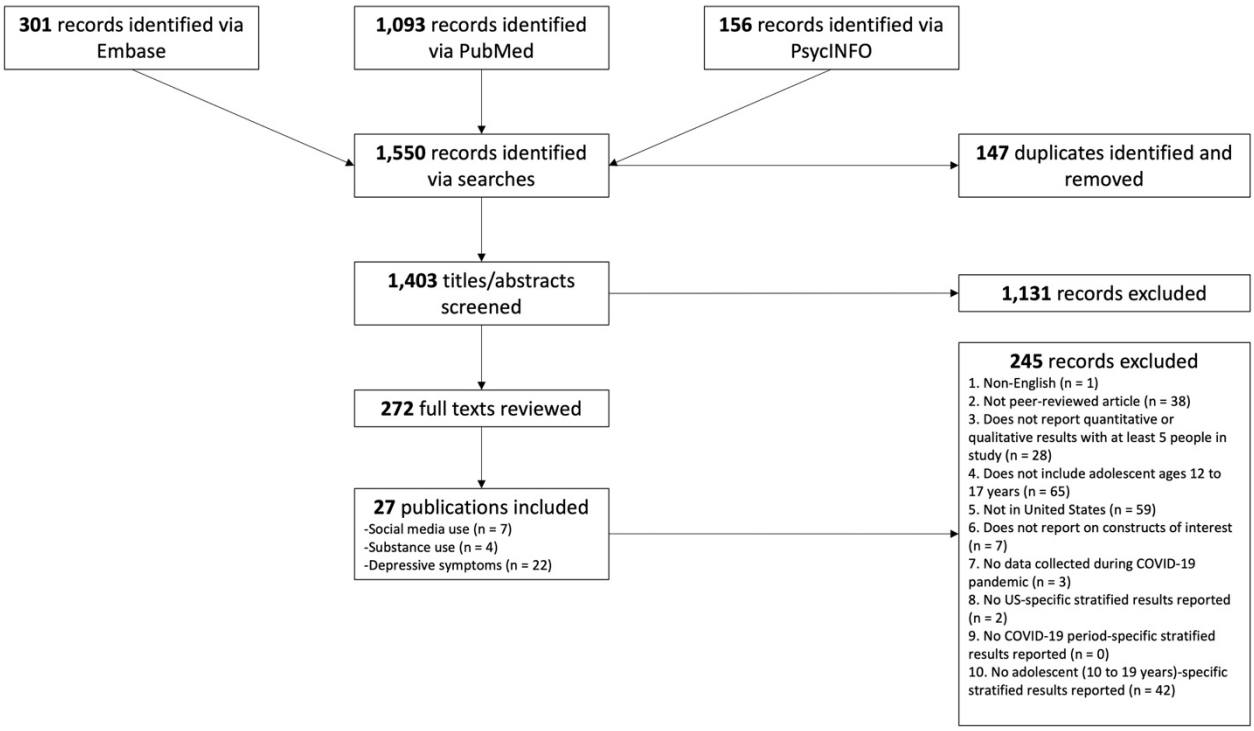


Table 5.1: Characteristics of Included Studies

First Author (Year)	Adolescent Age Range (Years)	Sample Description	Sample Size	Location	Dates of Data Collection	Study Design
Breaux (2021)	15 – 17	Adolescents with and without ADHD; 82% White, 7% biracial/multiracial, 6% Black, 4% Asian, and 1% identifying as another race; 4% Hispanic/Latinx	238	Ohio, Kentucky, and Virginia	1st: May 15, 2020 – June 14, 2020 (stay at home orders in place); 2nd: July 1, 2020 – August 5, 2020 (stay at home orders lifted); September 2018 – February 2020 (baseline)	Prospective cohort
Campbell (2021)	Grades 9 - 12	High school students at racially and economically diverse public schools	761	North-central Georgia	March 30, 2020 – May 8, 2020	Cross-sectional
Chaffee (2021)	10th and 11th grade students	Students in public high schools, approximately 50% non-Hispanic white and approximately 35% Hispanic/Latinx	1,423 at pre-COVID-19 baseline, 950 responses after March 19, 2020	Northern California	March 2019 – September 2020	Prospective cohort
Chahal (2021)	13 – 19 during COVID-19; 9 – 13 at baseline	Participants in longitudinal study of effects of early-life stress on psychobiological development	85	San Francisco Bay Area	April 3, 2020 – April 20, 2020 (COVID-19 data); 2013 – 2016 (baseline)	Prospective cohort

		throughout the course of puberty				
Drouin (2020)	22 – 62 years old (with a child(ren) age 19 years or younger)	Parents of children ages 19 or younger	260 (61 had a youngest child that was 13-18, though 205 had more than one child)	United States (64.6% Midwest)	March 20, 2020 – March 25, 2020	Cross-sectional
Fortgang (2021)	Adolescent sample: 12 – 19*	People recruited from adolescent in patient psychiatry unit (adolescents) or large urban hospital emergency department (adults) with suicidal thinking or a recent suicide attempt who were participating in an ongoing longitudinal study	55 (31 adolescents)	United States (not specified)	October 8, 2019 – April 17, 2020	Prospective cohort
Fitzpatrick (2020)	Caregivers: 18 – 60; children & adolescents: 1 – 19 (adolescents classified as 13 – 19)	Caregivers (81% female) who were racially and economically diverse	133 (29 adolescents)	United States (32 states, 116 cities)	April 20, 2020 – July 3, 2020	Cross-sectional
Gazmararian (2021)	9^{th} – 12^{th} graders	Students in semi-rural public high schools; includes some students with disabilities or who	761	Semi-rural north central Georgia	March 30, 2020 – May 8, 2020	Cross-sectional

		were English language learners				
Gaiha (2020)	13 – 24 (adolescents classified as 13 – 17)	Results weighted to be representative of US population	4,351 (1,442 adolescents)	United States (all states)	May 6, 2020 – May 14, 2020	Cross-sectional
Hawes (2021)	12 – 22 years (modeled estimates stratified for 16 – 19)	Participants in ongoing longitudinal studies; 69% female, 82% White/Non-Hispanic	532	Long Island, New York	1st: March 27, 2020 – May 15,2020; 2nd: April 27, 2020 – June 30, 2020; 3rd:May 25th – July 14th, 2020	Prospective cohort
Kreslake (2021)	15 – 24 years ("youth" classified as 15 to 17)	Recruited via Dynata opt-in online panel	5,164 (1,562 youth) completed survey between January 1, 2020 and June 29, 2020; 3,408 (944 youth) completed survey between March 14, 2020 and June 29, 2020	United States	January 1, 2020 – June 29, 2020	Cross-sectional
Lorenzo (2021)	16.78 – 19.04 at 1st assessment; 18.85 to 19.17 at 2nd assessment**	Participants in a larger, longitudinal study to examine temperament and psychopathology	291	Large metropolitan city in the Mid-Atlantic region	1st: April 20, 2020 – May 15, 2020; 2nd: approximately 1 month after T1 (mean = 26.48 days, SD = 7.31 days)	Prospective cohort

McGuine (2020)	13 – 19 (grades 9 – 12)	National sample of US high school adolescents who were athletes	13,002	National (majority Midwest (70.2%))	May 2020	Cross-sectional
McGuine (2021a)	13 – 19 (grades 9 – 12)	Students who were athletes in high school; 84% public schools, 58% females	3,243 (results are weighted)	Wisconsin	May 2020	Cross-sectional
McGuine (2021b)	13 – 19 (grades 9 – 12)	High school athletes (56.3% male; 66.2% reported schools canceled fall sports))	559	United States (state not specified by likely Wisconsin?)	October 2020	Cross-sectional
McKune (2021)	Kindergartners – 12th graders (with middle school and high school groups)	K-12 students at a research school; 62% White, 19% Hispanic, 10% multiracial, 9% Black	111 high school students, 82 middle school students	North Central Florida	April 2020	Cross-sectional
Murata (2021)	13+ ("adolescents" classified as 13 – 18)	Respondents to online survey; 80% Females, 71% White	4,909 (583 adolescents)	United States	April 27, 2020 – July 13, 2020	Cross-sectional
Nelson (2020)	14 – 17	Cisgender males who identify as gay/bisexual, report being sexually attracted to males or voluntary sexual contact with a male partner in the past year, report having intentionally viewed pornography,	151	United States (all regions)	March 27, 2020 – May 8, 2020	Cross-sectional

		and reside in the US (52% White, 27% Latino, 11% Black/African American, 11% mixed race/another race)				
O'Brien (2021)	15 to 19	Sexual minority adolescents; 58.3% white, 7.5% Asian/Pacific Islander, 7.8% Black or African American, 2.7% Native American, American Indian, or Alaska Native, 14.4% Latino/Hispanic, 9.2% Multiracial	770	United States (47 states, DC, and Puerto Rico)	May 13, 2020 – May 31, 2020	Qualitative
Oosterhoff (2020)	13 – 18	75.3% female, 22.7% male participants, 4.9% identifying as nonbinary; white/ Caucasian (77.0%), Hispanic/Latino (15.5%), African American/Black (5.6%), Asian American/Pacific Islander (11.1%), American Indian/Alaskan Native (3.2%), or other (2.9%)	683	United States	March 29, 2020 – March 30, 2020	Cross-sectional
Penner (2021)	10 – 14	In grades 5 to 8; 72.7% Hispanic/Latinx, 9.3% Black or African American	322 (any data collected during COVID-19); 185 (in	Large city in southwestern US	January 2020 – May 2020	Prospective cohort

			the COVID-19 survey subsample)			
Ridout (2021)	All ages (with 13 – 17 age category)	Kaiser Permanente Northern California patients (representative of population in surrounding areas)	165,696 contacts (94,720 patients of all ages) in 2019, 181,015 (94,589 patients of all ages) contacts in 2020	Northern California	March 9, 2019 – May 31, 2019 and March 9, 2020 – May 31, 2020	Pre-post
Rogers (2021)	14 – 17	Sampled based on national quotas for parent/guardian race/ethnicity, formal education, and child sex; recruited via parents participation on Bovitz (third party research service)	407	United States	April 11, 2020 – April 25, 2020; October 2019 (baseline)	Prospective cohort
Sinko (2021)	10 – 18	Children and adolescents who submitted a text or chat inquiry to The Childhelp National Child Abuse Hotline that were classified by counselors as having a co-occurring COVID-19 concern; 65.5% female	105 text and chat transcripts	United States***	May 1, 2020 – June 30, 2020	Qualitative
Thompson (2021)	11 – 18	Adolescents who were psychiatrically-hospitalized	142 (2020); 196 (2019)	Rhode Island	April 13, 2020 – September 14, 2020; April 13, 2019 –	Cross-sectional

					September 14, 2019 (comparison)	
Yard (2021)	12 – 25 (12 – 17 adolescents)	People who visited emergency departments for suicide attempts and nonsuicidal self-harm	Not specified	All US and DC (except Hawaii)	January 1, 2019 – May 15, 2021	Pre-post
Yarrington (2021)	13 – 100 (adolescents 13 – 18)	Users of Youper (app for cognitive and behavioral interventions); 83.91% women	157,213 (23,615 adolescents)	United States	February 2, 2020 – July 6, 2020	Pre-post

*Age range of adolescent sample via email from Dr. Becky Fortgang on 10/20/2021.

**Age range of sample from Dr. Nicole Lorenzo on 05/27/2021.

***Confirmed all of sample was from the United States via email from Dr. Laura Sinko on 10/07/2021.

Table 5.2: Key Findings of Studies Reporting on Social Media Use

Author (Year)	Social Media Measurement	Key Findings
Campbell (2021)	Responses to "Where do you get information on the coronavirus?"	57.7% of respondents indicated social media as a news source. Only peers (80.4%) was endorsed more frequently.
Drouin (2020)	Parent report to questions about their children's technology use	For adolescents ages 13-19, the mean response to "Has your child(ren) increased their use of technology TO CONNECT with others outside your home?" via a scale of 0 to 4 (0, does not use technology, 1, no, and 4, yes) was 3.07 (SD: 1.04) which was significantly higher than the means for 0-5 years old and 6-12 years old. 44.3% reported "yes, a lot", 27.9% reported "yes, some", 14.8% reported "yes, but only a little bit", 11.5% reported "no", and 0.0% reported "does not use technology". In factor analyses of the question "Since social distancing began, how frequently does YOUR CHILD do the following things on technology TO CONNECT with others outside your home?" with responses of 0 (never) to 5 (multiple times a day), the mean score for adolescents 13-19 years for social media/technology use was 3.51 (SD: 1.08) which was significantly higher than younger age groups.
Gazmararian (2021)	Indicating “social media” in response to the question “what strategies are you using to cope with stress, fear, or anxiety during the coronavirus pandemic?”	50.8% of participants reported using social media to cope, with no difference by racial/ethnic identity ($p = 0.0939$), free and reduced lunch eligibility ($p = 0.1019$), or grade level ($p = 0.5149$). More girls (56.6%) than boys (40.8%) reported using social media to cope ($p < 0.0001$).
Murata (2021)	Hours of social media use per day	The mean number of hours per day of social media use since COVID-19 was 4.6 (SD: 3.6).
Nelson (2020)	Responses to a sliding scale for changes in the past three months Open-ended response to “Please describe some of the	Participants reported messaging on men-seeking-men websites and/or phone applications at about the same amount since COVID-19 (on a scale of 0 less often to 100 more often; mean = 44.3, 95% CI: 35.2, 53.4). Some qualitative responses referenced an increase in virtual connection with sexual partners (mentioned by 10% of participants). For example, one quote

	main ways the new corona virus (COVID-19) has changed your sexual life in the past three months, if at all:”	concerning social media use by a Black/African American, not out 16 year old participant that was highlighted in the article was: "I definitely think that the age of physical sex is over for now. A lot more guys are bored, and horny, so they tend to want to have virtual sex via Skype or Snapchat.".
O’Brien (2021)	Open-ended responses to "what have you been doing to care for yourself in these difficult times?"	Participants noted the importance of support of friends and peers and noted social media as a communication venue and one quote indicated "browsing social media". Social media was also noted as a method of tuning out and ignoring “the stuff that’s going on”.
Penner (2021)	Reported frequency of contact with friends (video, social media)	There was a range of contact with friends during pandemic (video, social media) among the 185 participants who responded in mid-April 2020: 20.0% reported not at all, 30.8% reported a little, 28.1% reported a lot, 21.1% reported a whole lot.

Table 5.3: Key Findings of Studies Reporting on Substance Use

Author (Year)	Substance Use Measurement	Key Findings
Chaffee (2021)	Past-30 day substance use	Participants indicated whether and for how many days they had used substances in the past 30 days. Following the stay-at-home order, past 30-day e-cigarette was lower (17% to 11% for spring 2019 cohort; 20% to 11% for fall 2019 cohort; no significant difference in trajectory by cohort). There were no significant differences by cohort for cannabis or alcohol use trajectories. However, cannabis use was significantly lower at the 6 month follow up point for the fall 2019 cohort (OR: 0.56, 95% CI: 0.39, 0.79). Combining the cohorts, use of e-cigarettes was significantly lower (March 19, 2020 or later; before: 16.1%, after: 10.7%, $p < 0.001$) after the stay-at-home order, but cannabis ($p=0.24$) and alcohol ($p=0.57$) use were not statistically significantly different. Looking specifically at responses after April 18, 2020, e-cigarette use was significantly lower (before: 17.9%, after: 10.2%, $p < 0.001$), but cannabis ($p=0.10$) and alcohol ($p=0.60$) use were not statistically significantly different. However, in adjusted models for after the stay-at-home order and excluding follow up from March 20 to April 18 identified no statistically significant differences.
Gaiha (2020)	Ever-use of e-cigarettes	Among adolescents who were never-users, 16.1% reported COVID-19-related symptoms, 2.8% reported a COVID-19 test, and 0.1% reported a COVID-19-positive diagnosis. Among adolescents who were e-cigarette users, 25.5% reported COVID-19-related symptoms, 16.3% reported a COVID-19 tests, and 1.2% reported a COVID-19-positive diagnosis.
Kreslake (2021)	Past 30-day e-cigarette use	The prevalence of past-30 day e-cigarette use decreased from January 2020 (20.6%) to June 2020 (13.6%) among 15 – 17 year olds. The odds of e-cigarette use (OR = 0.72; 95% CI: 0.54, 0.96) and non-JUUL e-cigarette use (OR = 0.71, 95% CI: 0.52, 0.97) were significantly lower during the COVID-19 pandemic period compared to the pre-COVID-19 pandemic period. Compared to non-Hispanic White or other non-Hispanic respondents, non-Hispanic Black respondents had lower odds of past-30 day e-cigarette use (OR: 0.45, 95% CI: 0.26, 0.78) and non-JUUL e-cigarette use (OR: 0.37, 95% CI: 0.19, 0.73) during

		the COVID-19 pandemic. Compared to adolescents with higher perceived financial circumstances (meet basic needs with at least a little left over), individuals with low perceived financial circumstances had higher odds of past-30 day e-cigarette use during the COVID-19 pandemic (OR 1.44, 95% CI: 1.06, 1.96). Among a subsample of current e-cigarette users, 15 – 17 year olds were not more likely (aOR: 1.00, 95% CI: 0.64, 1.55) to report that they were using e-cigarettes less than before the COVID-19 pandemic compared to 21 – 24 year olds.
O'Brien (2021)	Open-ended responses to "what have you been doing to care for yourself in these difficult times?"	A small proportion (exact statistic not reported) of sexual minority adolescents noted substance use including vaping, alcohol, and cannabis. One participant described the process of relapsing after being sober.

Table 5.4: Key Findings of Studies Reporting on Depressive Symptoms

Author (Year)	Substance Use Measurement	Key Findings
Breaux (2021)	Depression symptoms measured with Vanderbilt ADHD Diagnostic Rating Scale	Depression symptoms were highest in spring 2020 (mean: 50.95, SD: 15.01), and significantly different from pre-COVID-19 (mean: 45.10, SD: 13.04) and summer 2020 (mean: 46.19, SD: 13.70). In repeated measures ANOVA, changes depression symptoms were significantly associated with emotion regulation abilities pre-COVID-19 ($p < 0.001$) such that adolescents with poorer emotion regulation abilities reported more depression symptoms at all time points (paired sample t-tests $p < 0.006$), but no differences were observed for sex (repeated measures ANOVA $p = 0.224$), race/ethnicity (repeated measures ANOVA $p = 0.312$), income (repeated measures ANOVA $p = 0.616$), or ADHD status (repeated measures ANOVA $p = 0.529$). There was no evidence of an interaction between pre-COVID-19 emotion regulation ability and ADHD status for this depression symptoms ($p = 0.519$).
Chahal (2021)	Internalizing symptom severity in the peri-COVID period through the emotions and worries domain of the Coronavirus Health Impact Survey and at baseline with the Youth Self Report.	Pubertal stage was positively associated with internalizing symptom severity at the COVID-19 time point ($p < 0.05$), but not at the pre-COVID-19 assessment ($p > 0.05$). Internalizing severity during COVID-19 was greater among girls ($t(83)=3.77$, $p < 0.01$). This was also true in the pre-COVID-19 period ($t(83)=2.37$, $p = 0.02$), but not at T1 ($p=0.11$). Internalizing symptoms at T1 were correlated with the severity of internalizing symptoms in the pre-COVID-19 period ($r(83)=0.22$, $p = 0.04$) but not the peri-COVID-19 period ($r(83) = 0.21$, $p = 0.05$). The average increase in internalizing severity in the recent 2 weeks during the COVID-19 time period was 0.42 (range: -1.50, 2.00; from a mean of 2.33 in the 3 months before COVID-19), and this was statistically different from the pre-COVID-19 internalizing scores ($t84 = 6.00$, $p < 0.0001$). This increase from pre to during COVID-19 was greater for participants who were at more advanced stages of puberty at T1 (controlled for age) ($B = 0.21$, $t65 = 2.07$, $p = 0.04$). However, this difference by pubertal stage was moderated by bilateral executive control network coherence ($B = -0.28$, $t65 = -2.81$, $p = 0.007$); in slope analyses, there was a positive association between pubertal stage and difference in internalizing severity

		with low bilateral executive control network coherence (B = 0.49, p < 0.01), but not high (B = 0.06, 0.63). A Johnson-Neyman plot demonstrated this difference comparing above and below average executive control network coherence. Sensitivity analyses indicated that only the left executive control network (t(63) = -2.25, p = 0.01) moderated this association and not the right (p = 0.10). In additional sensitivity analyses of the default mode network and salience network, neither had a significant main effect with the difference between the pre- and peri-COVID-19 internalizing severity scores (DMN: p = 0.08; SN: p = 0.66) nor for the interaction between pubertal stage and this difference (DMN: p = 0.11; SN: 0.73). In further sensitivity analyses, there was a three-way interaction between sex, pubertal stage, and executive control network coherence (t(62) = 2.14, p = 0.04), such that the positive association between pubertal stage and difference internalizing severity was significant when executive control network coherence was low (B=0.44, p=0.03), but not when it was high (B=0.04, p = 0.79). Among males, the positive association was observed when executive control network coherence was low (B=0.85, p < 0.01), but a negative association was observed when executive control network coherence was high (B = -0.56, p = 0.03; more advanced puberty at T1 was associated with decrease in internalizing severity during COVID-19).
Fitzpatrick (2020)	Caregiver responses to "Please list up to three of the top emotional, behavioral, or mental health problems this child has right now."	Problems with depression were more commonly reported among adolescents (as reported by caregivers) (t=7.02, p < 0.01, 95% CI: 4.28, 7.72). For 13 to 19 year olds, the most commonly reported problems were depression (55%) was the most commonly reported problem, compared to 18% among the 6 to 12 year old group.
Fortgang (2021)	Participants were asked multiple times a day to rate current suicidal urges and intent (both assessed with 0 to 10 and then summed to a suicidal thinking score ranging from 0 to 20).	There was no increase in suicidal thinking observed for adolescents (OR: 0.84, 95% CI: 0.69, 1.01], p = .067) from the pre-pandemic phase to the pandemic phase, though there was for adults (OR: 4.01, 95% CI: 3.28, 4.90, p < .001). Inspection of trends visually indicates a small increase in suicidal thinking for adolescents in January and then decreases in the period leading to the pandemic. Comparing the periods before the pandemic (before March 13, 2020) and after the pandemic (after March 13, 2020) among adolescents,

		average levels of suicidal thoughts increased for 35.48%, decreased for 58.06%, and did not change for 6.45%.
Gazmararian (2021)	Responses to "in the past 7 days, how often have you felt down, depressed, or hopeless?"	44.5% responded "not at all or less than 1 day", 25.9% "1-2 days", and 29.6% "3 or more days". More students (46%) in the "other" racial category (including multiracial, Asian, Native Hawaiian/Other Pacific Islander, and American Indian/Alaska Native students) indicated 3 or more days than other racial/ethnic groups ranging from 26% to 29% (chi-squared = 15.02, p = 0.0201). Girls (35.4%) were more likely than boys (19.3%) to report feeling depressed/down/hopeless for 3 or more days (p < 0.0001). Students in older grade levels reported feeling more depressed/hopeless than students in younger grade levels (p = 0.0059), but there was no difference by free and reduced lunch eligibility (p = 0.5617). In stratified tables, social media use (increased vs. no increase) did not appear to have an impact on feeling down, depressed, or hopeless.
Hawes (2021)	Depression measured using Children's Depression Inventory	There was an estimated positive slope for change in depression from April to July for 16 year olds (estimate = 2.45, SE = 0.49, t = 5.01, p < .001), 17 year olds (estimate = 1.62, SE = 0.35, t = 4.61, p < .001), and 18 year olds (estimate = 0.79, SE = 0.34, t = 2.32, p = .02), but a non-significant slope for 19 year olds (estimate = -0.04, SE = 0.47, t = -0.09, p = .93). There were negative curve effects for 16 year olds (estimate = -0.93, SE = 0.18, t = -5.15, p < .001), 17 year olds (estimate = -0.63, SE = 0.13, t = -4.76, p < .001), and 18 year olds (estimate = -0.34, SE = 0.13, t = -2.62, p = 0.01), but not for 19 year olds (estimate = -0.04, SE = 0.17, t = -0.25, p = 0.80).
Lorenzo (2021)	Depressive symptoms measured with short form Patient Health Questionnaire (PHQ-8). Internalizing symptoms were measured as an internalizing problem score (a sum of PHQ-8 and anxiety GAD-7 scores).	At T1, 30% of participants reported clinically significant depressive symptoms compared to 25% at T2. By paired samples t-test, there was a decrease in internalizing (depressive symptoms + anxiety) symptoms from T1 to T2 (t(145) = 3.26, p = 0.001). Adolescent internalizing symptoms at T2 where statistically significantly associated with adolescent internalizing at T1 (standardized B = 0.61, p < 0.001), parent internalizing at T1 (standardized ß = 0.11, p = 0.006), adolescent avoidant coping at T1 (standardized ß = 0.18, p = 0.007), an interaction between parent internalizing and adolescent coping at

		T1 (standardized ß = 0.13, p = 0.004) such that when adolescent avoidant coping was moderate (p = 0.006) or high (p < 0.001) (but not low (p = 0.914)) higher parent internalizing symptoms at T1 were predictive of higher adolescent T2 internalizing symptoms, adolescent time between stay-at-home order (standardized ß = -0.32, p = 0.002), and adolescent time between assessments (standardized ß = 0.20, p = 0.008). In a cross-lagged moderation model which also controlled for parent and adolescent anxiety symptoms at T2, a direct effect of T1 adolescent avoidant coping was observed on T2 adolescent depressive symptoms (standardized ß = 0.36, p = 0.007). Additional associations with adolescent depressive symptoms at T2 were observed for adolescent depressive symptoms at T1 (standardized ß = 0.36, p < 0.001), an interaction between parent depressive symptoms at T1 and adolescent coping at T1 (standardized ß = 0.12, p =0.023) such that there was a positive association between parent depressive symptoms at T1 and adolescent depressive symptoms at T2 when adolescent avoidant coping was high (p = 0.003) but not when moderate (p = 0.402) or low (p = 0.063), and adolescent anxiety at T2 (standardized ß = 0.40, p < 0.001).
McGuine (2020)	Depression was measured via the Patient Health Questionnaire 9-Item (PHQ-9) survey (possible score range of 0 to 27 with higher score indicating greater level of depression). PHQ-9 scores were categorized into minimal or none (0 to 4), mild (5 to 9), moderate (10 to 14), moderately severe (15 to 19), and severe (20+).	Among all participants, the mean total score was 8.7 (95% CI: 8.4, 9.0). It was higher among females (9.7, 95% CI: 9.4, 10) than males (7.3, 95% CI: 7.0, 7.7), and more males had minimal or no depression (40.3%; 95% CI: 40.0, 40.6) compare to females (24.7%; 95% CI: 24.4, 24.9). More females than males had moderate (female: 22.0%; 95% CI: 21.9, 22.2; male: 15.7; 95% CI: 15.6, 15.9) and moderately severe (female: 15.7%; 95% CI: 15.6, 15.9; male: 9.0; 95% CI: 8.8, 9.1) depression. Additionally, more females (7%; 95% CI: 6.8, 7.1) than males (3.5%; 95% CI: 3.4, 3.6) had severe depression. PHQ-9 score appeared to increase with grade level with a mean score of 7.4 (SD: 7.0, 7.7) for 9th graders up to a mean score of 9.9 (SD: 9.6, 10.2) for 12th graders. This increase was also reflected in differences in those with minimal or no depression (9th: 37.6%, 95% CI: 37.2, 38.0; 12th: 22.0%, 95% CI: 21.7, 22.3) and severe depression (9th: 4.0%, 95% CI: 3.9, 4.1; 12th: 8.1%, 8.0, 8.3). By type of sport participation (individual, individual and team, or team), mean

		PHQ-9 scores were higher for adolescents reporting team sport participation only (9.2; 95% CI: 8.9, 9.5) compared to individual only (7.9, 95% CI: 7.6, 8.3) and individual and team (8.0, 95% CI: 7.7, 8.4). Within PHQ-9 categories, the pattern was similar. By poverty level (defined by the percent of people under age 18 years living in poverty in participant zip code; low 2.5% to 10.9%, middle 10.95% to 17.7% and high 17.7% to 44.5%), mean PHQ-9 scores where higher for adolescents living in high poverty levels (9.6, 95% CI: 9.3, 10.0) than those living in middle (9.1, 95% CI: 7.7, 8.4) or low (7.8, 95% CI: 7.4, 8.1) areas. Similar patterns were observed when considering PHQ-9 scores in categories, with 32.8% (95% CI: 32.5, 33.1) low poverty area participants indicating minimal or no depression compared to 23.9% (95% CI: 23.6, 24.1) among high poverty area youth. Severe depression was lower among low poverty area youth (5.0%, 95% CI: 4.9, 5.1) than high poverty area youth (7.6%, 95% CI: 7.4, 7.7).
McGuine (2021a)	Patient Health Questionnaire-9 Item (PHQ-9) was used to measure depressive symptoms (range 0 to 27 with higher score indicating more depressive symptoms). This was also split categorically: minimal or none (0 to 4), mild (5 to 9), moderate (10 to 14), moderately severe (15 to 19), and severe (20+).	35% of females had a mild level of depression, which was significantly different from the comparison group before COVID-19 (24%, $p < 0.001$). This was similar among males (during COVID-19 = 35%, before COVID-19 = 15%, $p < 0.001$). The difference was greater for moderate, moderately severe, or severe levels of depression (females: during COVID-19 = 37%, before COVID-19 = 11%, $p < 0.001$; males: during COVID-19 = 27%, before COVID-19 = 6%, $p < 0.001$). The full percentages by category are provided in Figure 1. This was also reflected in the PHQ-9 scores, which were overall 2.5 times higher among participants during COVID-19 compared to those who participated before COVID-19. Among females, the mean during COVID-19 was 8.2 (95% CI: 7.9, 8.5) compared to before COVID-19 which was mean 3.6 (95% CI: 3.4, 3.8). Among males, the mean during COVID-19 was 7.8 (95%CI: 7.5, 8.1) as compared to 2.6 (95% CI: 2.2, 2.9) among 2015 to 2018 males.
McGuine (2021b)	Patient Health Questionnaire-9 Item (PHQ-9) was used to measure depressive symptoms (range 0 to 27 with	Participants who reported playing a fall sport (57.7%) more frequently reported minimal or no depression as compared to participants who did not play a fall sport (31.3%). Correspondingly, they were less likely to report moderate to severe depression (18.2% vs. 40.1%), though prevalence of mild

	higher score indicating more depressive symptoms). This was also split categorically: minimal or none (0 to 4), mild (5 to 9), moderate (10 to 14), moderately severe (15 to 19), and severe (20+).	depression was similar (played fall sport: 23.9%; did not play fall sport: 28.5%). The mean PHQ-9 score was higher among participants who did not play a fall sport as compared to those who did (mean: 7.6; 95% CI: 6.4, 8.8; vs. mean: 3.9, 95% CI: 2.8, 4.9, $p < 0.001$).
McKune (2021)	Depressive symptoms measured as "not at risk", "low risk", "medium risk", or "high risk" based on responses to Likert scales rating an abbreviated list of depressive symptoms (developed by team of school psychologists).	Among high school students, 30.6% of students were "at risk" and 8.1% were "high risk" for depressive symptoms. Among middle school students, 37.8% were "at risk" and 4.9% were "high risk" for depressive symptoms. Compared to high schoolers, middle schoolers were not at significantly higher risk for being "at risk" (as opposed to "no risk") for depressive symptoms (aOR: 1.67; 95%: 0.88, 3.18) or being "high risk" (as opposed to "no risk") for depressive symptoms (aOR: 0.83; 95% CI: 0.23-2.99), after adjusting for race/ethnicity, sex, household loss of income during the pandemic, parental occupation, knowledge score, attitude score, and practice score.
Murata (2021)	Depressive symptoms measured with 9-item Patient Health Questionnaire. Suicidal ideation, suicidal behavior, and non-suicidal self-injurious behavior measured via the Self-Injurious Thoughts and Behavior Interview, self report version.	31% reported lifetime nonsuicidal self-injurious behavior, 52% reported lifetime suicidal ideation, 13% reported lifetime actual suicide attempt, and 55% overall reported lifetime suicidal ideation or behavior. Psychiatric outcomes in the present day/since the COVID-19 pandemic were also reported: 55% depression, 37% suicidal ideation, 1.7% suicide attempt, 38% suicidal ideation or behavior. Statistically significant predictors of depression included higher loneliness since the COVID-19 pandemic (ß = 0.376, 98% CI: 0.24, 0.52, $p < 0.001$), lower rating of overall health (ß = -0.529, 98% CI: -0.92, -0.15, $p = 0.007$), greater than moderate severity sleep problems (ß = 1.674, 98% CI: 1.04, 2.34, $p < 0.001$), higher perceived stress (ß = 0.271, 98% CI: 0.13, 0.42, $p < 0.001$), and higher hours per day of social media use since COVID-19 (ß = 0.115, 98% CI: 0.03, 0.21, $p = 0.015$). Predictors of suicidal ideation or behavior included lifetime suicidal ideation (ß = 6.685, 98% CI: 5.09, 9.60, $p < 0.001$) and higher hours per day exposure to media reporting on COVID-19 (ß = 0.132, 98% CI: 0.03, 0.25, $p = 0.019$).

Nelson (2020)	Responses to "What other ways [beyond sexual life] has the new corona virus (COVID-19) changed your life in the past three months?"	32% of participants reported a negative mental health impact (depression, anxiety, stress, etc.), with similar rates by outness (out: 34%, not out: 30%).
O'Brien (2021)	Responses to "what have you been doing to care for yourself in these difficult times?"	Some participants noted keeping routines for the sake of mental health, as illustrated by the quote "I make sure to keep a schedule so I do not fall into a depression. Simple, like making sure I am awake around the same time every day and take care of myself.". In another quote, a participant noted "trying to bathe every other day or so (depression makes it hard for me to do it every day)".
Oosterhoff (2020)	Depressive symptoms were measured with the 8-item Patient-Reported Outcomes Measurement Information System depression scale, in which respondents provide answers on a 1 to 5 scale with a higher score indicating more depressive symptoms.	The mean score was 2.98 (SD: 1.07). In multiple linear regression analyses accounting for demographic characteristics, financial strain (-0.17, SE: 0.06, 95% CI: -0.29, -0.06) and the social distancing motivation of preferring to stay home (-0.35, SE: 0.10, 95% CI: -0.55, -0.14 .) were negatively associated with depressive symptoms. Female gender (0.38. SE: 0.11, 95% CI: 0.17, 0.60) and the social distancing motivation of "friends said I should" were positively associated with depressive symptoms (0.26, SE: 0.13, 95% CI: 0.02, 0.51).
Penner (2021)	Internalizing problems were measured via the Brief Problem Monitor.	Students in the highest 20% of scores (i.e. high endorsement of mental health problems) at baseline were considered to be "high scorers". The mean scores of the full sample (high and low scorers) decreased from the 1st (January 2020) to 2nd (mid-April 2020) time point and remained relatively stagnant through the 3rd (early May 2020) and the 4th (late May 2020) time points. Similar patterns were observed within high and low scoring groups. In analysis of covariance analyses, there was a significant interaction effect between time and group from baseline to the 1st follow up ($F_{1,313} = 84.32$, $p < 0.001$, $np2 = 0.21$). In simple effects analysis with Bonferroni adjustments, internalizing scores for both low scorers (mean difference = 0.58, $p = 0.003$) and high scorers (mean difference = 3.87, $p < 0.001$) significantly differed

		between baseline (January 2020) and 1st follow up (mid-April 2020). In post-hoc analyses of the impact of an immediate family member losing some or all hours of employment, there was no 3-way interaction between time, group, and job loss nor a 2-way interaction for time and job loss for internalizing problems. There was a significant 2-way interaction for time and job loss for BPM total problems (F1.18,315.45 = 3.54, p = 0.03). In post-hoc analyses considering the impact of family functioning (dichotomous split at median of mean of 7 family functioning items on survey) on mental health, the 3-way (time, group, and family functioning) and 2-way interactions (time and family functioning) were not statistically significant for internalizing problems or total problems. However, continuous family functioning scores (based on the 7 family functioning items), were significantly correlated with BPM scores across all domains (internalizing, externalizing, and attention) at the 3 COVID-19 follow up time points (all p < 0.004 with r ranging from -0.44 to -0.29 – internalizing specific results not stated).
Ridout (2021)	Psychiatric service utilization via electronic health records	For patients with psychiatric diagnoses (including anxiety disorders, depressive disorders, bipolar disorder, psychotic disorder, intellectual disabilities, developmental disorders, and disorders seen in childhood, substance use disorder, adjustment disorder, and other disorders), among 13-17 year olds, there was a decrease in the number of visits in 2020 (n = 9,161) as compared to 2019 (n = 9,524; standardized change: -5.4, 95% CI: -8.2, -2.7) for the March 9 to May 31 period.
Rogers (2021)	Qualitative responses; Depressive symptoms measured quantitatively with the Children's Depression Inventory short version; Changes in mood were measured with a Likert scale based on the Positive and Negative Affect Schedule –	In open ended responses, 28 participant responses were coded as "in a funk" including references to feeling "sad", "depressed", and that it is a "little harder to get through the day". When asked if any COVID-19 related changes have been good for the participant mentally or emotionally or for relationships with family and friends, 169 participant responses were coded as "there are no benefits" including "Not really, I get a little depressed sometimes because I'm missing out on my high school years.". Some respondents noted positive changes for mental health.

	perceived changes in negative affect included: nervous, irritable, upset, and distressed.	At T1, depressive symptoms were rated as mean 1.75 (0.52 SD; range: 1.00-3.58). At T2, depressive symptoms were rated as mean 1.84 (0.56 SD; range: 1.00-3.75). This difference was significant by paired samples t-test ($t(406) = 3.88$, $p < 0.001$; Cohen's $d = 0.19$). Depressive symptoms at T2 did not vary significantly by sex ($0.05 < p < 0.1$), race/ethnicity ($0.05 < p < 0.1$), or community type ($0.1 < p$; urban area, urban cluster, or rural). T2 depressive symptoms were negatively correlated with family income ($p < 0.001$), T2 positive affect ($p < 0.001$), time with ($p < 0.01$) and support from parents ($p < 0.01$), and support from friends ($p < 0.001$). T2 depressive symptoms were positively correlated with T1 depression ($p < 0.001$), T1 anxiety, ($p < 0.001$), T2 anxiety ($p < 0.001$), T1 loneliness ($p < 0.001$), T2 loneliness ($p < 0.001$), T2 negative affect ($p < 0.001$), conflict with parents ($p < 0.01$), and conflict with friends ($p < 0.05$). In hierarchical regression models, the T1 depressive symptoms were the strongest predictors of T2 depressive symptoms. Generally, adolescents with reported increases negative affect and family conflict and decreases in friend support during COVID-19 reported higher depressive symptoms at the April 2020 timepoint, above and beyond depressive symptoms in October 2019. Perceived changes in negative affect at T2 were rated as mean 3.24 (0.80 SD; range: 1.00-5.00), indicating that the majority reported increases in negative affect. Negative affect at T2 did not vary significantly by sex ($0.05 < p < 0.1$), race/ethnicity ($0.1 < p$), or community type ($0.05 < p < 0.1$; urban area, urban cluster, or rural). Negative affect was negatively correlated with positive affect ($p < 0.001$) and income ($p < 0.01$). Negative affect was positively correlated with T2 depression ($p < 0.001$), T1 anxiety ($p < 0.01$), T2 anxiety ($p < 0.001$), T1 loneliness ($p < 0.05$), T2 loneliness ($p < 0.001$), conflict with parents ($p < 0.001$), support from friends ($p < 0.05$), and income ($p < 0.01$).
Sinko (2020)	Qualitative analyses of text and chat inquiries to The	Broadly, some youth indicated that their parents did not let them seek out mental health services or did not take their mental health concerns seriously. One quote from an adolescent specifically indicated that their parent "acts

	Childhelp National Child Abuse Hotline	like it never happened" in reference to a doctor telling the adolescent that they might have mild to severe depression and anxiety.
Thompson (2021)	Suicidal ideation measured via Suicidal Ideation Questionnaire-Junior. Suicidal ideation linked specifically to COVID-19 was measured via response to: "To what extent have you felt suicidal in relation to COVID-19?". Past 7 day and past 30 day suicide attempts were measured via response to: "Have you made any suicide attempts in the [30 or 7] days before you came to the hospital?"	The past 7-day suicide attempts rate was significantly greater in 2020 compared to 2019 (small effect (phi = 0.11): 24.6% versus 15.8%; $x^2 = 4.09$, p = 0.043). Similarly, the past 30-day suicide attempt rate was significantly greater in 2020 than in 2019 (small effect (phi = 0.13): 31.0% versus 19.4%; $x^2 = 6.03$, p = 0.014). Higher SIQ-Jr scores (indicating higher risk) were reported in 2020 (m = 36.08, SD = 27.66) than in 2019 (m = 30.05, SD = 26.23; t(336) = −2.04, p = .042, small effect – Hedges' g = 0.22). In 2020, 47.2% of participants reported feeling suicidal in relation to COVID-19 to some extent (m = 2.57, SD = 1.16). Past 7-day and past 30-day suicide attempts did not differ by COVID-19 suicidal ideation status. However, SIQ-Jr scores were higher among those with COVID-19 suicidal ideation (m = 46.99, SD = 24.22) than those without ((m = 26.35, SD = 27.05; t(140) = -4.77, p < .001), large effect Hedges' g = 0.80). Not being able to attend special events (p = 0.011) was the only significantly different stressor between adolescents with COVID-19 suicidality and those without. Money problems, conflict at home, and changing living circumstances were endorsed more highly among adolescents with COVID-19 suicidality (0.10 > p > 0.05). COVID-19 suicidal ideation did not differ comparing those with and without previous psychiatric hospitalizations. For adolescents experiencing their first hospitalization, those with COVID-19 suicidal ideation had higher ratings for being cutoff from contact with others (t(65) = -2.16, p = .034; Hedges' g = 0.53), being unable to leave home (t(65) = - 2.34, p = .022; Hedges' g = 0.58), missing events (t(65) = -2.57, p = .013; Hedges' g = 0.63), and not being able to see people they care about (t(65) = −2.14, p = .036; Hedges' g = 0.52). For adolescents with a history of hospitalization, those with COVID-19 suicidal ideation were more worried about contracting COVID-19 themselves (t(71.33) = -2.22, p = .030, Hedges' g = 0.51).

Yard (2021)	Suicide attempts recorded in the National Syndromic Surveillance Program	Visits for adolescents (ages 12 to 17) were lower in spring (March 29 to April 25) 2020 than in spring 2019 by 26.5%. However, in summer (July 26-August 22,) 2020 and winter (February 21-March 20,) 2021, the number of visits was higher for both sexes than in the corresponding period in the 2019 reference periods (i.e., summer 2019, winter 2019) by 22.3% and 39.1%, respectively. Comparing winter periods, the increase in visits in winter 2021 (compared to winter 2019) was larger for females (50.6%) than males (3.7%). Across the pandemic, the number of visits increased, which was largely driven by visits among females. In all periods, the ratio comparing the proportion of emergency department visits that were suspected suicide attempts comparing girls to boys was above 1 (range: 2.51 to 3.44). Table 1 contains more information on exact numbers of visits and rates.
Yarrington (2021)	Depressive symptoms measured with 8 item version of PHQ-9 (excluding question regarding suicide ideation).	There was no significant interaction effect with age and time that predicted depressive symptoms ($p > 0.05$).

5.9 Appendices

Appendix 5.1: PubMed Search Terms

("COVID-19"[Mesh] OR “coronavirus”[Mesh] OR "coronavirus infections"[MeSH] OR "COVID-19"[Supplementary Concept] OR "severe acute respiratory syndrome coronavirus 2"[Supplementary Concept] OR coronavirus[Title/Abstract] OR “corona virus”[Title/Abstract] OR coronavirinae[Title/Abstract] OR coronaviridae[Title/Abstract] OR “coronaviridae infection”[Title/Abstract] OR COVID[Title/Abstract] OR COVID-19[Title/Abstract] OR COVID19[Title/Abstract] OR COVID2019[Title/Abstract] OR COVID-2019[Title/Abstract] OR SARS-CoV-2[Title/Abstract] OR SARSCoV2[Title/Abstract] OR “sars cov2”[Title/Abstract] OR “SARS coronavirus 2”[Title/Abstract] OR 2019-nCoV[Title/Abstract] OR 2019nCoV[Title/Abstract] OR nCoV2019[Title/Abstract] OR nCoV-2019[Title/Abstract] OR cov22[Title/Abstract] OR ncov[Title/Abstract] OR "SARS-CoV-19"[Title/Abstract] OR "novel cov"[Title/Abstract] OR "severe acute respiratory pneumonia outbreak”[Title/Abstract] OR ((Wuhan[Title/Abstract] OR Hubei[Title/Abstract]) AND coronavirus*[Title/Abstract]) OR ((2019[dp] OR 2020[dp] OR 2021[dp]) AND (new[Title/Abstract] OR novel[Title/Abstract] OR pandemic*[Title/Abstract] OR epidemic*[Title/Abstract]) AND (coronavirus*[Title/Abstract] OR “corona virus*”[Title/Abstract])))

AND

("Adolescent"[Mesh] OR teen*[Title/Abstract] OR adoles*[Title/Abstract] OR youth[Title/Abstract] OR "high school"[Title/Abstract] OR "middle school"[Title/Abstract])

AND

(("Substance-Related Disorders"[Mesh] OR "Drinking Behavior"[Mesh] OR "Drug-Seeking Behavior"[Mesh] OR "Marijuana Use"[Mesh] OR "Recreational Drug Use"[Mesh] OR "Vaping"[Mesh] OR "Smoking, Non-Tobacco Products"[Mesh] OR alcohol*[Title/Abstract] OR marijuan*[Title/Abstract] OR cannab*[Title/Abstract] OR weed[Title/Abstract] OR vaping[Title/Abstract] OR vapor[Title/Abstract] OR e-cigarette[Title/Abstract] OR “electronic cigarette”[Title/Abstract] OR “electronic vaporizer”[Title/Abstract] OR “substance us*”[Title/Abstract] OR “substance abuse”[Title/Abstract] OR “drug us*”[Title/Abstract] OR “drug abuse”[Title/Abstract])

OR

(“Mood Disorders”[Mesh] OR “Depression”[Mesh] OR “Suicide”[Mesh] OR “Self-Injurious Behavior”[Mesh] OR depress*[Title/Abstract] OR suici*[Title/Abstract] OR “self harm”[Title/Abstract] or “self-harm”[Title/Abstract] OR “self injury”[Title/Abstract] OR “self-injury”[Title/Abstract] OR internalizing[Title/Abstract] OR “psychological distress”[Title/Abstract])

OR

("Social Media"[Mesh] OR “Online Social Networking”[Mesh] OR “Internet Use”[Mesh] OR “Internet Addiction Disorder”[Mesh] OR "social media"[Title/Abstract] OR “social network”[Title/Abstract] OR internet[Title/Abstract] OR Facebook[Title/Abstract] OR Twitter[Title/Abstract] OR tweet[Title/Abstract] OR Instagram[Title/Abstract] OR TikTok[Title/Abstract] OR Reddit[Title/Abstract] OR Pinterest[Title/Abstract] OR Snapchat[Title/Abstract] OR WhatsApp[Title/Abstract] OR Kik[Title/Abstract] or Tumblr[Title/Abstract] OR Discord[Title/Abstract] OR YouTube[Title/Abstract]))

AND

(English[Language]) AND ("2019/01/01"[Date - Publication] : "3000"[Date - Publication]) NOT ("editorial"[Publication Type] OR "letter"[Publication Type] OR "review"[Publication Type])

Appendix 5.2: Embase Search Terms

('coronavirinae'/exp OR 'coronavirus infection'/exp OR coronavirus:ab,ti OR 'corona virus':ab,ti OR 'coronavirinae':ab,ti OR coronaviridae:ab,ti OR 'coronaviridae infection':ab,ti OR COVID:ab,ti OR COVID-19:ab,ti OR COVID19:ab,ti OR COVID2019:ab,ti OR COVID-2019:ab,ti OR SARS-CoV-2:ab,ti OR SARSCoV2:ab,ti OR 'sars cov2':ab,ti OR 'SARS coronavirus 2':ab,ti OR 2019-nCoV:ab,ti OR 2019nCoV:ab,ti OR nCoV2019:ab,ti OR nCoV-2019:ab,ti OR cov22:ab,ti OR ncov:ab,ti OR 'SARS-CoV-19':ab,ti OR 'novel cov':ab,ti OR 'severe acute respiratory pneumonia outbreak':ab,ti OR

((Wuhan:ab,ti OR Hubei:ab,ti) AND coronavirus*:ab,ti) OR

((2019/py OR 2020/py OR 2021/py) AND

(new:ab,ti OR novel:ab,ti OR pandemic*:ab,ti OR epidemic*:ab,ti) AND

(coronavirus*:ab,ti OR 'corona virus*':ab,ti)))

AND

('adolescent'/exp OR teen*:ab,ti OR adoles*:ab,ti OR youth:ab,ti OR 'high school':ab,ti OR 'middle school':ab,ti)

AND

(('alcohol consumption'/exp OR 'cannabis use'/exp OR 'drug dependence'/exp OR 'cannabis smoking'/exp OR 'cocaine smoking'/exp OR 'electronic cigarette vapor'/exp OR 'electronic

cigarette'/exp OR 'vaping'/exp OR 'recreational drug use'/exp OR 'cannabis'/exp OR 'recreational drug use'/exp OR 'recreational drug'/exp OR 'drug abuse'/exp OR alcohol*:ab,ti OR marijuan*:ab,ti OR cannab*:ab,ti OR weed:ab,ti OR vaping:ab,ti OR vapor:ab,ti OR e-cigarette:ab,ti OR 'electronic cigarette':ab,ti OR 'electronic vaporizor':ab,ti OR 'substance us*':ab,ti OR 'substance abuse':ab,ti OR 'drug us*':ab,ti OR 'drug abuse':ab,ti)

OR

('mood disorder'/exp OR 'suicide'/exp OR 'automutilation'/exp OR depress*:ab,ti OR suici*:ab,ti OR 'self harm':ab,ti or 'self-harm':ab,ti OR 'self injury':ab,ti OR 'self-injury':ab,ti OR internalizing:ab,ti OR 'psychological distress':ab,ti)

OR

('social media'/exp OR 'online social network'/exp OR 'internet use'/exp OR 'internet addiction'/exp OR 'social media':ab,ti OR 'social network':ab,ti OR internet:ab,ti OR Facebook:ab,ti OR Twitter:ab,ti OR tweet:ab,ti OR Instagram:ab,ti OR TikTok:ab,ti OR Reddit:ab,ti OR Pinterest:ab,ti OR Snapchat:ab,ti OR WhatsApp:ab,ti OR Kik:ab,ti or Tumblr:ab,ti OR Discord:ab,ti OR YouTube:ab,ti))

AND

English:la AND [2019-2021]/py NOT ([editorial]/lim OR [letter]/lim OR [note]/lim OR [review]/lim) AND [embase]/lim NOT ([embase]/lim AND [medline]/lim)

Appendix 5.3: PsycINFO Search Terms

(SU "coronavirus" OR TI coronavirus OR AB coronavirus OR TI "corona virus" OR AB "corona virus" OR TI coronavirinae OR AB coronavirinae OR TI coronaviridae OR AB coronaviridae OR TI

“coronaviridae infection” OR AB “coronaviridae infection” OR TI COVID OR AB COVID OR TI COVID-19 OR AB COVID-19 OR TI COVID19 OR AB COVID19 OR TI COVID2019 OR AB COVID19 OR TI COVID-2019 OR AB COVID-2019 OR TI SARS-CoV-2 OR AB SARS-CoV-2 OR TI SARSCoV2 OR AB SARSCoV2 OR TI “sars cov2” OR AB “sars cov2” OR TI “SARS coronavirus 2” OR AB “SARS coronavirus 2” OR TI 2019-nCoV OR AB 2019-nCoV OR TI 2019nCoV OR AB 2019nCoV OR TI nCoV2019 OR AB nCoV2019 OR TI nCoV-2019 OR AB nCoV-2019 OR TI cov22 OR AB cov22 OR TI ncov OR AB ncov OR TI SARS-CoV-19 OR AB SARS-CoV-19 OR TI “novel cov” OR AB “novel cov” OR TI "severe acute respiratory pneumonia outbreak” OR AB "severe acute respiratory pneumonia outbreak” OR

((TI Wuhan OR AB Wuhan OR TI Hubei OR AB Hubei) AND (TI coronavirus* OR AB coronavirus*)) OR

((PY 2019 OR PY 2020 OR PY 2021) AND

(TI new OR AB new OR TI novel OR AB novel OR TI pandemic* or AB pandemic* OR TI epidemic* OR AB epidemic*) AND

(TI coronavirus* OR AB coronavirus* OR TI “corona virus*” OR AB “corona virus*”)))

AND

(OR SU “Adolescent psychopathology” OR SU “Adolescent development” OR SU “Adolescent psychotherapy” OR SU “Adolescent psychopathology” OR SU “Adolescent psychology” OR SU “Adolescent psychiatry” OR SU “Adolescent attitudes” OR SU “Child health” OR TI teen* OR AB teen* OR TI adoles* OR AB adoles* OR TI youth OR AB youth OR TI “high school” OR AB “high school” OR TI “middle school” or AB “middle school”)

AND

((SU “Substance Use Disorder” OR SU “Drinking Behavior” OR SU “Drug seeking” OR SU “Drug addiction” OR SU “Electronic cigarettes” OR SU “Drugs” OR TI alcohol* OR AB alcohol* OR TI marijuana* OR AB marijuana* OR TI cannib* OR AB cannib* OR TI weed OR AB weed OR TI vaping OR AB vaping OR TI vapor OR AB vapor OR TI e-cigarette OR AB e-cigarette OR TI “electronic cigarette” or AB “electronic cigarette” OR TI “substance us*” OR AB “substance us*” TI “substance abuse” OR AB “substance abuse” OR TI “drug us*” OR AB “drug us*” OR TI “drug abuse” OR AB “drug abuse”)

OR

(SU “Affective disorders” OR SU “Suicide” OR SU “Self-Injurious Behavior” OR SU “Suicidal Ideation” OR TI depress* or AB depress* OR TI suici* OR AB suici* OR TI “self harm” OR AB “self harm” OR TI “self-harm” or AB “self-harm” OR TI “self injury” OR AB “self injury” OR TI “self-injury” OR AB “self-injury” OR TI internalizing OR AB internalizing OR TI “psychological distress” OR AB “psychological distress”)

OR

(SU “Social Media” OR SU “Internet” OR SU “Internet usage” OR SU “Internet Addiction” OR TI “social media” OR AB “social media” OR TI “social network” OR AB “social network” OR TI Internet OR AB Internet OR TI Facebook OR AB Facebook OR TI Twitter OR AB Twitter OR TI tweet OR AB tweet OR TI Instagram OR AB Instagram OR TI TikTok OR AB TikTok OR TI Reddit OR AB Reddit OR TI Pinterest OR AB Pinterest OR TI Snapchat OR AB Snapchat OR TI WhatsApp OR AB WhatsApp OR TI Kik OR AB Kik OR TI Tumblr OR AB Tumblr OR TI Discord OR AB Discord OR TI YouTube OR AB YouTube))

AND

(LA English) AND (PY 2019 OR PY 2020 OR PY 2021) NOT (PZ editorial OR PZ letter OR PZ review)

Chapter 6. A Survey-Based Study of Adolescent Social Media Use, Substance Use, and Depressive Symptoms During the COVID-19 Pandemic

6.1 Abstract

Purpose: To assess adolescent social media use, substance use, and depressive symptoms within the context of the COVID-19 pandemic.

Methods: From November 2021 to April 2022, we conducted an anonymous, REDCap-based online survey of adolescents in the United States assessing retrospective reports of social media use, substance use (i.e., electronic vapor products, cannabis, prescription pain medicine, and alcohol), and depressive symptoms in April 2019, April 2020, and April 2021. Adolescents were eligible to participate if they lived in the United States and were currently ages 13 to 19 years. The survey included questions on demographics, social media use, substance use, and depressive symptoms. Descriptive statistics (frequencies and percentages) were used to summarize participant responses and Fisher's exact tests (due to small sample size) were used to assess for differences over time. All study procedures were reviewed and approved by the University of Washington Human Subjects Division.

Results: A total of 27 participants submitted valid survey responses. The sample was primarily White (96.3%) and between ages 13 (48.1%) and 14 (22.2%) years. The majority of participants were from Missouri (92.6%). In April 2019, April 2020, and April 2021, 70.4%, 81.5%, and 88.9% of respondents reported using social media use at least once a day, respectively, reflecting increases in social media use over time ($p = 0.04$). Substance use increased from April 2019 (cannabis: 11.1%, electronic vapor product use: 7.4%, alcohol use: 7.4%, binge drinking: 7.4%,

prescription pain medicine misuse: 0%) to April 2021 (cannabis: 18.5%, electronic vapor product use: 25.9%, alcohol use: 14.8%, binge drinking: 11.1%, prescription pain medicine misuse: 7.4%), though these differences across years were not statistically significant (p range = 0.33 to > 0.99). The prevalence of depressive symptoms increased after the pandemic from 48.1% in April 2019, to 70.4% in April 2020 and 66.7% in April 2021, though the years were not statistically significantly different (p = 0.22).

Conclusions: Similar to previous reports, we found that social media use, substance use, and depressive symptoms increased in the context of the COVID-19 pandemic. Larger and more diverse and/or representative studies are needed in this area. Our findings suggest the need for encouraging healthy coping skills and facilitating access to appropriate care by families, adolescent caregivers, and clinicians.

Sources of Support: This work was supported in part by a student project stipend from the Northwest Public Health Training Center at the Northwest Center for Public Health Practice (sponsored by the Health Resources and Services Administration (HRSA) of the U.S. Department of Health and Human Services (HHS) (grant # 6 UB6HP31690-04-01)). REDCap at ITHS is supported by the National Center For Advancing Translational Sciences of the National Institutes of Health under Award Number UL1 TR002319.

6.2 Introduction

As called to attention by the U.S. Surgeon General in December 2021, the COVID-19 pandemic has not only resulted in unprecedented disruptive and stressful conditions for adolescents and their caregivers, but it has also highlighted the substantial existing public

health problem of poor adolescent mental health in the United States (1). Youth Risk Behavior Survey data from 2019, prior to the COVID-19 pandemic, indicate a high prevalence of past 12 month depressive symptoms with 36.7% of student participants indicating feelings of sadness or hopelessness for at least a two week period (2). Notably, this figure has increased by more than ten percentage points since 2009 (26.1%). Substance use and misuse were also prevalent among adolescents in the United States prior to the COVID-19 pandemic. In 2019, 45.6% of twelfth grade students reported having used an electronic vapor product in their lifetime and 43.7% reported cannabis use, with 6.4% reporting daily cannabis use within the last 30 days (3). More than half (58.5%) reported alcohol use at least once in their life.

Reflecting an increasingly technophilic society, adolescents report frequent use of the internet and social media. Based on 2018 estimates from Pew Research Center, 45% of adolescents use the internet “almost constantly” and that 95% of adolescents have access to a smartphone (4). Social media use among adolescents is associated with many benefits to adolescent development and identity formation including connecting with existing and new friends and exploration of self (5). Social media can also serve as a conduit for news among adolescents and young adults (6,7). However, social media use has also been associated with negative consequences including depressive symptoms, poor sleep quality, and being a victim of cyberbullying (5).

With the onset of the COVID-19 pandemic and the corresponding public health guidance, adolescents across the United States experienced substantial changes to their daily lives in the face of transitions to online learning, cancellation of in-person academic and extracurricular activities, social distancing, heightened reliance on technology and the internet,

and spending increased time in the home environment (8,9), particularly within the first year following the onset of pandemic-related restrictions. These changes may have a variety of potential implications depending on the student. Some may have reduced exposure to negative interactions with peers (e.g., in-person experience of bullying) and reduced anxiety due to not being present in the school environment. Others may experience negative impacts such as decreased in-person socialization with peers, lack of in-person support from teachers and other school administrators, diminished access to resources typically provided in the school environment (e.g., meals, mental health support, etc.), and, for students in physically or emotionally unsafe home environments, extended exposure to dangerous conditions. Each of these negative implications may be associated with changes in stressors which could result in differences in mental health status and health risk behaviors such as substance use and frequency and type of social media use. Further, the experience of collective trauma in the wake of the pandemic and the corresponding desire and/or necessity to consume news media for updates may be associated with deleterious health impacts. Among college students, the prevalence of COVID-19-related news among all news articles was found to be associated with depression (10).

Given the recency of the COVID-19 pandemic, little is known about the impact of the current crisis on adolescent depressive symptoms, substance use, and social media use in the United States. Further, available information lacks consistency; studies have indicated high or increased depressive symptoms (11–18) and reductions in depressive symptoms (19). Increased suicidality (20) and changes in substance use behaviors (3,21–24) have also been reported. There is also evidence of substantial social media use among adolescents during the COVID-19

pandemic (11,16,19,25). An improved understanding of current trends in social media use, depressive symptoms, and substance use will identify intervention targets to best meet the immediate emotional and physical health needs of adolescents in the face of the COVID-19 pandemic. In addition, these findings will shed light on challenges, and supportive factors, of this period that may have implications for the mental health of current adolescents throughout their lifespan and for adolescents coping with future pandemics or similarly life-altering circumstances. To explore trends, we conducted an online, anonymous survey of adolescents of retrospective reports of social media use, substance use, and depressive symptoms, assessing the impact of the pandemic in both early (April 2020) and later (April 2021) periods compared to the pre-pandemic period (April 2019).

6.3 Methods

Study Design

Our cross-sectional study of adolescent-reported social media use, substance use (cannabis use, electronic vapor product use, prescription pain medication misuse, and alcohol use), and depressive symptoms utilized data collected from a simple, non-random survey design. In the context of the cross-sectional nature of the data collection and the desire to understand how adolescent depressive symptoms, social media use, and substance use have changed in relation to the COVID-19 pandemic, the survey queried participants about three time points – April 2019 (pre-pandemic), April 2020 (early pandemic), and April 2021 (late pandemic). All study procedures were reviewed and approved by the University of Washington Human Subjects Division.

Sampling and Data Collection

Adolescents were eligible to participate in our study if they were ages 13 to 19 years at the time of the survey and reported living in the United States, Washington, D.C., or a territory of the United States. Participants were sampled using a convenience, non-probability method via distribution of the survey link and information to relevant adolescent health organizations who shared study information via their channels. Data were collected using the Research Electronic Data Capture (REDCap) tool hosted at the University of Washington (26,27). Potential participants were directed to a link for an anonymous, online survey via REDCap. This link first provided relevant background information, descriptions of potential risks, and relevant resources. Participants agreed to participate by advancing in the questionnaire. This analysis includes responses received from November 29, 2021 to April 21, 2022.

Our survey was designed to assess demographic characteristics of the participants (including inclusion eligibility), social media use, substance use, and depressive symptoms using questionnaire items based on and informed by other surveys in order to improve the validity and coherence of survey items. Participants were asked about demographic information including ethnicity (28), race (29), language spoken most frequently at home, sexual orientation (30), gender identity (30), state of residence, urbanicity of area of residence (31), grade in school in the 2019-2020 school year, and current age. The survey items are available in Appendix 6.1.

Next, participants were asked to respond to questions with information on their behaviors and feelings in April 2019 (pre-pandemic), April 2020 (early pandemic), and April 2021 (late pandemic). To report social media use, participants were asked “In April 20XX, how

often did you use social media (e.g. Instagram, TikTok, etc.) on a computer, cellphone, tablet, or any other electronic device?" with the following response options: almost constantly, several times a day, about once a day, several times a week, once a week, and less often. This question was informed by Pew Research Center's 2018 Teen Survey (4) and consultation with dissertation committee members. Substance use items were based on 2019 Youth Risk Behavior Survey questions (32) with additional sources as needed and/or appropriate. Items for use of electronic vapor products (32,33), alcohol use (32), and binge drinking (32,34,35) queried the number of days in a month in which the substance was used with the following response options: 0 days, 1 or 2 days, 3 to 5 days, 6 to 9 days, 10 to 19 days, 20 to 29 days, and all 30 days. Items for cannabis use (32) queried the number of times of use in a month with the following response options: 0 times, 1 or 2 times, 3 to 9 times, 10 to 19 times, 20 to 39 times, and 40 or more times. Prescription pain medication misuse (32) in the specified month was reported as yes or no. Finally, depressive symptoms were assessed with a yes or no response to the item "During the month of April 20XX, did you ever feel little interest or pleasure in doing things and/or feel down, depressed, or hopeless almost every day for two weeks or more in a row?", which was informed by the Patient Health Questionnaire-2 (36).

Statistical Analyses

After exclusion of ineligible survey responses (n = 14) (i.e., those who did not meet inclusion criteria), data were analyzed descriptively with frequencies and percentages for categorical measures. We assessed for differences in social media use, substance use, and depressive symptoms across the three queried time periods with Fisher's exact tests due to the small sample size and, correspondingly, small cell size. We conducted an exploratory analysis of

differences in social media use, substance use, and depressive symptoms in the most recent period (April 2021) by urbanicity (i.e., rural, suburban, and urban). We assessed for statistical significance with two-sided alternative hypotheses and a significance level of 0.05. Analyses were conducted in R version 3.6.2.

6.4 Results

After exclusion of ineligible potential respondents, 27 participants provided useable responses. The survey respondents were primarily not of Hispanic, Latina/a/x, or Spanish origin (92.6%) (Table 6.1). The races reported by participants were White (96.3%), Asian (3.7%), and other race (3.7%). The language spoken most frequently at home was English (85.2%); the remaining 14.8% of participants did not report a language. Straight or heterosexual was the sexual orientation most frequently reported (48.1%), followed by bisexual (18.5%), lesbian, gay, or homosexual (11.1%), pansexual (11.1%), panromantic (3.7%), and something else without additional specification (3.7%). The majority of the sample identified as female (63.0%), followed by male (11.1%), non-binary (11.1%), transgender male/transgender man (7.4%), and gender fluid (3.7%); one participant (3.7%) chose not to disclose their gender identity.

Most participants were from Missouri (92.6%), with other participants from Arizona (3.7%) and Michigan (3.7%). The distribution of urbanicity was relatively even with 37.0% of participants living in rural areas, 37.0% living in suburban areas, and 25.9% living in urban areas. The most common grade in the 2019 to 2020 school year was sixth grade (44.4%), followed by eighth (18.5%) and tenth (18.5%) grades, ninth grade (11.1%), and seventh grade (7.4%). Finally, the current age of participants was generally in early adolescence with nearly half (48.1%) of

survey participants at 13 years old, 22.2% at 14 years old, 3.7% at 15 years old, 14.8% at 16 years old, and 11.1% at 17 years old.

Social Media Use

Social media use was prevalent in all three periods assessed (Table 6.2). In April 2019, April 2020, and April 2021, 70.4%, 81.5%, and 88.9% of respondents reported using social media use at least once a day, respectively. Reports of using social media less than once a week decreased over time (April 2019: 18.5%, April 2020: 7.4%, April 2021: 3.7%). Changes over time were statistically significant ($p = 0.04$).

Substance Use

In general, use of all substances reported by participants increased over time (Table 6.3), but none of the differences were statistically significant. Any use of electronic vapor products was low (7.4%) in April 2019, but increased in 2020 to 14.8%. In 2021, electronic vapor products were the most prevalently used substance at 25.9% ($p = 0.70$). Any use of alcohol was relatively low, with some increase in use over time from 7.4% in April 2019 and April 2020 to 14.8% in April 2021 ($p = 0.85$). The prevalence of any binge drinking reported was similar, with 7.4% in 2019 and 2020 and 11.1% in 2021 ($p > 0.99$). Any cannabis use was also lowest in April 2019 (11.1%) and April 2020 (11.1%), with an increase in April 2021 (18.5%) ($p = 0.65$). Finally, no participants reported prescription pain medicine misuse for April 2019 and April 2020. However, for April 2021, 7.4% reported misuse of prescription pain medicine ($p = 0.33$).

In all three periods assessed, prevalence of reports of ≥ 2 week periods of feeling down, depressed, or hopeless and/or little pleasure or interest in doing things were high (Table 6.4). For April 2019, 48.1% of participants reported depressive symptoms. There was a sharp

increase for April 2020 with 70.4% of participants reporting depressive symptoms. April 2021 was similar to April 2020, with one-third (66.7%) of participants indicating depressive symptoms. The differences over time were not statistically significant ($p = 0.22$).

Exploratory Analysis: Differences by Urbanicity

As an exploratory analysis, we assessed for differences in the April 2021 period by urbanicity (rural: n = 10, suburban: n = 10, and urban: n = 7). Comparisons for differences across groups were not statistically significant for social media use ($p = 0.36$), electronic vapor product use ($p = 0.86$), alcohol use ($p = 0.41$), binge drinking ($p = 1.0$), cannabis use ($p = 0.92$), prescription pain medicine misuse ($p = 0.32$), or depressive symptoms ($p = 0.67$). These analyses are exploratory and should be considered within the context of the small sample size.

6.5 Discussion

In our online survey-based study of adolescent experience of social media use, substance use, and depressive symptoms, we observed high prevalence of social media use and depressive symptoms at all three time points (i.e., April 2019, April 2020, and April 2021). Additionally, prevalence of social media use and depressive symptoms was substantially higher in 2021 (at least several times a day social media use: 88.9%; depressive symptoms: 66.7%) than in 2019 (at least several times a day social media use: 55.6%; depressive symptoms: 48.1%). For social media use, this difference was statistically significant. Substance use also increased over time, though somewhat less dramatically except for electronic vapor product use from 7.4% in April 2019 to 25.9% in April 2021. Prescription pain medicine misuse was least prevalent at all time periods.

Our findings of high social media use during the pandemic period are similar to what has been reported in existing literature. A 2022 systematic review and meta-analysis of adolescent digital media use and mental health during the COVID-19 pandemic reported an increase in social media use and noted that three studies indicated that approximately one-third of adolescents used social media for more than five hours a day (37). While high social media use has historically been associated with depressive symptoms (18) and may negatively impact self-esteem among girls (25), use of social media to directly connect with one or a few individuals during the pandemic may have had a positive impact on feelings of loneliness (37). Further, some forms of coping via social media, such as humor and actively facing the pandemic, may have improved adolescent mood during the pandemic (38). These improvements in mood following use of social media may have had the effect of positive reinforcement and therefore resulted in increased social media use.

Reports of substance use trends during the COVID-19 pandemic are somewhat more varied. Findings from meta-analyses of alcohol use in people ages 12 years and older suggest that about one-quarter of people reported increased alcohol use and another approximate one-quarter reported decreased alcohol use comparing pre- and during pandemic periods (39). Our findings for alcohol use suggest an increasing trend over time, though our observations should be considered within the context of a relatively young adolescent sample and small sample size. With that said, 14.8% of our sample reported alcohol use in the April 2019 period which was similar to the 19.5% reported by high school students in January 2021 to June 2021 in the Centers for Disease Control and Prevention Adolescent Behaviors and Experiences Survey (ABES) (40).

Our findings for any use of electronic vapor products in April 2019 (25.9%) were substantially higher than reported by ABES (15.4%). In a Qualtrics-based cross-sectional study in May 2020 among 13 to 24 year olds who reported using e-cigarettes at least once in their lives, 55.1% of participants less than age 21 reported a change in e-cigarette use since the pandemic began (23). Approximately half of those reporting a change reported quitting or reducing use by half. We observed both an increase in reported electronic vapor product use comparing April 2019 and April 2020, but also a change in the distribution leaning more towards fewer days per month of use. Again, these findings should be considered within the young age distribution and small sample size of our study participants.

Reports of cannabis use were similar to what was observed in ABES, in which 12.8% reported use in the past 30 days (40). Another study of adolescents and young adults in the United States in May 2020 suggested a decrease in cannabis vaping among individuals who reported ever vaping cannabis (24). Comparing these results of reported cannabis vaping to our own findings for electronic vapor product use and cannabis use, we observed an increase in electronic vapor product use, but not cannabis use, from April 2019 to April 2020, though the comparability of our study may be limited by the age distribution of our participants. Finally, observed levels of prescription pain medicine in our study were comparable to those reported in ABES (40).

A 2021 global meta-analysis of adolescent depressive symptoms suggests that one-quarter of adolescents had clinically elevated depressive symptoms during the COVID-19 pandemic, which reflects a doubling from pre-pandemic levels (41). We observed much higher levels in both pre-pandemic (April 2019: 48.1%) and during pandemic periods (April 2020:

70.4%; April 2021: 66.7%), but our study did not assess for clinically elevated depressive symptoms. Our findings were also higher than those reported by adolescent participants in ABES, in which 31.1% reported poor mental health during the past 30 days and 44.2% reported a period of two or more weeks of sadness or hopelessness in the past twelve months (40). Notably, ABES used a complex survey design which produces a weighted sample that is representative of the United States, while our sample is not nationally representative. Most participants were from Missouri. Another possible contributor to the differences observed in our study and ABES may also be the high proportion of individuals identifying as female, transgender male, non-binary, and gender fluid. While ABES does not report gender identity, sex-stratified estimates of feelings of sadness or hopelessness suggest elevated depressive symptoms among females (56.5%) compared to males (31.4%) (40).

Key strengths of our study include assessment of important public health issues (i.e., adolescent depressive symptoms and substance use) and facets of adolescent life (i.e., social media use) across pre-pandemic (April 2019), early pandemic (April 2020), and later pandemic (April 2021) periods. Because our survey queried individuals about three time points, we are able to minimize potential confounding that may occur when comparing multiple cross-sectional reports of different respondents. Our survey questions were designed based on survey items used in other surveys including the Pew Research Center's 2018 Teen Survey (4) and the 2019 Youth Risk Behavior Survey (32) in an effort to improve validity. We also collected information on sexual orientation and gender identity and allowed for write in options, which are not often collected or reported in adolescent surveys, such as the national 2019 Youth Risk Behavior Survey, but are key to informing adolescent public health.

All findings of our survey must be considered within the context of its limitations. The main limitation is the likely lack of generalizability to the general population of adolescents in the United States. We had a small sample size of 27 participants and most (92.6%) of the sample was from Missouri. The racial, ethnic, and gender distributions of our participants are not representative of the adolescent population in the United States. Our sample was also relatively young with 60% being ages 13 or 14 years. Observed increases in prevalence of social media use, substance use, and depressive symptoms over time may be due to aging of participants. The method of participation in our study required access to the internet, which inherently excludes adolescents without stable access to an internet connection. In 2019, 5% of children did not have access to the internet at home, with wide variation across racial/ethnic groups and parental education levels (42). This figure may have increased due to financial hardship and instability associated with the COVID-19 pandemic and could have led to differential participation in our study. Due to the sensitive nature of substance use and depressive symptom questions, adolescent responses may have been influenced by social desirability bias which could result in our estimates reflecting lower prevalence than the truth. Our findings may also be subject to substantial recall bias, as participants may be reporting on their behaviors from up to three years before the point in time at which they were taking the survey.

In all, we observed high prevalence of adolescent-reported social media use, substance use, and depressive symptoms and increases from pre-pandemic periods to during pandemic periods. While some of our findings may be reflective of increasing age over time of the participants, they bring to attention critical concerning issues. Caregivers of adolescents should

encourage and model healthy social media use. Providers should be aware of and assess for changes in adolescent substance use. Resources should be allocated for prevention and/or intervention strategies to address adolescent substance use in the context of the pandemic. Finally, adults living and working with adolescents must take heed of the observed increase in adolescent depressive symptoms. Adolescent caregivers, teachers, and healthcare providers can encourage healthy coping skills, identify adolescents who are struggling, and aid adolescents in accessing appropriate mental healthcare. As the impacts of the pandemic continue to persist, further research is needed to delineate specific risk factors for problematic social media use, substance use, and depressive symptoms during and after the pandemic to inform effective and impactful programming.

6.6 References

1. The U.S. Surgeon General's Advisory. Protecting Youth Mental Health. U.S. Department of Health and Human Services; (Accessed March 29, 2022).(https://www.hhs.gov/sites/default/files/surgeon-general-youth-mental-health-advisory.pdf). (Accessed March 29, 2022)

2. Centers for Disease Control and Prevention. Youth Risk Behavior Survey Data Summary & Trends Report: 2009-2019. (Accessed March 29, 2022).(https://www.cdc.gov/healthyyouth/data/yrbs/pdf/YRBSDataSummaryTrendsReport2019-508.pdf). (Accessed March 29, 2022)

3. Johnston LD, Miech RA, O'Malley PM, et al. Monitoring the Future national survey results on drug use 1975-2021: Overview, key findings on adolescent drug use. Ann Arbor: University of Michigan Institute for Social Research; 2022 (Accessed May 17, 2022).(http://www.monitoringthefuture.org//pubs/monographs/mtf-overview2021.pdf). (Accessed May 17, 2022)

4. Anderson M, Jiang J. Teens, Social Media & Technology 2018. Pew Research Center; 2018.(https://www.pewresearch.org/internet/2018/05/31/teens-social-media-technology-2018/)

5. Uhls YT, Ellison NB, Subrahmanyam K. Benefits and Costs of Social Media in Adolescence. *Pediatrics* [electronic article]. 2017;140(Supplement_2):S67–S70. (https://publications.aap.org/pediatrics/article/140/Supplement_2/S67/34168/Benefits-and-Costs-of-Social-Media-in-Adolescence). (Accessed March 29, 2022)

6. Craft S, Ashley S, Maksl A. Elements of News Literacy. *Electronic News*. 2016;10(3):143–160.

7. Tandoc EC, Johnson E. Most students get breaking news first from Twitter. *Newspaper Research Journal*. 2016;37(2):153–166.

8. Fegert JM, Vitiello B, Plener PL, et al. Challenges and burden of the Coronavirus 2019 (COVID-19) pandemic for child and adolescent mental health: A narrative review to highlight clinical and research needs in the acute phase and the long return to normality. *Child and Adolescent Psychiatry and Mental Health* [electronic article]. 2020;14(1):1–11. (https://doi.org/10.1186/s13034-020-00329-3)

9. Singh S, Roy D, Sinha K, et al. Impact of COVID-19 and lockdown on mental health of children and adolescents: A narrative review with recommendations. *Psychiatry Research* [electronic article]. 2020;293:113429. (https://linkinghub.elsevier.com/retrieve/pii/S016517812031725X)

10. Huckins JF, da Silva AW, Wang W, et al. Mental health and behavior of college students during the early phases of the COVID-19 pandemic: Longitudinal smartphone and ecological momentary assessment study. *Journal of Medical Internet Research*. 2020;22(6).

11. Gazmararian J, Weingart R, Campbell K, et al. Impact of COVID-19 Pandemic on the Mental Health of Students From 2 Semi-Rural High Schools in Georgia. *The Journal of school health*. 2021;91(5):356–369.

12. Breaux R, Dvorsky MR, Marsh NP, et al. Prospective impact of COVID-19 on mental health functioning in adolescents with and without ADHD: protective role of emotion regulation abilities. *Journal of child psychology and psychiatry, and allied disciplines*. 2021;

13. Chahal R, Kirshenbaum JS, Miller JG, et al. Higher Executive Control Network Coherence Buffers Against Puberty-Related Increases in Internalizing Symptoms During the COVID-19 Pandemic. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging* [electronic article]. 2021;6(1):79–88. (https://doi.org/10.1016/j.bpsc.2020.08.010)

14. Lorenzo NE, Zeytinoglu S, Morales S, et al. Transactional Associations Between Parent and Late Adolescent Internalizing Symptoms During the COVID-19 Pandemic: The Moderating Role of Avoidant Coping. *Journal of youth and adolescence*. 2021;50(3):459–469.

15. McKune SL, Acosta D, Diaz N, et al. Psychosocial health of school-aged children during the initial COVID-19 safer-at-home school mandates in Florida: a cross-sectional study. *BMC public health*. 2021;21(1):603.

16. Murata S, Rezeppa T, Thoma B, et al. The psychiatric sequelae of the COVID-19 pandemic in adolescents, adults, and health care workers. *Depression and anxiety*. 2021;38(2):233–246.

17. Rogers AA, Ha T, Ockey S. Adolescents' Perceived Socio-Emotional Impact of COVID-19 and Implications for Mental Health: Results From a U.S.-Based Mixed-Methods Study. *The Journal of adolescent health : official publication of the Society for Adolescent Medicine*. 2021;68(1):43–52.

18. Ivie EJ, Pettitt A, Moses LJ, et al. A meta-analysis of the association between adolescent social media use and depressive symptoms. *Journal of Affective Disorders* [electronic article]. 2020;275:165–174. (https://linkinghub.elsevier.com/retrieve/pii/S0165032720323727). (Accessed April 24, 2022)

19. Penner F, Hernandez Ortiz J, Sharp C. Change in Youth Mental Health During the COVID-19 Pandemic in a Majority Hispanic/Latinx US Sample. *Journal of the American Academy of Child & Adolescent Psychiatry* [electronic article]. 2021;60(4):513–523. (https://linkinghub.elsevier.com/retrieve/pii/S0890856720322127)

20. Thompson EC, Thomas SA, Burke TA, et al. Suicidal thoughts and behaviors in psychiatrically hospitalized adolescents pre- and post- COVID-19: A historical chart review and examination of contextual correlates. *Journal of affective disorders reports*. 2021;4:100100.

21. Kreslake JM, Simard BJ, O'Connor KM, et al. E-Cigarette Use Among Youths and Young Adults During the COVID-19 Pandemic: United States, 2020. *American journal of public health*. 2021;e1–e9.

22. Maggs JL, Cassinat JR, Kelly BC, et al. Parents Who First Allowed Adolescents to Drink Alcohol in a Family Context During Spring 2020 COVID-19 Emergency Shutdowns. *The Journal of adolescent health : official publication of the Society for Adolescent Medicine*. 2021;68(4):816–818.

23. Gaiha SM, Lempert LK, Halpern-Felsher B. Underage Youth and Young Adult e-Cigarette Use and Access Before and During the Coronavirus Disease 2019 Pandemic. *JAMA network open*. 2020;3(12):e2027572.

24. Nguyen N, Mathur Gaiha S, Halpern-Felsher B. Self-reported changes in cannabis vaping among US adolescents and young adults early in the COVID-19 pandemic. *Preventive Medicine Reports* [electronic article]. 2021;24:101654. (https://linkinghub.elsevier.com/retrieve/pii/S2211335521003454). (Accessed April 24, 2022)

25. Steinsbekk S, Wichstrøm L, Stenseng F, et al. The impact of social media use on appearance self-esteem from childhood to adolescence – A 3-wave community study. *Computers in Human Behavior* [electronic article]. 2021;114:106528. (https://linkinghub.elsevier.com/retrieve/pii/S0747563220302806). (Accessed April 24, 2022)

26. Harris PA, Taylor R, Thielke R, et al. Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of Biomedical Informatics* [electronic article]. 2009;42(2):377–381. (https://linkinghub.elsevier.com/retrieve/pii/S1532046408001226)

27. Harris PA, Taylor R, Minor BL, et al. The REDCap consortium: Building an international community of software platform partners. *Journal of Biomedical Informatics* [electronic article]. 2019;95:103208. (https://linkinghub.elsevier.com/retrieve/pii/S1532046419301261)

28. Harvard Office of Regulatory Affiars and Research Compliance. ORARC Tip Sheet: INCLUSIVE DEMOGRAPHIC DATA COLLECTION. 2020;(https://cdn1.sph.harvard.edu/wp-content/uploads/sites/2102/2020/04/ORARC-Tip-Sheet-Inclusive-Demographic-Data-Collection.pdf). (Accessed June 7, 2021)

29. Marks R, Rios-Vargas M. Improvements to the 2020 Census Race and Hispanic Origin Question Designs, Data Processing, and Coding Procedures. United States Census Bureau; 2021 (Accessed March 29, 2022).(https://www.census.gov/newsroom/blogs/random-samplings/2021/08/improvements-to-2020-census-race-hispanic-origin-question-designs.html). (Accessed March 29, 2022)

30. Ready, Set, Go! A Guide for Collecting Data on Sexual Orientation and Gender Identity. National LGBT Health Education Center; 2020 (Accessed March 29, 2022).(https://www.lgbtqiahealtheducation.org/wp-content/uploads/2018/03/TFIE-47_Updates-2020-to-Ready-Set-Go-publication_6.29.20.pdf). (Accessed March 29, 2022)

31. Igielnik Wieder R. Evaluating what makes a U.S. community urban, suburban or rural. 2019 (Accessed March 29, 2022).(https://medium.com/pew-research-center-decoded/evaluating-what-makes-a-u-s-community-urban-suburban-or-rural-159f9d082842). (Accessed March 29, 2022)

32. Centers for Disease Control and Prevention. 2019 YRBS Data User's Guide. 2020.(https://www.cdc.gov/healthyyouth/data/yrbs/pdf/2019/2019_National_YRBS_Data_Users_Guide.pdf)

33. Miech RA, Johnston LD, Bachman JG, et al. Monitoring the Future: A Continuing Study of American Youth (12th-Grade Survey), 2019. 2020;

34. Flentje A, Barger BT, Capriotti MR, et al. Screening gender minority people for harmful alcohol use. *PLOS ONE* [electronic article]. 2020;15(4):e0231022. (https://dx.plos.org/10.1371/journal.pone.0231022)

35. Gilbert PA, Pass LE, Keuroghlian AS, et al. Alcohol research with transgender populations: A systematic review and recommendations to strengthen future studies. *Drug and Alcohol Dependence* [electronic article]. 2018;186:138–146. (https://linkinghub.elsevier.com/retrieve/pii/S0376871618301212)

36. Kroenke K, Spitzer RL, Williams JBW. The Patient Health Questionnaire-2: Validity of a Two-Item Depression Screener. *Medical Care* [electronic article]. 2003;41(11):1284–1292. (https://journals.lww.com/00005650-200311000-00008). (Accessed March 29, 2022)

37. Marciano L, Ostroumova M, Schulz PJ, et al. Digital Media Use and Adolescents' Mental Health During the Covid-19 Pandemic: A Systematic Review and Meta-Analysis. *Front. Public Health* [electronic article]. 2022;9:793868. (https://www.frontiersin.org/articles/10.3389/fpubh.2021.793868/full). (Accessed April 24, 2022)

38. Cauberghe V, Van Wesenbeeck I, De Jans S, et al. How Adolescents Use Social Media to Cope with Feelings of Loneliness and Anxiety During COVID-19 Lockdown. *Cyberpsychology, behavior and social networking*. 2021;24(4):250–257.

39. Acuff SF, Strickland JC, Tucker JA, et al. Changes in alcohol use during COVID-19 and associations with contextual and individual difference variables: A systematic review and meta-analysis. *Psychology of Addictive Behaviors* [electronic article]. 2022;36(1):1–19. (http://doi.apa.org/getdoi.cfm?doi=10.1037/adb0000796). (Accessed April 24, 2022)

40. Brener ND, Bohm MK, Jones CM, et al. Use of Tobacco Products, Alcohol, and Other Substances Among High School Students During the COVID-19 Pandemic — Adolescent Behaviors and Experiences Survey, United States, January–June 2021. *MMWR Suppl.* [electronic article]. 2022;71(3):8–15. (http://www.cdc.gov/mmwr/volumes/71/su/su7103a2.htm?s_cid=su7103a2_w). (Accessed April 24, 2022)

41. Racine N, McArthur BA, Cooke JE, et al. Global Prevalence of Depressive and Anxiety Symptoms in Children and Adolescents During COVID-19: A Meta-analysis. *JAMA Pediatr* [electronic article]. 2021;175(11):1142. (https://jamanetwork.com/journals/jamapediatrics/fullarticle/2782796). (Accessed April 24, 2022)

42. Hussar B, Zhang J, Hein S, et al. The Condition of Education 2020 (NCES 2020-144). Washington, DC: U.S. Department of Education. Washington, DC: National Center for Education Statistics.; 2020.(https://nces.ed.gov/pubs2020/2020144.pdf)

6.7 Funding

This work was supported in part by a student project stipend from the Northwest Public Health Training Center at the Northwest Center for Public Health Practice (sponsored by the Health Resources and Services Administration (HRSA) of the U.S. Department of Health and Human

Services (HHS) (grant # 6 UB6HP31690-04-01)). REDCap at ITHS is supported by the National Center For Advancing Translational Sciences of the National Institutes of Health under Award Number UL1 TR002319.

6.8 Tables

Table 6.1: Demographic Characteristics of Survey Participants (N = 27)

	n (%)
Ethnicity	
Hispanic, Latino/a/x, or of Spanish Origin	2 (7.4%)
Not Hispanic, Latino/a/x, or of Spanish Origin	25 (92.6%)
Race*	
American Indian or Alaska Native	0 (0%)
Asian	1 (3.7%)
Black or African American	0 (0%)
Pacific Islander	0 (0%)
White	26 (96.3%)
Other Race	1 (3.7%)
Language Spoken Most Frequently At Home	
English	23 (85.2%)
No Response	4 (14.8%)
Sexual Orientation	
Straight or Heterosexual	13 (48.1%)
Lesbian, Gay, or Homosexual	3 (11.1%)
Bisexual	5 (18.5%)
Something Else: Pansexual	3 (11.1%)
Something Else: Panromantic	1 (3.7%)
Something Else: Unspecified	1 (3.7%)
Don’t Know	0 (0%)
No Response	1 (3.7%)
Gender Identity	
Female	17 (63.0%)
Male	3 (11.1%)
Transgender Male/Transgender Man	2 (7.4%)
Gender Fluid	1 (3.7%)
Non-Binary	3 (11.1%)
Choose Not to Disclose	1 (3.7%)
State	
Arizona	1 (3.7%)
Michigan	1 (3.7%)
Missouri	25 (92.6%)
Urbanicity	
Rural	10 (37.0%)
Suburban	10 (37.0%)
Urban	7 (25.9%)
Grade in 2019-2020 School Year	

6th Grade	12 (44.4%)
7th Grade	2 (7.4%)
8th Grade	5 (18.5%)
9th Grade	3 (11.1%)
10th Grade	5 (18.5%)
Current Age	
13	13 (48.1%)
14	6 (22.2%)
15	1 (3.7%)
16	4 (14.8%)
17	3 (11.1%)

Note: Percentages may not sum to 100% due to rounding.
*Participants could indicate more than one race.

Table 6.2: Social Media Use Reported by Participants (N = 27)

Used Social Media…			**p = 0.04***
	April 2019	**April 2020**	**April 2021**
Almost Constantly	3 (11.1%)	9 (33.3%)	10 (37.0%)
Several Times a Day	12 (44.4%)	13 (48.1%)	14 (51.9%)
About Once a Day	4 (14.8%)	0 (0%)	0 (0%)
Several Times a Week	2 (7.4%)	0 (0%)	0 (0%)
Once a Week	1 (3.7%)	3 (11.1%)	2 (7.4%)
Less Often	5 (18.5%)	2 (7.4%)	1 (3.7%)

*Fisher's exact test p-value

Note: Percentages may not sum to 100% due to rounding.

Table 6.3: Substance Use Reported by Participants (N = 27)

	April 2019	April 2020	April 2021
Electronic Vapor Product			**p = 0.71***
0 days	25 (92.6%)	23 (85.2%)	20 (74.1%)
1 or 2 days	0 (0%)	1 (3.7%)	2 (7.4%)
3 to 5 days	0 (0%)	1 (3.7%)	2 (7.4%)
6 to 9 days	0 (0%)	1 (3.7%)	1 (3.7%)
10 to 19 days	1 (3.7%)	1 (3.7%)	1 (3.7%)
20 to 29 days	1 (3.7%)	0 (0%)	0 (0%)
All 30 days	0 (0%)	0 (0%)	1 (3.7%)
Alcohol			**p = 0.85***
0 days	24 (88.9%)	25 (92.6%)	23 (85.2%)
1 or 2 days	1 (3.7%)	1 (3.7%)	1 (3.7%)
3 to 5 days	0 (0%)	0 (0%)	2 (7.4%)
6 to 9 days	1 (3.7%)	0 (0%)	1 (3.7%)
10 to 19 days	0 (0%)	1 (3.7%)	0 (0%)
20 to 29 days	0 (0%)	0 (0%)	0 (0%)
All 30 days	0 (0%)	0 (0%)	0 (0%)
Missing	1 (3.7%)	0 (0%)	0 (0%)
Binge Drinking			**p = 1.0***
0 days	25 (92.6%)	25 (92.6%)	24 (88.9%)
1 or 2 days	2 (7.4%)	1 (3.7%)	2 (7.4%)
3 to 5 days	0 (0%)	0 (0%)	1 (3.7%)
6 to 9 days	0 (0%)	1 (3.7%)	0 (0%)
10 to 19 days	0 (0%)	0 (0%)	0 (0%)
20 to 29 days	0 (0%)	0 (0%)	0 (0%)
All 30 days	0 (0%)	0 (0%)	0 (0%)
Cannabis			**p = 0.65***
0 times	24 (88.9%)	24 (88.9%)	22 (81.5%)
1 or 2 times	2 (7.4%)	2 (7.4%)	1 (3.7%)
3 to 9 times	1 (3.7%)	0 (0%)	1 (3.7%)
10 to 19 times	0 (0%)	0 (0%)	2 (7.4%)
20 to 39 times	0 (0%)	0 (0%)	0 (0%)
40 or more times	0 (0%)	1 (3.7%)	1 (3.7%)
Prescription Pain Medicine			**p = 0.33***
No	27 (100%)	27 (100%)	25 (81.5%)
Yes	0 (0%)	0 (0%)	2 (7.4%)

*Fisher's exact test p-value

Note: Percentages may not sum to 100% due to rounding.

Table 6.4: Depressive Symptoms Reported by Participants (N = 27)

Depressive Symptoms			**p = 0.22***
	April 2019	**April 2020**	**April 2021**
Yes	13 (48.1%)	19 (70.4%)	18 (66.7%)
No	14 (51.9%)	8 (29.6%)	9 (33.3%)

*Fisher's exact test p-value

Note: Percentages may not sum to 100% due to rounding.

6.9 Appendix

Appendix 6.1: Questionnaire Items

1. Are you of Hispanic, Latino/a/x, or of Spanish origin?
    a) Yes
        - Option to add additional detail: "Print, for example, Mexican, Puerto Rican, Cuban, etc." _____
    b) No

2. What is your race (checkboxes with option to select more than one)?
    a) White
        - Option to add additional detail: "Print, for example, German, Irish, English, Italian, Lebanese, Egyptian, etc."_____
    b) Black or African American
        - Option to add additional detail: "Print, for example, African American, Jamaican, Haitian, Nigerian, Ethiopian, Somali, etc." _____
    c) American Indian or Alaska Native
        - Option to add additional detail: "Print name of enrolled or principal tribe(s), for example, Navajo Nation, Blackfeet Tribe, Mayan, Aztec, Native Village of Barrow Inupiat Traditional Government, Nome Eskimo Community, etc." _____
    d) Asian
        - Option to add additional detail: "Print, for example, Chinese, Filipino, Asian Indian, Vietnamese, Korean, Japanese, Pakistani, Cambodian, Hmong, etc." _____
    e) Pacific Islander
        - Option to add additional detail: "Print, for example, Native Hawaiian, Samoan, Chamorro, Tongan, Fijian, Marshallese, etc." _____
    f) Other Race
        - Option to add additional detail: "Print race or origin." _____

3. What language do you speak most frequently at home?
_____

4. Do you think of yourself as:
    a) Straight or heterosexual
    b) Lesbian, gay, or homosexual
    c) Bisexual
    d) Something else (e.g., queer, pansexual, asexual.) Please specify: _____
    e) Don't know
    f) Choose not to disclose

5. What is your current gender identity?
   a) Female
   b) Male
   c) Transgender woman/transgender female
   d) Transgender man/transgender male
   e) Other (e.g., non-binary, genderqueer, gender-diverse, or gender fluid) Please specify: _____
   f) Don't know
   g) Choose not to disclose

6. What state do you currently live in?
Dropdown box listing all states, an option for "Washington, D.C. or U.S. Territory", and an option for "I do not live in the United States" – **CHOOSING "I DO NOT LIVE IN THE UNITED STATES" WILL AUTOMATICALLY DIRECT PARTICIPANTS TO THE EXCLUDED DEBRIEF/THANK YOU SCREEN AFTER QUESTION 9**

7. How would you describe the area in which you live?
   a) Rural (a less-dense area far from the city with lots of nature and open spaces)
   b) Suburban (a moderately dense area where people live outside, but not far from a city or town)
   c) Urban/city (a densely populated area in a city or town, or very close to a city or town, where there are lots of buildings close together)

8. What was your grade in school in the 2019-2020 school year?
   a) 6th grade
   b) 7th grade
   c) 8th grade
   d) 9th grade
   e) 10th grade
   f) 11th grade
   g) 12th grade
   h) College equivalent
   i) I was not in school

9. What is your current age?
   a) 12 or younger – **CHOOSING THIS OPTION WILL AUTOMATICALLY DIRECT PARTICIPANTS TO THE EXCLUDED DEBRIEF/THANK YOU SCREEN AFTER QUESTION 9**
   b) 13
   c) 14
   d) 15
   e) 16
   f) 17
   g) 18
   h) 19

i) 20 or older– **CHOOSING THIS OPTION WILL AUTOMATICALLY DIRECT PARTICIPANTS TO THE EXCLUDED DEBRIEF/THANK YOU SCREEN AFTER QUESTION 9**

The first group of questions will ask about social media use.

10. During the month of **April 2019**, about how often did you use social media (e.g. Instagram, TikTok, etc.) on a computer, cellphone, tablet, or any other electronic device?

a) Almost constantly
b) Several times a day
c) About once a day
d) Several times a week
e) Once a week
f) Less often

11. During the month of **April 2020**, about how often did you use social media (e.g. Instagram, TikTok, etc.) on a computer, cellphone, tablet, or any other electronic device?

a) Almost constantly
a) Several times a day
b) About once a day
c) Several times a week
d) Once a week
e) Less often

12. During the month of **April 2021**, about how often did you use social media (e.g. Instagram, TikTok, etc.) on a computer, cellphone, tablet, or any other electronic device?

a) Almost constantly
b) Several times a day
c) About once a day
d) Several times a week
e) Once a week
f) Less often

The next group of questions will ask about substance use.

13. During the month of **April 2019**, on how many days did you use an electronic vapor product (e.g. vape-pen, e-cigarette, e-hookah, or e-vaporizer)?

a) 0 days
b) 1 or 2 days
c) 3 to 5 days
d) 6 to 9 days
e) 10 to 19 days
f) 20 to 29 days
g) All 30 days

14. During the month of **April 2020**, on how many days did you use an electronic vapor product (e.g. vape-pen, e-cigarette, e-hookah, or e-vaporizer)?

a) 0 days
b) 1 or 2 days
c) 3 to 5 days
d) 6 to 9 days
e) 10 to 19 days
f) 20 to 29 days
g) All 30 days

15. During the month of **April 2021**, on how many days did you use an electronic vapor product (e.g. vape-pen, e-cigarette, e-hookah, or e-vaporizor)?

a) 0 days
b) 1 or 2 days
c) 3 to 5 days
d) 6 to 9 days
e) 10 to 19 days
f) 20 to 29 days
g) All 30 days

16. During the month of **April 2019**, on how many days did you have at least one drink of alcohol?

a) 0 days
b) 1 or 2 days
c) 3 to 5 days
d) 6 to 9 days
e) 10 to 19 days
f) 20 to 29 days
g) All 30 days

17. During the month of **April 2020**, on how many days did you have at least one drink of alcohol?

a) 0 days
b) 1 or 2 days
c) 3 to 5 days
d) 6 to 9 days
e) 10 to 19 days
f) 20 to 29 days
g) All 30 days

18. During the month of **April 2021**, on how many days did you have at least one drink of alcohol?

a) 0 days
b) 1 or 2 days

c) 3 to 5 days
d) 6 to 9 days
e) 10 to 19 days
f) 20 to 29 days
g) All 30 days

19. During the month of **April 2019**, on how many days did you have 5 or more drinks of alcohol in a row, that is, within a couple of hours?

a) 0 days
b) 1 or 2 days
c) 3 to 5 days
d) 6 to 9 days
e) 10 to 19 days
f) 20 to 29 days
g) All 30 days

20. During the month of **April 2020**, on how many days did you have 5 or more drinks of alcohol in a row, that is, within a couple of hours?

a) 0 days
b) 1 or 2 days
c) 3 to 5 days
d) 6 to 9 days
e) 10 to 19 days
f) 20 to 29 days
g) All 30 days

21. During the month of **April 2021**, on how many days did you have 5 or more drinks of alcohol in a row, that is, within a couple of hours?

a) 0 days
b) 1 or 2 days
c) 3 to 5 days
d) 6 to 9 days
e) 10 to 19 days
f) 20 to 29 days
g) All 30 days

22. During the month of **April 2019**, how many times did you use marijuana?

a) 0 times
b) 1 or 2 times
c) 3 to 9 times
d) 10 to 19 times
e) 20 to 39 times
f) 40 or more times

23. During the month of **April 2020**, how many times did you use marijuana?
    a) 0 times
    b) 1 or 2 times
    c) 3 to 9 times
    d) 10 to 19 times
    e) 20 to 39 times
    f) 40 or more times

24. During the month of **April 2021**, how many times did you use marijuana?
    a) 0 times
    b) 1 or 2 times
    c) 3 to 9 times
    d) 10 to 19 times
    e) 20 to 39 times
    f) 40 or more times

25. During the month of **April 2019**, did you ever take prescription pain medicine without a doctor's prescription or differently than how a doctor told you to use it?
    a) Yes
    b) No

26. During the month of **April 2020**, did you ever take prescription pain medicine without a doctor's prescription or differently than how a doctor told you to use it?
    a) Yes
    b) No

27. During the month of **April 2021**, did you ever take prescription pain medicine without a doctor's prescription or differently than how a doctor told you to use it?
    a) Yes
    b) No

The last group of questions will ask about feeling depressed.

28. During the month of **April 2019**, did you ever feel little interest or pleasure in doing things and/or feel down, depressed, or hopeless almost every day for two weeks or more in a row?
    c) Yes
    d) No

29. During the month of **April 2020**, did you ever feel little interest or pleasure in doing things and/or feel down, depressed, or hopeless almost every day for two weeks or more in a row?
    a) Yes
    b) No

30. During the month of **April 2021**, did you ever feel little interest or pleasure in doing things and/or feel down, depressed, or hopeless almost every day for two weeks or more in a row?

a) Yes
b) No

Chapter 7. Discussion

7.1 Overall Findings

Using 2019 Youth Risk Behavior Survey (YRBS) data to assess associations of past 12 month depressive symptoms and suicidality with substance use, in fully adjusted models including covariates for demographic factors and use of other substances, we identified the strongest associations for prescription pain medicine misuse, with statistically significant associations of reports of past 12 month depressive symptoms (aOR: 2.62; 95% CI: 1.97, 3.48; $p < 0.001$), seriously considered attempting suicide (aOR: 3.08; 95% CI: 2.35, 4.04; $p < 0.001$), having made a suicide plan (aOR: 3.18; 95% CI: 2.40, 4.21; $p < 0.001$), and suicide attempts (aOR: 2.02; 95% CI: 1.75, 2.33; $p < 0.001$) with past 30 day prescription pain medicine misuse. We also observed significant, fully adjusted associations of past 12 month depressive symptoms, consideration of suicide attempts, suicide plans, and suicide attempts with past 30 day ever alcohol use, cannabis use, and electronic vapor product use (with the exception of having made a suicide plan and alcohol use). We did not find statistically significant differences in associations of depressive symptoms and suicidality with substance use among groups defined by demographic factors (i.e., race/ethnicity, sex, and sexual identity). There was evidence of bidirectional association between lifetime substance use and past 12 month depressive symptom and suicidality.

In assessing these cross-sectional associations of depressive symptoms and suicidality with substance use over time using YRBS data from 1991 to 2019, we were limited with respect to data availability for each substance for each year. However, we generally identified that all associations (adjusted for sex, age, and race/ethnicity) of past 12 month depressive symptom

and suicidality indicators with past 30 day ever use of alcohol and cannabis have increased slightly over time and that associations for past 30 day ever use of alcohol and cannabis were relatively similar to one another over time. For the time points at which past 30 day binge drinking, past 30 day electronic vapor product use, and lifetime prescription pain medicine misuse were assessed, associations were relatively stable over time.

Also using 2019 YRBS data, we found that the experience of having been bullied in the past 12 months at school was associated with any ever use of electronic vapor products in the past 30 days (aOR: 1.49; 95% CI: 1.21, 1.84; $p < 0.001$) and ever prescription pain medicine misuse in the past 30 days (aOR: 2.10; 95% CI: 1.72, 2.55; $p < 0.001$) in fully adjusted models including a covariate for use of other substances. Similarly, the experience of having been bullied at school in the past 12 months was associated with any use of electronic vapor products in the past 30 days (aOR: 1.89; 95% CI: 1.55, 2.31; $p < 0.001$) and any prescription pain medicine misuse in the past 30 days (aOR: 1.99; 95% CI: 1.48, 2.67; $p < 0.001$) in fully adjusted models. However, we did not identify significant associations of either experience of having been bullied and past 30 day alcohol use, binge drinking, and cannabis use in fully adjusted models, but associations were generally statistically significant in partially adjusted models excluding a covariate for use of other substances. We did we find evidence of significant moderation by race/ethnicity, sex, and sexual identity. Mediation analyses suggested that nearly one half of the associations of past 12 month experience of having been bullied at school (proportion mediated = 0.46) and having been bullied electronically (proportion mediated = 0.48) with past 30 day any prescription pain medicine misuse were mediated through past 12 month depressive symptoms in fully adjusted models.

In our scoping review of published literature on adolescent social media use, substance use, and depressive symptoms during the COVID-19 pandemic in the United States, we identified 29 studies that met inclusion criteria. Broadly, the included studies suggested high levels of social media use and that social media was used for connection and coping during the pandemic. Reports on substance use were heterogenous, but two studies suggested lower e-cigarette use during the pandemic. With regard to depressive symptoms which were measured in a variety of ways, cross-sectional estimates indicated high prevalence of depressive symptoms during the pandemic, while studies that measured the longitudinal trajectory of depressive symptoms and suicidality suggest a possible decrease in the first few months following the onset of the pandemic.

Finally, in our online, anonymous survey of adolescents in which participants retrospectively reported on behaviors in April 2019, April 2020, and April 2021, we observed a significant increase in reported social media use over time ($p = 0.04$), with 70.4%, 81.5%, and 88.9% of participants reporting using social media at least once a day in April 2019, April 2020, and April 2021, respectively. Though not statistically significantly different over time (p range = 0.33 to > 0.99), substance use also increased from April 2019 (cannabis: 11.1%, electronic vapor product use: 7.4%, alcohol use: 7.4%, binge drinking: 7.4%, prescription pain medicine misuse: 0%) to April 2021 (cannabis: 18.5%, electronic vapor product use: 25.9%, alcohol use: 14.8%, binge drinking: 11.1%, prescription pain medicine misuse: 7.4%). Depressive symptoms similarly increased following the onset of the pandemic (April 2019: 48.1;, April 2020: 70.4%; April 2021: 66.7%), but this difference was also not significant ($p = 0.22$).

7.2 Strengths and Limitations

For YRBS analyses, key strengths include the use of nationally representative data of high school students in public and private schools. As of the time of writing (June 2022), we have used the most recent YRBS data available, which has allowed us to assess and report the most recent associations and trends for the experience of having been bullied, depressive symptoms, suicidality, and substance use, including recently introduced substance use (i.e., electronic vapor product use). In our analyses using YRBS data, we additionally assessed for differences in associations by demographic factors (i.e., sex, race/ethnicity, and sexual identity) in order to account for the role of stress that individuals with marginalized identities may face.

Our aims utilizing YRBS data were limited with respect to the fact that they exclude adolescents who are not present in school, which may result in exclusion of adolescents who are at higher risk of being bullied, depressive symptoms, suicidality, and/or substance use. Our YRBS analyses were cross-sectional, with limitations in establishing temporal sequences of independent and dependent variables. Therefore, we were unable to draw any causal inferences. YRBS data are self-reported by participants, and therefore may be subject to social desirability bias, particularly for sensitive topics like mental health and substance use. When assessing for change in cross-sectional associations of depressive symptoms and suicidality with substance use over time, we were limited by the years in which specific questions were asked, particularly for binge drinking, electronic vapor product use, and prescription pain medicine misuse.

With respect to our COVID-related aims, we were able to assess potential impacts of a relatively recent, and ongoing, source of substantial stress and hardship. Our scoping review

was guided by established guidelines for scoping reviews, utilized a comprehensive search strategy of three sources, and minimized reviewer bias through double review for the title/abstract screening, full text review, and extraction stages. Our survey sought to address recent public health issues and to narrow a pressing knowledge gap. We queried participants about three timepoints which allowed us to minimize confounding through comparing the same individuals across multiple cross-sectional reports. We additionally attempted to improve validity of our survey questions by adapting questions from existing surveys of adolescents.

Our scoping review was limited in that the landscape of published research during the COVID-19 pandemic is rapidly changing. Due to the dates of the literature search, our findings may not reflect those of the most recent publications. Because of our inclusion of only studies reporting on adolescents in the United States, our findings may not be generalizable to other locations. Our survey findings were substantially limited by the small sample size, the young average age of participants, and the non-representative racial, ethnic, and gender distribution of participants. Finally, because participation in the survey required access to the internet, adolescents without consistent access to internet were inherently excluded.

7.3 Public Health Implications and Recommendations for Future Work

We observed a high prevalence of depressive symptoms, suicidality, and substance use, as well as evidence of associations of depressive symptoms and suicidality and substance use. These findings suggest that adults with prominent roles in the lives of adolescents should be aware that that youth who experience depressive symptoms and suicidality may be more likely to engage in substance use, and vice versa. Because we observed particularly strong

associations in both directions for prescription pain medicine misuse, particular emphasis may be warranted for prevention and intervention efforts relating to this association.

The findings of our work assessing adolescent social media use, substance use, and depressive symptoms during the COVID-19 pandemic suggest that adolescents may need additional mental health support. Caregivers, healthcare providers, and teachers should encourage healthy coping skills and help adolescents in need of additional support to access mental healthcare. Because of evidence for increased social media use, adults should continue to discuss and model healthy social media use habits. Lastly, healthcare providers should assess for changes in substance use and, if applicable, encourage continued decreased or discontinued use.

Future research directions that would address gaps identified by this work include longitudinal studies of adolescent experience of being bullied, depressive symptoms, suicidality, and substance use in order to establish temporality in these associations. Additionally, continued monitoring of cross-sectional associations in ongoing studies will benefit understanding over time and priority should be placed on ensuring consistency in questions in future survey administrations in order to enable adequate comparison of trends over time. Future work should ensure recruitment of diverse participants so as to achieve adequate study power to assess for differences by adolescent identity factors. Additional research will be needed to characterize the impact of the COVID-19 pandemic on adolescent social media use, substance use, and depressive symptoms in the present and as the pandemic continues.