Washington State Institute for Public Policy
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Does Substance Use or Nutrition in Adolescence Predict Mental Health in Young Adulthood?
A Systematic Review

In 2021, the Washington State Legislature directed the Washington State Institute for Public Policy (WSIPP) to review the research literature on any relationships between adolescent substance use and nutrition on subsequent mental illness in early adulthood.[1]

In this report, we summarize the research on young adult mental health outcomes given adolescent use of the following:

- Alcohol
- Cannabis,
- Opioids, and
- Cocaine.

We also examine young adult mental health as predicted by the following aspects of nutrition during adolescence:

- Diet quality,
- Obesity, and
- Consumption of omega-3 fatty acids.

This report is presented in five sections. Section I provides background information. Section II describes our approach to this study. In Section III we present our findings on the relationships between youth substance use and young adult mental health. In Section IV we present our findings on the effects of diet in adolescence on young adult mental health. In Section V we provide a summary of our findings and the limitations of the work.

Summary

The 2021 Washington State Legislature directed WSIPP to review the research for any relationships between adolescent substance use and adolescent nutrition on subsequent mental illness in early adulthood.

We found the following for adolescent substance use:

- Adolescent alcohol use was associated with increased risk of depression;
- Adolescent cannabis use was associated with increased risk for depression and psychosis; and
- We found no evidence that adolescent misuse of opioids or cocaine is associated with mental illness in young adults.

We found the following for adolescent nutrition:

- Higher quality diet in adolescence was associated with lower risk for depression;
- Obesity during adolescence was associated with increased risk for depression, especially in females; and
- We found no evidence of a link between adolescent intake of omega-3 fatty acids and any mental illness in young adulthood.

Suggested citation: Miller, M., & Kelley, K.M. (2022). *Does substance use or nutrition in adolescence predict mental health in young adulthood? A systematic review* (Document Number 22-12-3901). Olympia: Washington State Institute for Public Policy.

[1] Engrossed Substitute Senate Bill 5092, Chapter 334, Laws of 2021.

I. Background

There is a considerable body of research describing and examining the prevalence of co-occurring conditions. That is, persons diagnosed with both substance abuse and symptoms of mental illness. Co-occurring conditions have been observed in adults[2] as well as adolescents.[3]

Further, accumulating evidence suggests that diet and nutrition may have significant effects on mental well-being in the general population.[4] The new field of "nutritional psychiatry" has provided information on ways in which diet is associated with mental health. Broadly, this field seeks to understand if diet may be a modifiable risk factor or treatment option for mental disorders.[5]

It is now well known that adolescent brains are still developing.[6] There is evidence that substance use[7] and nutrition[8] during adolescence may affect brain development in ways that predispose youth to mental illness.

WSIPP Legislative Assignment

…institute to review available research literature to investigate and describe any relationship between early substance abuse of cannabis, opioids, or cocaine and mental health disorders in young adults; and any relationship between nutrition and mental health disorders in young adults. The institute shall report its findings to the legislature no later than June 30, 2022.

ESSB 5092

WSIPP's Board of Directors extended the study deadline to December 1, 2022.

Against this background, the legislature directed WSIPP to review the research literature on mental health outcomes in young adulthood that may occur as a result of substance use and/or aspects of nutrition during adolescence. In other words, do specific kinds of adolescent behavior predispose people to develop mental illness later?

[2] A full list of citations is provided in the Appendix.

[3] For example, see Deas, D., & Brown, E.S. (2006). Adolescent substance abuse and psychiatric comorbidities. *Journal of Clinical Psychiatry, 67*(7), 18 and Bukstein, O.G., Brent, D.A., & Kaminer, Y. (1989). Comorbidity of substance abuse and other psychiatric disorders in adolescents. *The American Journal of Psychiatry, 146*(9), 1131–1141.

[4] Adan, R.A., van der Beek, E.M., Buitelaar, J.K., Cryan, J.F., Hebebrand, J., Higgs, S., . . . Dickson, S.L. (2019). Nutritional psychiatry: Towards improving mental health by what you eat. *European Neuropsychopharmacology, 29*(12), 1321-1332.

[5] Marx, W., Moseley, G., Berk, M., & Jacka, F. (2017). Nutritional psychiatry: the present state of the evidence. *Proceedings of the Nutrition Society, 76*(4), 427-436.

[6] Arain, M., Haque, M., Johal, L., Mathur, P., Nel, W., Rais, A., . . . Sharma, S. (2013). Maturation of the adolescent brain. *Neuropsychiatric Disease and Treatment, 9*, 449.; Casey, B.J., Getz, S., & Galvan, A. (2008). The adolescent brain. *Developmental Review, 28(*1), 62-77.

[7] Squeglia, L.M., Jacobus, J., & Tapert, S.F. (2009). The influence of substance use on adolescent brain development. *Clinical EEG and Neuroscience, 40*(1), 31-38.

[8] Loewen, O.K., Maximova, K., Ekwaru, J.P., Faught, E.L., Asbridge, M., Ohinmaa, A., & Veugelers, P.J. (2019). Lifestyle behavior and mental health in early adolescence. *Pediatrics, 143*(5), 1-9 and Jacka, F.N., Rothon, C., Taylor, S., Berk, M., & Stansfeld, S.A. (2013). Diet quality and mental health problems in adolescents from East London: a prospective study. *Social Psychiatry and Psychiatric Epidemiology*, *48*(8), 1297-1306.

II. Study Methods

To address this assignment, we reviewed the research literature to understand whether certain adolescent behaviors or aspects of nutrition affect mental health in young adulthood (age 18 or older).

In both broad topic areas, most studies focus on single measurements in time which are typically large population surveys. These are referred to as "cross-sectional" studies. If a person exhibits two conditions together (e.g., poor nutrition and mental illness), it is difficult to tease out which causes which or if an entirely unrelated factor is influencing both conditions. That is, did poor diet precede the mental disorder or the other way around? Or is it possible that something else entirely is leading to a poor diet and a mental disorder at the same time?

For this reason, we rely almost entirely on longitudinal studies. That is, studies that follow a group of adolescents as they mature into young adulthood with measures taken at multiple times. In order to be certain that a mental illness did not already exist, we also require that all studies control for the presence of mental illness in adolescence.

In these longitudinal studies, years have elapsed—and many life events have occurred—in the intervening years between adolescence and the measurement of mental illness in young adulthood.

For this reason, we can only identify associations between adolescent substance use and nutrition and any later mental illness; we cannot make "causal" statements. That is, we are unable to say with certainty that any subsequent mental illness was caused by substance use or nutrition during adolescence.

Characteristics of Mental Illness Investigated in this Study

Anxiety is an emotion characterized by feelings of tension, worried thoughts, and physical changes like increased blood pressure.

Depression is extreme sadness or despair that lasts more than days. It interferes with the activities of daily life and can cause physical symptoms such as pain, weight loss or gain, sleeping pattern disruptions, or lack of energy.

Psychosis (psychotic disorder) is characterized by symptoms such as delusions, hallucinations, and markedly disorganized speech, thought, or behavior; individuals may have little or no insight into their symptoms. Some examples of psychotic disorders are schizophrenia, schizophreniform disorder, schizoaffective disorder, delusional disorder, brief psychotic disorder, and psychotic disorders due to a substance … or to a medical condition.

Source: American Psychological Society

Outcome Measures

For the most part, we focused on the two most common categories of mental illness among adolescents and young adults anxiety and depression.[9] However, because we also found considerable literature related to psychosis, which is much less common, we include this condition.

The American Psychiatric Association publishes the Diagnostic and Statistical Manual of Mental Disorders (DSM). It lists the criteria (symptoms and severity) of disorders. Diagnosis typically requires a minimum number of symptoms over specific periods of time. In the studies we located, we sometimes found authors reported diagnoses of mental illness. Other studies reported average scores on instruments designed to measure symptoms and severity. For example, one group had an average depression score higher than the other. Given the diverse nature of the metrics used in the studies, we considered diagnoses and symptoms in a similar manner.

Article Search

For each broad topic, we began by searching the literature for keywords. For example, "adolescent," "alcohol," "mental illness," and "longitudinal."[10]

Searches typically produced a large number of studies. Most were not relevant to our assignment. For example, we set aside studies that focused on adults or studies where measurements were taken at only one point in time. We narrowed the collection of studies to longitudinal studies with measures of adolescent behavior and young adult mental illness in the same individuals or where young adults provided information on specific behaviors or experiences in adolescence. Occasionally, we also found systematic reviews or meta-analyses using the same criteria we required.

In topics where we found more than a single study measuring the same outcome from similar aspects of nutrition or substance use, we combine results in a meta-analysis. We calculate an *effect size* for every study; an effect size is a measure of the magnitude and direction of the effect. We then conduct a *meta-analysis*, a statistical approach that combines results from multiple studies to produce a weighted average estimate of the average effect.

For topics where we conduct a meta-analysis, we provide the average (mean) effect size and the *p*-value. *P*-value is a statistical term that indicates the likelihood that an outcome is due to chance. For example, a $p = 0.05$ means an outcome could be expected to occur 5% of the time, simply due to chance. *P*-values less than 0.05 are considered statistically significant.

[9] Merikangas, K.R., He, J.P., Burstein, M., Swanson, S.A., Avenevoli, S., Cui, L., . . . Swendsen, J. (2010). Lifetime prevalence of mental disorders in U.S. adolescents: results from the National Comorbidity Survey Replication—Adolescent Supplement (NCS-A). *Journal of the American Academy of Child and Adolescent Psychiatry, 49*(10), 980–989.; Kessler, R.C., & Wang, P.S. (2008). The descriptive epidemiology of commonly occurring mental disorders in the United States. *Annual Review of Public Health, 29*(1), 115-129.

[10] Diagrams describing our literature searches can be found in the Appendix.

We were able to conduct meta-analyses on three nutrition topics and one substance use topic. However, because of the range of ways substance use was reported in the studies, meta-analyses were not feasible for others. In one instance, we were able to rely on a meta-analysis conducted by others where the authors used criteria similar to those we imposed.

WSIPP Meta-Analyses

Although many of the systematic review and meta-analysis techniques we use in the current study are similar to previous WSIPP research reviews, the nature of the relationships we study here are distinct from other WSIPP meta-analyses. Typically, WSIPP meta-analyzes the research evidence on programs or interventions—e.g., how the outcomes for participants in a specific intervention compare to outcomes for similar people who do not participate, all else being equal.

The current study instead examines aspects of adolescent behavior and nutrition and estimates the associations with later mental health outcomes. Rather than looking at how an intervention might impact participants, we are investigating relationships between early behavior and later outcomes. While the systematic research review and meta-analysis methods are the same as previous WSIPP reports, the content of the relationships is fundamentally different.

III. Adolescent Substance Use

In considering substance use, our assignment specifically mentioned cannabis, opioids, and cocaine. We also included studies that report on the most common form of drug used by adolescents in Washington, alcohol. The table below lists the percentage of Washington 12th graders who had used a substance in the past 30 days as reported in Washington's Healthy Youth Survey (HYS) in 2021.[11]

Exhibit 1

Current Substance Use by 12th graders In Washington (2021)

Substance	Percentage of 12th graders
Alcohol	20%
Cannabis	16%
Opioids	1%
Any other illegal drug*	3%

Note:
*Not including alcohol, tobacco, or cannabis.

The HYS does not report on cocaine use. However, the national Youth Risk Behavior Survey does provide statistics on the percentage of all high school youth (grades 9 through 12) in the United States who reported ever using cocaine. In 2019, the most recent estimate, 3.9% of high school students had **ever** used cocaine.[12]

There is abundant literature on later outcomes linked with adolescent substance use, such as delinquency[13] and educational attainment.[14]

The question of whether substance use by adolescents predisposes them to anxiety or depression in adulthood is complex. Eleven longitudinal studies[15] have found that mental health conditions in youth **preceded** either the use or problem use of alcohol, cannabis, or other drugs.

The studies we located assessed youth substance use in a variety of ways, displayed in Exhibit 2.

Exhibit 2

Measures of Adolescent Substance Use

Substance use

- Ever used before age 18
- Age at first use
- Frequency of use
- Times "very high" or binge drinking
- Recency of use
- Trajectory of use

[11] Washington Healthy Youth Survey.
[12] Youth Risk Behavior Survey.
[13] For example, see Ellickson, P.L., Tucker, J.S., & Klein, D.J. (2003). Ten-year prospective study of public health problems associated with early drinking. *Pediatrics, 111*(5), 949-55 and Green, K.M., Doherty, E.E., Zebrak, K.A., & Ensminger, M.E. (2011). Association between adolescent drinking and adult violence: evidence from a longitudinal study of urban African Americans. *Journal of Studies on Alcohol and Drugs, 72*(5), 701-10.
[14] For example, see Breslau, J., Miller, E., Joanie, C.W.J., & Schweitzer, J.B. (2011). Childhood and adolescent onset psychiatric disorders, substance use, and failure to graduate high school on time. *Journal of Psychiatric Research, 45*(3), 295-301 and Renna, F. (2008). Teens' alcohol consumption and schooling. *Economics of Education Review, 27*(1), 69-78.
[15] A full list of citations is provided in the Appendix.

After identifying the substances and mental illnesses, we used terms such as "adolescent" "alcohol," "depression," and "longitudinal" to collect studies on the respective associations.

As mentioned in the methods section, this variation in reporting made meta-analyses of these topics infeasible for the most part. The exception was for studies linking psychosis to any cannabis use before age 18.

In this section, we report our findings by substance. For each substance, we identify (where possible) the following:

- Associations between adolescent use and young adult mental health outcomes;
- Relationships in which mental health outcomes precede the use of that substance;
- Cross-sectional relationships where research identifies substance use and mental health issues co-occurring at the same point in time; and
- Instances where there was no research about a particular relationship.

A summary of findings on associations between early use of specific substances and mental illnesses in young adulthood is provided in Exhibit 4 at the end of this section.

Alcohol

Alcohol and Anxiety and Depression

While studies consistently found that early onset alcohol use and adolescent binge drinking predicted young adult alcohol use disorder,[16] there is less evidence of the relationship between adolescent alcohol use and mental illness.

One study found the onset of alcohol use earlier in adolescence was associated with an increased risk of adult depression.[17] Two cross-sectional surveys of adolescents found an association between adolescent anxiety and drinking, where youth reported both at the same point in their lives.[18] In three longitudinal studies, youth anxiety and externalizing symptoms were found to predispose youth to problem alcohol use and later alcohol use disorder.[19] Those studies found that mental health issues preceded alcohol use.

We found no studies linking youth alcohol use with later psychosis or anxiety disorders.

[16] McCambridge, J., McAlaney, J., & Rowe, R. (2011). Adult consequences of late adolescent alcohol consumption: A systematic review of cohort studies. *PLOS Medicine 8*(2).
[17] Brook, D.W., Brook, J.S., Zhang, C., Cohen, P., & Whiteman, M. (2002). Drug use and the risk of major depressive disorder, alcohol dependence, and substance use disorders. *Archives of General Psychiatry, 59*(11), 1039-1044.;
[18] Johannessen, E.L., Andersson, H.W., Bjorngaard, J.H., Pape, K. (2017). Anxiety and depression symptoms and alcohol use among adolescents - a cross sectional study of Norwegian secondary school students. *BMC Public Health, 17,* 494.; Marmorstein, N.R., White, H.R., Loeber, R., Stouthamer-Loeber, M. (2010). Anxiety as a predictor of age at first use of substances and progression to substance use problems among boys. *Journal of Abnormal Child Psychology, 38*, 211–24.
[19] McKenzie, M., Jorm, A.F., Romaniuk, H., Olsson, C.A., & Patton, G.C. (2011). Association of adolescent symptoms of depression and anxiety with alcohol use disorders in young adulthood: findings from the Victorian Adolescent Health Cohort Study. *The Medical Journal of Australia, 195*, 3.; Pardini D., White H.R., & Stouthamer-Loeber, M. (2007). Early adolescent psychopathology as a predictor of alcohol use disorders by young adulthood. *Drug and Alcohol Dependence, 88*, S38–S49.; Stanley L.R., Miller K.A., Beauvais F., Walker P.S., & Walker, R. (2014). Predicting an alcohol use disorder in urban American Indian youths. *Journal of Child and Adolescent Substance Abuse; 23*, 101.

Cannabis

Cannabis and Depression and Anxiety

A recent meta-analysis of longitudinal studies, using criteria similar to our approach in this study, looked at the relationship between adolescent cannabis use and depression and anxiety in young adulthood.[20] Based on seven studies, the authors found that those using cannabis during adolescence were significantly more likely to have depression when they became adults. The study found that, compared to those who had not used cannabis, the odds of later depression were increased by 1.37. The lifetime prevalence of depression among 18- to 29-year-olds is estimated to be 15%.[21] Thus, based on the odds ratio, adolescent cannabis use might be expected to increase the risk of later depression to 19%. Three of the studies measured anxiety in young adults. The meta-analysis found no effect of adolescent cannabis use on adult anxiety.

Cannabis and Psychosis

There has been considerable research linking cannabis with the development of psychosis or psychotic symptoms.[22]

Further, at least two genetic variants have been identified that greatly increase the susceptibility of cannabis users. That is persons who carry these particular genes are more likely than others to develop a psychotic disorder after the use of cannabis.[23]

We conducted a meta-analysis based on the three longitudinal studies[24] that investigated the effects of adolescent cannabis use on the development of psychosis in young adulthood.

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[20] Gobbi, G., Atkin, T., Zytynski, T., Wang, S., Askari, S., Boruff, J., ... & Mayo, N. (2019). Association of cannabis use in adolescence and risk of depression, anxiety, and suicidality in young adulthood: a systematic review and meta-analysis. *JAMA Psychiatry, 76*(4), 426-434.

[21] Kessler & Wang (2008).

[22] National Institute on Drug Abuse. (2020). *Cannabis (marijuana) research report; Is there a link between marijuana use and psychiatric disorders?*

[23] Caspi, A., Moffitt, T.E., Cannon, M., McClay, J., Murray, R., Harrington, H., . . . Craig, I.W. (2005). Moderation of the effect of adolescent-onset cannabis use on adult psychosis by a functional polymorphism in the catechol-O-methyltransferase gene: Longitudinal evidence of a gene X environment interaction. *Biological psychiatry*, *57*(10),1117-1127 and Di Forti, M., Iyegbe, C., Sallis, H., Kolliakou, A., Falcone, M.A., Paparelli, A., . . . Murray, R.M. (2012). Confirmation that the AKT1 (rs2494732) genotype influences the risk of psychosis in cannabis users. *Biological psychiatry*, *72*(10), 811-816.

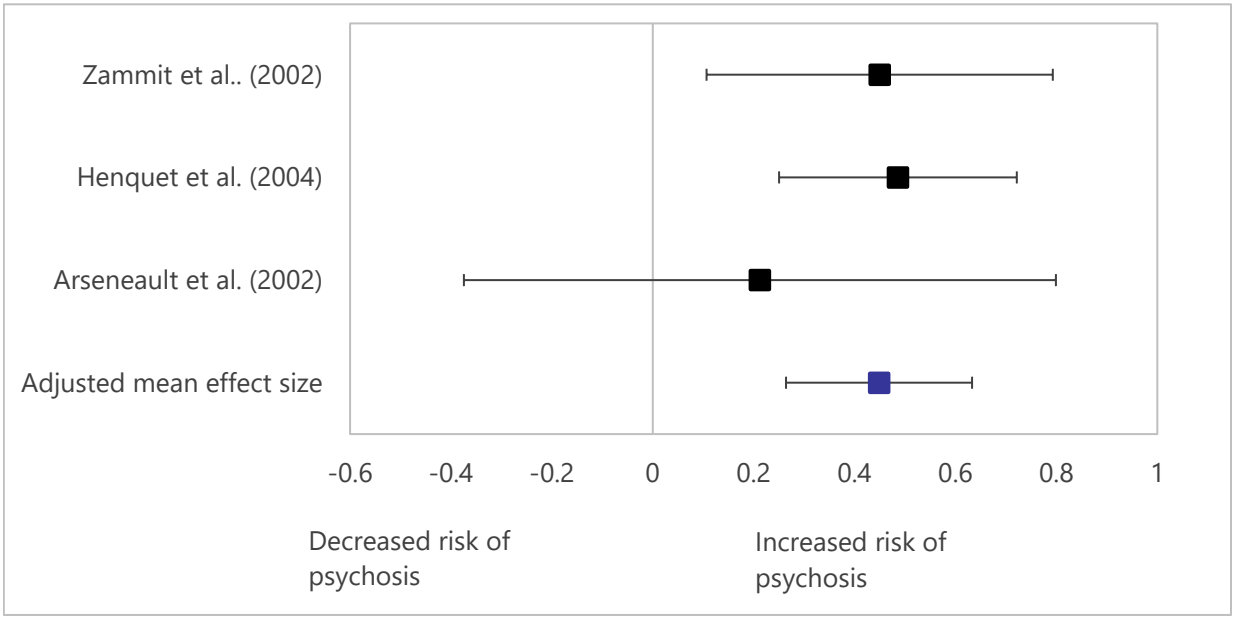
[24] Arseneault, L., Cannon, M., Poulton, R., Murray, R., Caspi, A., & Moffitt, T.E. (2002). Cannabis use in adolescence and risk for adult psychosis: Longitudinal prospective study. *British Medical Journal, 325*(7374), 1212-1213; Henquet, C., Krabbendam, L., Spauwen, J., Kaplan, C., Lieb, R., Wittchen, H.U., & Van Os, J. (2004). Prospective cohort study of cannabis use, predisposition for psychosis, and psychotic symptoms in young people. *British Medical Journal, 330*(7481), 11; and Zammit, S., Allebeck, P., Andreasson, S., Lundberg, I., & Lewis, G. (2002). Self reported cannabis use as a risk factor for schizophrenia in Swedish conscripts of 1969: historical cohort study. *British Medical Journal, 325*(7374), 1199.

A graphical representation of the results is shown in Exhibit 3. In this "forest plot," the effect size for each study is displayed along the horizontal axis. An effect size of zero signifies no effect. The points show the calculated value, and the bars indicate the 95% confidence intervals—the statistical range that would be expected to contain the "true" value. If a study showed a statistically significant reduction in depression, its bar would not include zero.

Over the three studies, we found that adolescent use of cannabis significantly increased the likelihood of later psychosis (ES = 0.448, p = 0.00). It is estimated that the prevalence of psychotic disorders among adults in the US is 0.05%.[25] Based on this effect size, we estimate that for those using cannabis before age 18, the risk of developing psychosis increases to 1.0%.

Exhibit 3

Effect of Adolescent Cannabis Use on Risk of Psychosis in Young Adulthood



[25] Kessler, R.C., Birnbaum, H., Demler, O., Falloon, I.R., Gagnon, E., Guyer, M., . . . Wu, E.Q. (2005). The prevalence and correlates of nonaffective psychosis in the National Comorbidity Survey Replication (NCS-R). *Biological Psychiatry*, *58*(8), 668-676.

Cannabis and Those at High Risk for Psychosis

Psychotic disorders typically appear in the late teens to early 20s. It is not uncommon for people to begin experiencing some symptoms before the disorder progresses to the point of a first psychotic episode. People with these early symptoms are referred to as "ultra-high risk", also referred to as the "prodromal" phase of the disorder.

Studies linking cannabis use with psychosis in the general population have prompted others to study cannabis use in ultra-high-risk groups. We identified three studies on this population that evaluated past use of cannabis on conversion to the first psychotic episode.

Three studies examined the effect of cannabis use on the rate of conversion to first-episode psychosis in this patient population. Two prospective studies found that lifetime cannabis use had no relation to conversion to the first episode.[26] Another study of patients already diagnosed with psychotic disorders found that those who reported prior cannabis use experienced their first episode three years earlier than those who had been abstinent.[27]

Cannabis Potency

We know that the potency of cannabis products has increased greatly since many of the people in these studies were adolescents. Based on confiscated samples, the concentration of THC—the active ingredient in cannabis—increased from 4% in the early 1990s to over 15% in 2019.[28] By virtue of the time elapsed from adolescence for study participants to the present day, it is likely that the cannabis used by youth in the studies was not as strong as what is currently available. Thus, future similar studies may observe different results than what we report here.

[26] Auther, A.M., McLaughlin, D., Carrion, R.E., Nagachandran, P., Correll, C.U., & Cornblatt, B.A. (2012). Prospective study of cannabis use in adolescents at clinical high-risk for psychosis: Impact on conversion to psychosis and functional outcome. *Psychological Medicine, 42*(12), 2485-2497; Baeza, I., Graell, M., Moreno, D., Castro-Fornieles, J., Parellada, M., Gonzalez-Pinto, A., Paya, B., . . . Arango, C. (2009). Cannabis use in children and adolescents with first episode psychosis: Influence on psychopathology and short-term outcome (CAFEPS study). *Schizophrenia Research, 113,* 129-137.

[27] Helle, S., Ringen, P.A., Melle, I., Larsen, T.-K., Gjestad, R., Johnsen, E., Lagerberg, T.V., . . . Løberg, E.-M. (2016). Cannabis use is associated with 3 years earlier onset of schizophrenia spectrum disorder in a naturalistic, multi-site sample (N = 1119*). Schizophrenia Research, 170*(1), 217-221.

[28] National Institute on Drug Abuse. (2020). *Cannabis (Marijuana) research report: Is there a link between marijuana use and psychiatric disorders?*

Opioids

The most common type of opioid use by adolescents is the misuse of prescription painkillers. Two longitudinal studies have reported on adolescent opioid use and mental illness. One study concluded that depression preceded the misuse of opioids.[29] That study found that past year depression was significantly associated with an increased risk of misuse of painkillers. The second study found no effect of adolescent opioid use on mental health in young adulthood.[30] Thus, to date, we find no evidence linking adolescent misuse of opioids to later mental health.

Cocaine

We located only one study that followed the trajectory of adolescent cocaine use into young adulthood. That found that adolescent cocaine use was related to later use of other drugs.[31] We, therefore, find no studies linking adolescent cocaine use to later mental health.

Limitations

Some limitations restrict our ability to identify causal relationships between adolescent substance use and subsequent mental health. Many factors may influence substance use, such as family functioning, poverty, and peer influences. Further, youth substance use is self-reported and may be under- or over-reported.

Exhibit 4

Associations Between Early Substance Use and Later Mental Health Disorders

Substance use in adolescence	Mental health disorders in adulthood		
	Anxiety	**Depression**	**Psychosis**
Alcohol	No studies	Associated with increased risk	No studies
Cannabis	No association	Associated with increased risk	Associated with increased risk
Opioid painkillers	No association (one study)	No studies	No studies
Cocaine	No studies	No studies	No studies

Notes:
"No studies" means we found no rigorous studies measuring the relationship between adolescent substance use and the specific outcome.
"No association" means that although there was at least one study measuring the relationship, the average effect was null.

[29] Edlund, M.J., Forman-Hoffman, V.L., Winder, C.R., Heller, D.C., Kroutil, L.A., Lipari, R.N., & Colpe, L.J. (2015). Opioid abuse and depression in adolescents: Results from the National Survey on Drug Use and Health. *Drug and Alcohol Dependence, 152*, 131-138.

[30] D'Amico, E.J., Davis, J.P., Tucker, J.S., Seelam, R., & Stein, B. D. (2021). Opioid misuse during late adolescence and its effects on risk behaviors, social functioning, health, and emerging adult roles. *Addictive Behaviors, 113*, 106696.

[31] Newcomb, M.D., Bentler, P.M., & Fahy, B. (1987). Cocaine use and psychopathology: Associations among young adults. *International Journal of the Addictions, 22(*12), 1167-1188.

IV. Adolescent Nutrition

In the early 2000s, when interest in the link between what we eat and how we feel first gained momentum, much of the initial research focused on single-nutrient therapies (e.g., folate supplementation). There has since been a shift toward investigating the role of diet more generally in the prevention and treatment of mental health disorders.

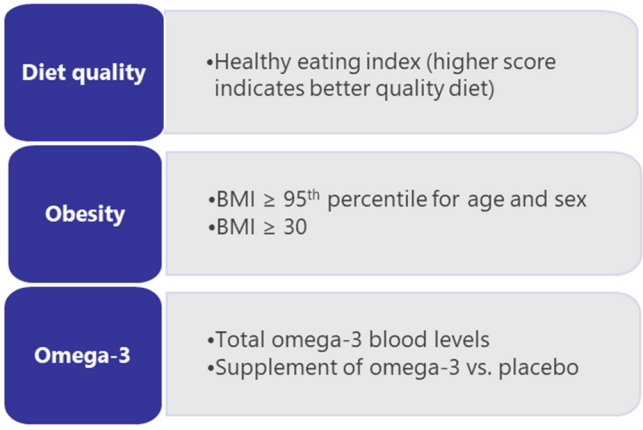
Many nutrition studies use a general population sample and are cross-sectional.[32] These studies can detect an association between diet and mental health but do not allow us to discern the meaning of the relationship (e.g., whether poor diet leads to a mental health disorder, mental health disorder leads to poor diet, or if another factor entirely leads to changes in both diet and mental health).

The other prominent type of research in this field investigates the treatment effects of supplementary nutrients or diet intervention on specialized populations (e.g., those diagnosed with depression).

Our literature review identified three categories of dietary patterns or supplements that were most researched in association with mental health outcomes for the general population. The three nutritional categories are overall diet quality, obesity, and intake or supplementation of omega-3s. This informed our search for associations between adolescent nutrition and mental health outcomes as a young adult.

Exhibit 5

Measures of Adolescent Nutrition



After identifying the common categories within the nutrition literature, we used terms such as "adolescent," "diet," "obesity," "omega-3," "mental illness," and "depression" to collect studies on the respective associations.

In general, while there is a plethora of research centered on nutrition and its association with mental health, there are few longitudinal studies, and even less information specifically looking at nutritional quality during adolescence and psychological outcomes as a young adult.

[32] Jacka, F.N. (2017). Nutritional psychiatry: Where to next? *EBioMedicine, 17,* 24-29

In this section, we report our findings by aspects of nutrition. For each nutrition topic, we identify (where possible) the following:

- Associations between adolescent nutrition and young adult mental health outcomes;
- Cross-sectional relationships where research identifies nutrition and mental health issues co-occurring at the same point in time; and
- Instances where there was no research about a particular relationship.

An overview of our findings can be found in Exhibit 8.

Diet Quality

There is some variation in the research literature on what constitutes a healthy diet, however, most measures follow national dietary guidelines set to achieve at least minimum intakes of a variety of whole foods, while limiting sugar, fat, and salt.[33] Using a food diary or food frequency questionnaire, researchers typically calculate a healthy eating score or index to use as the independent variable of interest, where a higher score reflects a higher quality diet.

Our literature search produced three relevant studies investigating the relationship between adolescent diet quality and young adult mental health.

Diet Quality and Depression

In adult populations, there is a general, albeit weak, indication that dietary patterns including fruits, vegetables, fish, olive oil, nuts, and legumes may protect against depression. [34]

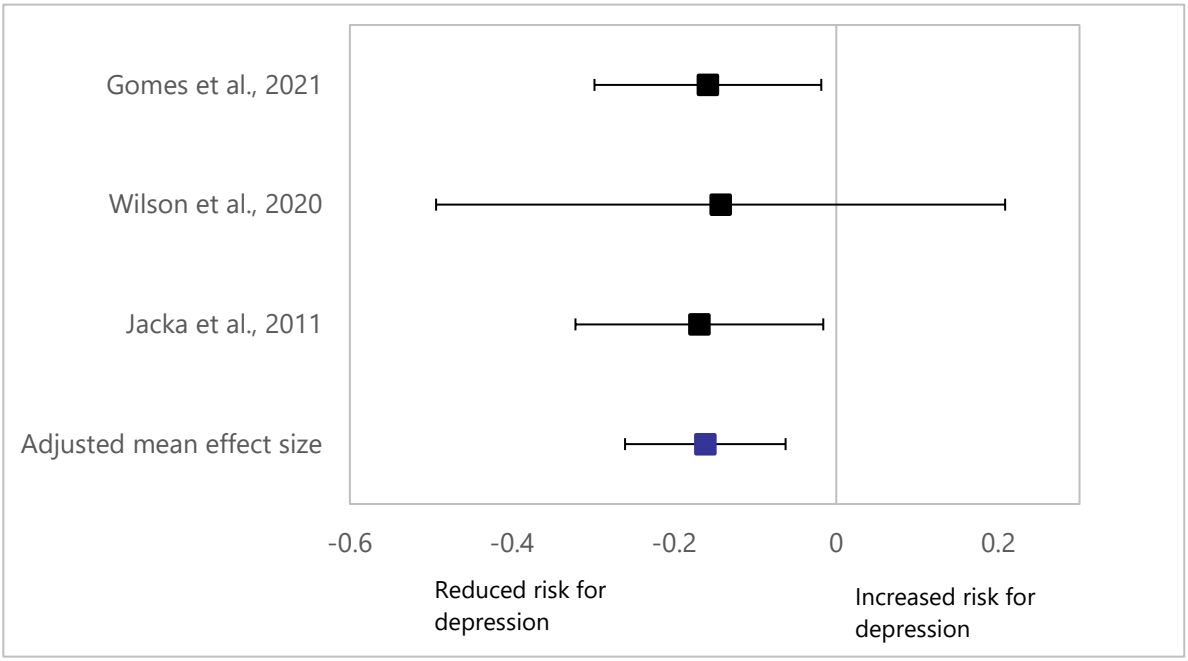
The potential protective effects of a healthy diet are less well-researched in the period between adolescence and young adulthood. We identified and meta-analyzed three studies that investigated the effects of diet quality as an adolescent on depression outcomes as a young adult.

[33] Wilson, J.E., Blizzard, L., Gall, S., Magnussen, C., Oddy, W., Dwyer, T., . . . Smith, K. (2020). Youth diet quality and hazard of mood disorder in adolescence and adulthood among an Australian cohort. *Journal of Affective Disorders, 276*, 511–518.

[34] Sanhueza, C., Ryan, L., & Foxcroft, D.R. (2013). Diet and the risk of unipolar depression in adults: systematic review of cohort studies. *Journal of Human Nutrition and Dietetics, 26*(1), 56-70.

Exhibit 6

Effect of Improved Adolescent Diet Quality on Young Adult Depression



Two of the three studies included in our meta-analysis found a higher-quality diet to be significantly associated with a lower risk of depression in young adulthood. The other included study, Wilson et al. (2020), showed a similar pattern, but the estimate was not statistically different than zero.

Taken together, the meta-analyzed effect size is -0.162, and statistically significant (p= 0.00). This means, on average, a higher quality diet as an adolescent may have a small protective effect against developing depression as a young adult.

The lifetime prevalence of depression among 18- to 29-year-olds is estimated to be 15%.[35] Based on this effect size, adolescents with higher-quality diets could decrease their risk of depression to 12%.

We also identified seven rigorous studies that looked into cross-sectional associations between diet quality and the psychological well-being of adolescents. Again, these studies can only detect if there is an association between overall diet and depression at a single point in time.

Each of these studies found that higher diet quality was associated with better emotional health.[36]

Diet Quality and Anxiety

Only one paper reported anxiety outcomes for young adults as a function of their diet quality during adolescence

[35] Kessler & Wang (2008).

[36] A full list of citations is provided in the Appendix.

This study found no association between diet quality at age 18 and diagnosis of generalized anxiety disorder at age 22.[37]

Obesity

Obesity is defined by the Centers for Disease Control and Prevention as a body-mass index (BMI) of 30 or greater for adults. BMI is a value derived from the weight and height of a person. Adjustments are made for children and adolescents.[38] The standard threshold for identifying obesity in adolescents is a BMI at or above the 95th percentile for age and sex.

While obesity is not a one-to-one representation of nutrition, nutrition is an important component of obesity. Given the prevalence of childhood obesity in the United States (20%),[39] researchers have given considerable attention to its potential influence on depression. In Washington state, 13% of youth (10-17 years old) are obese, which ranks the state 40th nationally.[40]

It is possible that any relationship we see between obesity and depression may be attributable to other factors such as stigmatization surrounding obesity, bullying, or body image. Such factors are typically unobserved in studies; they are, therefore, not accounted for in the findings.

Obesity and Depression

In the general population, there is some evidence to suggest obesity can increase the risk for the development of depression. In a systematic review of nine population-based studies that tested obesity as a predictor of depression, six found that increased BMI was prospectively associated with depression onset or elevated depression levels.[41]

Our literature search produced six relevant studies that investigated the impact of adolescent obesity, as measured by BMI, on young depression in adult young adults.

Four of these studies define an adolescent as obese if their BMI was at or above the 95th percentile for their respective age and sex. Two studies define obesity as a BMI at or above 30. More information on individual study components can be found in Appendix II.

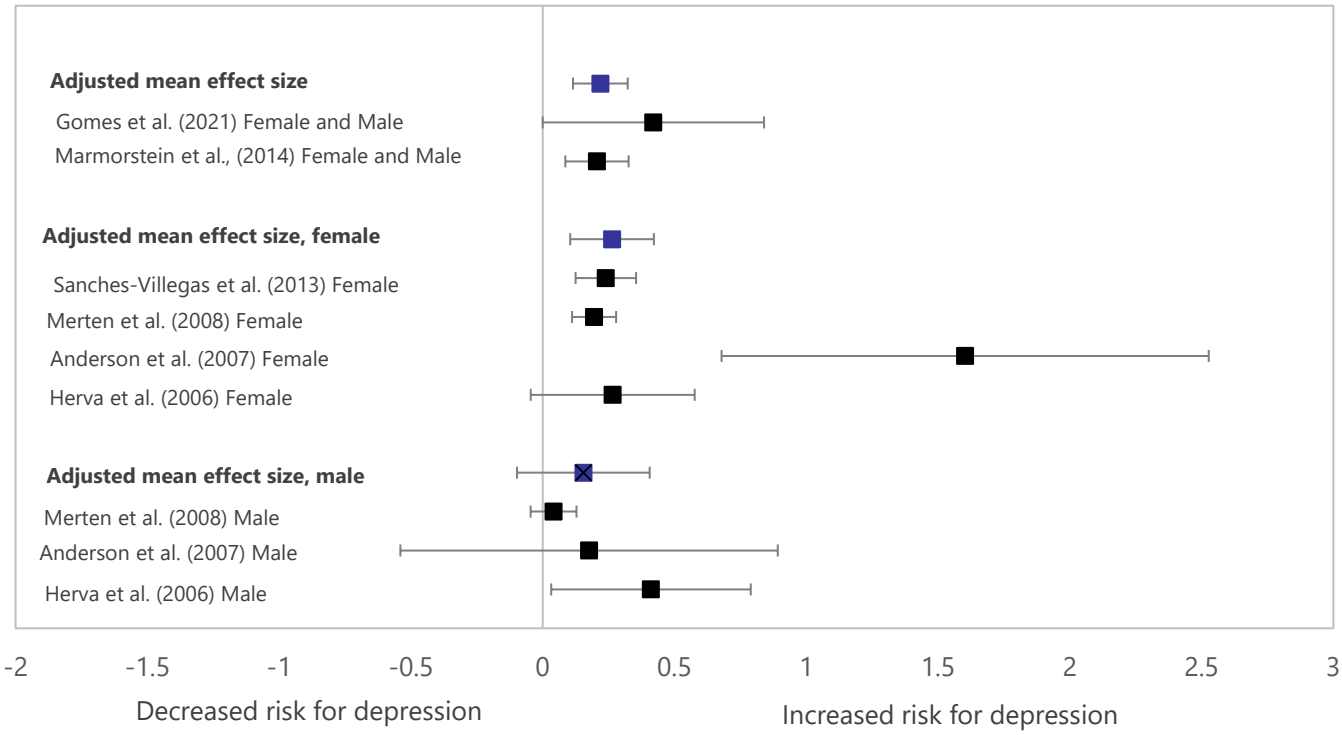
Among these studies, three investigated female and male outcomes separately, one looked solely at female outcomes, and two studies reported combined outcomes for females and males. The meta-analytic findings for these studies are shown in Exhibit 7.

The overall effect size is positive and statistically significant (ES = 0.219, p = 0.00), indicating higher BMI during adolescence is associated with higher rates of young adult depression. In the general population of adolescents, the average rate of depression is 15%.[42] Given our meta-analytic results, an effect size of 0.219 would increase that rate from 15% to 20%.

[37] Gomes, A.P., Gonçalves, H., dos Santos Vaz, J., Kieling, C., Rohde, L.A., Oliveira, I.O., & Soares, A.G. (2021). Do inflammation and adiposity mediate the association of diet quality with depression and anxiety in young adults? *Clinical Nutrition, 40*(5), 2800-2808.
[38] More information on individual study components can be found in Section II of the Appendix.
[39] Childhood Obesity Facts. (2022). *Centers for Disease Control and Prevention.*
[40] Washington. The State of Childhood Obesity.
[41] Luppino, F.S., de Wit, L.M., Bouvy, P.F., Stijnen, T., Cuijpers, P., Penninx, B.W., & Zitman, F.G. (2010). Overweight, obesity, and depression: a systematic review and meta-analysis of longitudinal studies. *Archives of General Psychiatry, 67*(3), 220-229.
[42] Kessler & Weng (2008).

Exhibit 7

Effect of Adolescent Obesity on Young Adult Depression



When these results are analyzed by sex, the results remain significant for females only (female ES = 0.263, p = 0.00; male ES = 0.154, p = 0.23). This means that the increase in risk is driven primarily by women.

Marmorstein et al. examined the inverse relationship—the association between adolescent depression and young adult obesity. They found depression in early adolescence predicted the onset of young adult obesity and depression in late adolescence predicted young adult obesity in females only.[43]

Obesity and Anxiety

In general, anxiety was treated as a secondary outcome in papers investigating the relationship between obesity and depression.

We identified two longitudinal papers that reported anxiety outcomes for young adults.

Together, the average effect size is positive and not significant. While the effect size indicated that on average, obesity was associated with higher anxiety in early adulthood, the relationship was not statistically significant.

[43] Marmorstein, N.R., Iacono, W.G., & Legrand, L. (2014). Obesity and depression in adolescence and beyond: reciprocal risks. *International Journal of Obesity London, 38*, 906–911.

Like with depression, obesity may have disparate effects on female and male adolescents regarding anxiety. One paper, by Anderson et al., analyzed outcomes separately by sex. They found adolescent obesity predicted an increased risk for subsequent anxiety disorder in females but not in males.[44]

Omega-3

Omega-3 polyunsaturated fatty acids, specifically EPA and DHA,[45] cannot be synthesized by the human body and therefore must be obtained through diet.[46]

Our literature search produced three relevant studies investigating the relationship between adolescent omega-3 consumption and young adult mental health.

Omega-3 and Depression

National epidemiological surveys have observed an inverse correlation between per capita fish consumption (a food source high in omega-3) and lifetime prevalence rates of major depressive disorder, meaning that higher fish consumption is associated with lower rates of depression in a population. [47]

Additionally, a meta-analysis of 13 cross-sectional studies found that higher rates of fish consumption were significantly associated with lower rates of depression in adults.[48]

The prospective relationship between omega-3 consumption and depression in the general population is less documented and the findings are mixed. A birth cohort study of 31-year-olds in Finland found that low frequency of fish consumption in the prior six months was significantly associated with depression in women but not men.[49] Another longitudinal study, which used a cumulative average of fish-oil consumption at two different points in time, observed no protective effect of fish intake on the risk of depression in women.[50]

We did not locate any longitudinal studies that reported depression outcomes as a function of omega-3 levels for our target population (adolescent exposure with young adult outcomes).

Omega-3 and Psychosis

Research indicates that patients with schizophrenia have reduced cell membrane levels of omega-3 and omega-6 polyunsaturated fatty acids (PUFAs) compared to non-schizophrenic individuals. This discovery has led to increased academic and clinical interest in omega-3 PUFAs potential for the prevention of psychosis.[51]

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[44] Anderson, S.E., Cohen, P., Naumova, E.N., Jacques, P.F., & Must, A. (2007). Adolescent obesity and risk for subsequent major depressive disorder and anxiety disorder: prospective evidence. *Psychosomatic Medicine, 69*(8), 740-747.

[45] EPA=Ethyl eicosapentaenoic acid, DHA=docosahexaenoic acid.

[46] Logan, A.C. (2004). Omega-3 fatty acids and major depression: a primer for the mental health professional. *Lipids in Health and Disease, 3*(1), 1-8.

[47] McNamara, R.K. (2016). Role of omega-3 fatty acids in the etiology, treatment, and prevention of depression: current status and future directions. *Journal of Nutrition & Intermediary Metabolism, 5*, 96-106.

[48] Lai, J.S., Hiles, S., Bisquera, A., Hure, A.J., McEvoy, M., & Attia, J. (2014). A systematic review and meta-analysis of dietary patterns and depression in community-dwelling adults. The American journal of clinical nutrition, 99(1), 181-197.

[49] Timonen, M., Horrobin, D., Jokelainen, J., Laitinen, J., Herva, A., & Räsänen, P. (2004). Fish consumption and depression: the Northern Finland 1966 birth cohort study. *Journal of Affective Disorders, 82*(3), 447-452.

[50] Lucas, M., Mirzaei, F., O'Reilly, E.J., Pan, A., Willett, W.C., Kawachi, I., . . . Ascherio. A. (2011). Dietary intake of n-3 and n-6 fatty acids and the risk of clinical depression in women: a 10-y prospective follow-up study. *American Journal of Clinical Nutrition, 93*(6), 1337–134.

[51] Amminger, G.P., Schäfer, M.R., Schlögelhofer, M., Klier, C.M., & McGorry, P.D. (2015). Longer-term outcome in the

Our literature search identified three studies reporting longer-term associations between omega-3 levels and psychosis.

One study looks at the relationship between total omega-3 blood levels for a general population of 16-year-olds and the development of psychotic disorders by age 18. They find no statistically significant association between total omega-3 levels and psychotic outcomes.[52]

Two studies look specifically at adolescents and young adults that have been clinically termed ultra-high risk (UHR) for psychosis. Both papers are longer-term follow-ups to randomized control trials where the treatment group was given a daily supplement of omega-3 and the control group was given a placebo.

Combined, the average effect size for UHR adolescents who received the omega-3 treatment is not statistically significant. This means there is no statistical evidence for omega-3 supplementation having a protective effect against psychotic disorders for adolescents and young adults with an at-risk mental state.

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Limitations

Some limitations restrict our ability to identify causal relationships between adolescent nutrition and subsequent mental health. For example, methods for accurately measuring diet quality remain problematic and nonuniform. And many things beyond nutrition may contribute to mental illness.

Exhibit 8

Associations Between Early Nutrition and Later Mental Health Disorders

Adolescent diet and nutrition factors	Mental health disorder in young adulthood		
	Depression	Anxiety	Psychosis
Diet quality	Associated with decreased risk	No association	No studies
Obesity	Associated with increased risk	No association	No studies
Omega-3	No evidence for target population	No studies	No association

Notes:
"No studies" means we found no rigorous studies measuring the relationship between adolescent nutrition and the specific outcome.
"No association" means that although there was at least one study measuring the relationship, the average effect was null.

prevention of psychotic disorders by the Vienna omega-3 study. *Nature Communications, 6*(1), 1-7.

[52] Thompson, A.D., Jones, H.J., Heron, J., Hibbeln, J., Sullivan, S., & Zammit, S. (2020). Omega-3 and Omega-6 fatty acids and risk of psychotic outcomes in the ALSPAC birth cohort. *Schizophrenia Research, 224,* 108-115.

V. Findings and Limitations

In this review of longitudinal and similar studies, we found that adolescent alcohol use was associated with increased depression, increased alcohol use disorder, and reduced educational attainment in young adults. We found no evidence that adolescent substance use predicted later anxiety, but instead, that adolescent anxiety preceded alcohol use.

We found no evidence that adolescent use of cocaine or opioid painkillers was associated with increased rates of the three mental illnesses we studied, depression, anxiety, or psychosis.

Several studies found adolescent use of cannabis to be associated with an increased risk of later depression and psychosis, but we found no evidence for an effect of early cannabis use on anxiety as a young adult.

Among a population of adolescents and young adults at ultra-high risk for psychosis, we found that prior use of cannabis *may* shorten the time to conversion to diagnosed psychosis, although the findings were mixed.

We found that higher diet quality in adolescence was associated with a lower risk of later depression, but we found no evidence that diet quality predicts a reduced risk of anxiety or psychosis.

The studies we reviewed found that adolescent obesity is associated with an increased risk of depression as a young adult, especially for young women.

We found no evidence that a higher level of omega-3 fatty acids in the adolescent diet predicted young adult anxiety, depression, or psychosis. Among a population who were at ultra-high risk for psychosis, treatment with omega-3 fatty acids had varying results across studies—overall, there was no convincing evidence that omega-3 supplementation delayed conversion to psychosis.

Because the research question was prospective, we were restricted primarily to longitudinal studies that were initiated years or even decades in the past. Given the recent increases in the potency of cannabis available in the marketplace and the timing of the studies, it is possible that studies of current adolescents may find different results than the existing body of research.

Similarly, the prevalence of overweight and obesity in the population has increased. According to the Centers for Disease Control and Prevention, in 1990, 12% of the adult population was obese; by 2018 the rate was 42%. It is possible that as obesity has become more normative, the effects on depression may have changed.

Some limitations restrict our ability to identify causal relationships between adolescent nutrition and substance use and subsequent mental health. Many factors may influence nutrition and/or substance use, such as family functioning, poverty, and peer influences. For example, methods for accurately measuring diet quality remain problematic and nonuniform. Youth substance use is self-reported and may be under- or over-reported. And many things beyond nutrition and substance use may contribute to mental illness. Further, given the many possible life events and dietary changes that may have elapsed in the years-long follow-up periods of the studies, we cannot say with certainty that adolescent nutrition or substance use caused any mental illness.

Implications

Although these findings do not lay out clear causal links between adolescent substance use or nutrition and mental health in young adulthood, they do provide some information about *potential* influences on mental health. For example, adolescent use of alcohol and cannabis was associated with later depression, and cannabis use was associated with later psychosis. WSIPP and others have identified many interventions that might be used to address early substance use.[53] If the pathways between early substance use and later mental health are indeed causal, then prevention or early intervention for substance use could also reduce the later mental health risks.

Similarly, we found a high-quality diet in adolescence to be associated with a lower risk of depression. If that relationship is causal, then we would expect interventions or programs that support a high-quality diet to also improve later depression. On this front, WSIPP has not identified a clear set of interventions with evidence of improving diet quality, but school nutrition programs are a clear example of a diet quality intervention.

Finally, there are many behaviorally oriented mental health prevention and treatment interventions found to be effective in reducing symptoms of depression, anxiety, and other mental health disorders.[54] In the absence of clear evidence about adolescent precursors of mental illness, many of these programs can provide effective treatment for mental health issues.

[53] See Washington State Institute for Public Policy. (2019, December). *Public health & prevention* benefit-cost results. Olympia, WA: Author.

[54] See Washington State Institute for Public Policy. (2019, December). Adult mental health benefit-cost results. Olympia, WA: Author.

Appendices

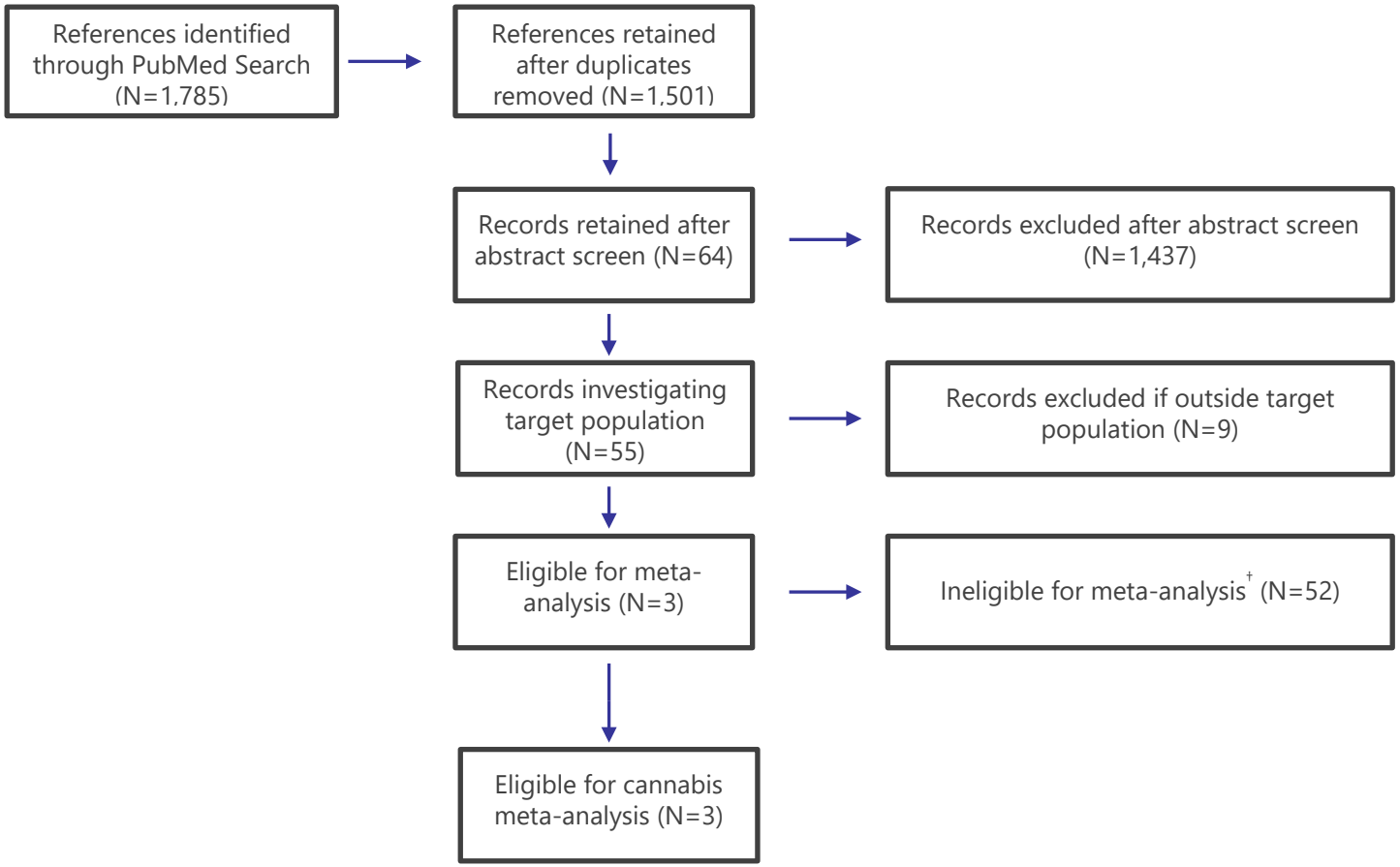
Does Substance Use or Nutrition in Adolescence Predict Mental Health in Young Adulthood? A Systematic Review

Appendices

I. Meta-Analysis Systematic Review Flow Charts

Exhibit A1

Substance Use Systematic Review Flow Chart

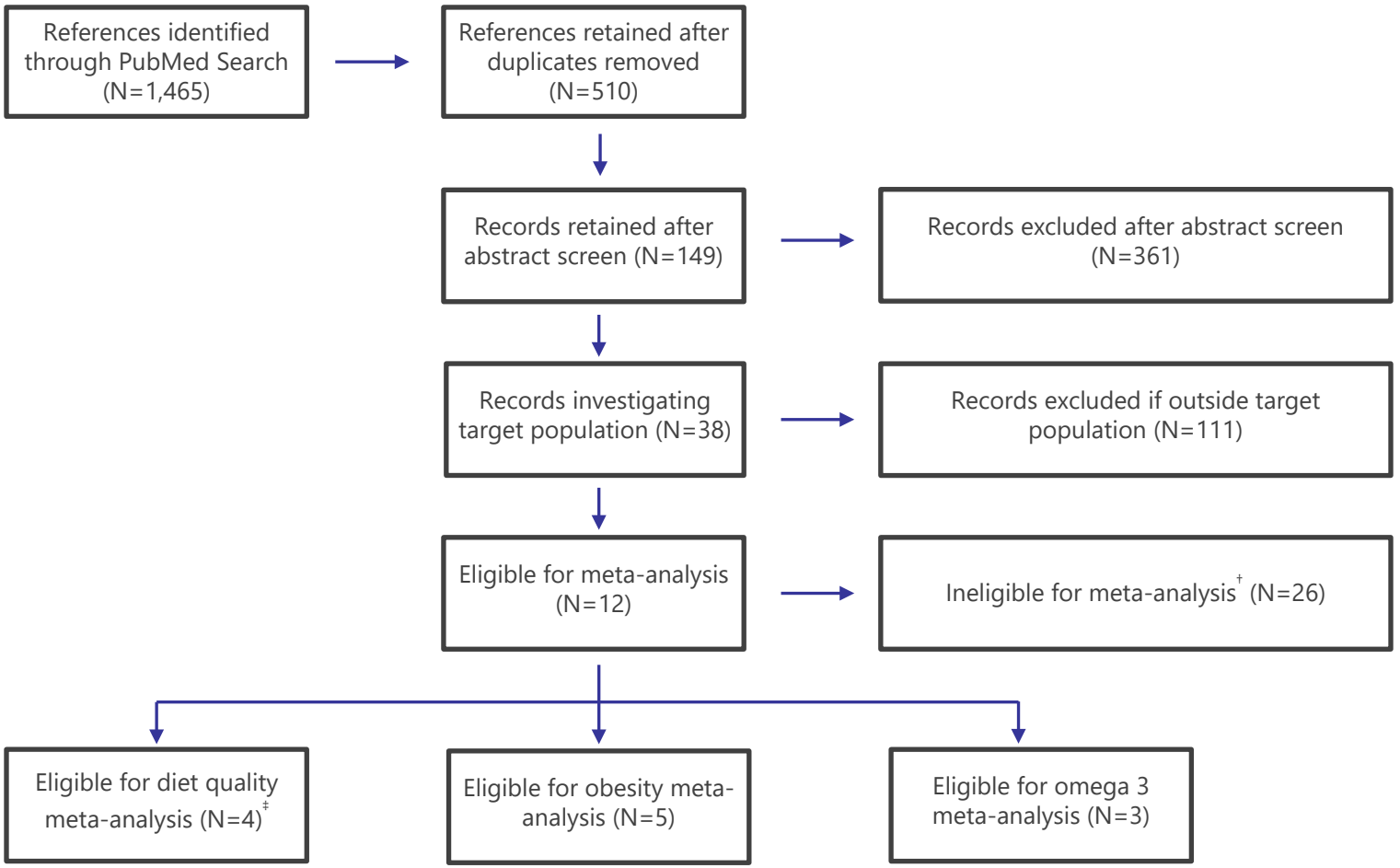


Note:

†Reasons for exclusion: lacked statistical rigor, looked at reverse relationship, failed to measure mental health outcome, provided inconsistent measures of substance use, or used same data as other included study.

Exhibit A2

Nutrition Systematic Review Flow Chart



Notes:

† Reasons for exclusion: lacked statistical rigor, looked at reverse relationship, or used same data as other included study.

‡ One study was eligible for inclusion but did not provide enough information for coding. We reached out to the author but did not get a response.

II. Descriptions of Included Studies

The following tables provide descriptions of studies included in our analyses and are listed by exposure during adolescence.

Substance Use

Exhibit A3

Cannabis, Outcome: Psychosis

Citation [date published]	Age baseline, follow-up	Study location	Measure of substance use	Outcomes examined (data type)	Effect size	95% CI
Arseneault et al. [2002]	15, 26	New Zealand	Any cannabis use before age 18)	Diagnosed schizophreniform disorder based clinical diagnostic interview	0.21	[-0.37, .080]
Henquet et al. [2004]	18, 261	Germany	Any cannabis use before age 18	At least 2 psychotic symptoms based on Composite International Diagnostic Interview	0.49	[0.25, 0.72]
Zammit et al. [2002]	18, 44	Sweden	Any cannabis use before age 18	Hospitalized with a diagnosis of schizophrenia	0.45	[0.11, 0.79]

Nutrition

Exhibit A4

Aspect of Nutrition: Diet Quality, Outcome: Depression, Population: Female and Male

Citation [date published]	Age baseline, follow-up	Study location	Way nutrition was measured	Outcomes examined (data type)	Effect size	95% CI
Gomes et al. [2011]	18, 22	Brazil	Brazilian Healthy Eating Index	Mini International Neuropsychiatric Interview, matched with DSM-5 (diagnosed)	-0.16	[-0.30, -0.02]
Jacka et al. [2011]	11-18, 18-21	Australia	Healthy Diet Score	Pediatric Quality of Life Inventory (self-report)	-0.17	[-0.32, -0.02]
Wilson et al. [2020]	10-15, 20-25	Australia	Dietary Guidelines Index	Composite International Diagnostic Interview (diagnosed)	-0.14	[-0.49, 0.21]

Exhibit A5

Aspect of Nutrition: Diet Quality, Outcome: Anxiety

Citation [date published]	Age baseline, follow-up	Study location	Way nutrition was measured	Outcomes examined (data type)	Effect size	95% CI
Gomes et al. [2011]	18, 22	Brazil	Brazilian Healthy Eating Index	Mini International Neuropsychiatric Interview, matched with DSM-5 (diagnosed with a generalized anxiety disorder)	-0.01	[-0.09, 0.07]

Exhibit A6

Aspect of Nutrition: Obesity, Outcome: Depression, Population: Female

Citation [date published]	Age baseline follow-up	Study location	Way nutrition was measured	Outcomes examined (data source)	Effect size	95% CI
Anderson et al. [2007]	12-17, 28-39	New York	BMI ≥ 95th percentile age/sex	Structured Clinical Interview for DSM-IV Disorders (diagnosed)	1.60	[0.68, 2.53]
Herva et al. [2006]	14, 31	Northern Finland	BMI ≥ 95th percentile age/sex	Hopkins Symptoms Checklist-25, strictest cutoff = 2.01 (self-report)	0.27	[-0.05, 0.58]
Merten et al. [2008]	12-18, 19-26	U.S.	BMI ≥ 95th percentile age/sex	Center for Epidemiological Studies Depression Scale (self-report)	0.20	[0.11, 0.28]
Sanches-Villegas et al. [2013]	18, 28-48	U.S.	BMI ≥ 30	Lifetime history of depressive symptoms, and/or use of antidepressants (self-report)	0.24	[0.13, 0.35]

Exhibit A7

Aspect of Nutrition: Obesity, Outcome: Depression, Population: Male

Citation [date published]	Age baseline follow-up	Study location	Way nutrition was measured	Outcomes examined (data source)	Effect size	95% CI
Anderson et al. [2007]	12-17, 28-39	New York	BMI ≥ 95th percentile age/sex	Structured Clinical Interview for DSM-IV Disorders (diagnosed)	0.18	[-0.54, 0.90]
Herva et al. [2006]	14, 31	Northern Finland	BMI ≥ 95th percentile age/sex	Hopkins Symptoms Checklist-25, strictest cutoff = 2.01 (self-report)	0.41	[-0.03, 0.79]
Merten et al. [2008]	12-18, 19-26	U.S.	BMI ≥ 95th percentile age/sex	Center for Epidemiological Studies Depression Scale (self-report)	0.04	[-0.05, 0.13]

Exhibit A8

Aspect of Nutrition: Obesity, Outcome: Depression, Population: Female and Male

Citation [date published]	Age baseline follow-up	Study location	Way nutrition was measured	Outcomes examined (data source)	Effect size	95% CI
Gomes et al. [2021]	18, 22	Brazil	BMI ≥ 30	Mini International Neuropsychiatric Interview, matched with DSM-5 (diagnosed)	0.42	[0.00, 0.84]
Marmorstein et al. [2014]	14-20, 20-24	Minnesota	BMI ≥ 95th percentile age/sex	Structured Clinical Interview for DSM-III-R, (diagnosed)	0.21	[0.09, 0.33]

Exhibit A9

Aspect of Nutrition: Obesity, Outcome: Anxiety, Population: Female and Male

Citation [date published]	Age baseline follow-up	Study location	Way nutrition was measured	Outcomes examined (data source)	Effect size	95% CI
Anderson et al. [2007]	12-17, 28-39	New York	BMI ≥ 95th percentile age/sex	Structured Clinical Interview for DSM-IV Disorders (diagnosed)	0.88	[0.51, 1.24]
Gomes et al. [2021]	18, 22	Brazil	BMI ≥ 30	Mini International Neuropsychiatric Interview, matched with DSM-5 (diagnosed)	0.20	[-0.04, 0.45]

Exhibit A10

Aspect of Nutrition: Omega-3, Outcome: Psychosis, Population: General

Citation [date published]	Age baseline follow-up	Study location	Way nutrition was measured	Outcomes examined (data source)	Effect size	95% CI
Thompson et al. [2020]	16,18	United Kingdom	Total Omega-3 levels	Psychosis-like symptoms interview, suspected or definitely present (diagnosed)	-0.03	[-0.14, 0.07]

Exhibit A11

Aspect of Nutrition: Omega-3, Outcome: Psychosis, Population: Ultra-high risk for Psychosis

Citation [date published]	Age	Study location	Way nutrition was measured	Outcomes examined (data source)	Effect size	95% CI
Amminger et al. [2015]	13-25	Vienna, Austria	12-week supplementation of Omega-3	Conversion to Psychosis - Positive and Negative Syndrome Scale (diagnosed)	-1.09	[-1.82, -0.36]
Nelson et al. [2018]	13-40	International	6-month supplementation of Omega-3	Conversion to Psychosis - Positive and Negative Syndrome Scale (diagnosed)	-0.11	[-0.51, 0.30]

III. Citations:

Studies Finding Co-occurring Substance Use and Mental Illness in Adults

(These citations correspond to footnote 2)

Davis, L., Uezato, A., Newell, J.M., & Frazier, E. (2008). Major depression and comorbid substance use disorders. *Current Opinion in Psychiatry, 21*(1), 14-18.

Hunt, G.E., Large, M.M., Cleary, M., Lai, H.M.X., & Saunders, J.B. (2018). Prevalence of comorbid substance use in schizophrenia spectrum disorders in community and clinical settings, 1990–2017: Systematic review and meta-analysis. *Drug and Alcohol Dependence, 191,* 234-258.

Kessler, R.C., Chiu, W.T., Demler, O., Merikangas, K.R., Walters, E.E. (2005). Prevalence, severity, and comorbidity of 12-month DSM-IV disorders in the National Comorbidity Survey Replication. *Archives of General Psychiatry*, *62*(6), 617–627.

Swendsen, J., Conway, K.P., Degenhardt, L., Glantz, M., Jin, R., Merikangas, K.R., . . . Kessler, R.C. (2010). Mental disorders as risk factors for substance use, abuse and dependence: results from the 10-year follow-up of the National Comorbidity Survey. *Addiction, 105*(6), 1117-1128.

Studies Finding Youth Mental Illness Preceded Substance Use

(These citations correspond to footnote 15)

Abram K.M., Zwecker N.A., Welty L.J., Hershfield J.A., Dulcan M.K., & Teplin L.A. (2015) Comorbidity and continuity of psychiatric disorders in youth after detention: a prospective longitudinal study. *JAMA Psychiatry, 72*, 84–93.

Cerda, M., Prins, S.J., Galea, S., Howe, C.J., Pardini, D. (2016). When psychopathology matters most: identifying sensitive periods when within-person changes in conduct, affective and anxiety problems are associated with male adolescent substance use. *Addiction,* 111, 924–35.

Frojd, S., Ranta, K., Kaltiala-Heino, R., & Marttunen, M. (2011). Associations of social phobia and general anxiety with alcohol and drug use in a community sample of adolescents. *Alcohol &l Alcoholism, 46*, 192–199.

Goodwin, R.D., Lieb, R., Hoefler, M., Pfister, H., Bittner, A., Beesdo, K. (2004). Panic attack as a risk factor for severe psychopathology. *American Journal Of Psychiatry, 161*, 2207–14.;

Gorka, S.M., Shankman, S.A., Olino, T.M., Seeley, J.R., Kosty, D.B., Lewinsohn, P.M. (2014). Anxiety disorders and risk for alcohol use disorders: the moderating effect of parental support. *Drug Alcohol Dependence, 140*, 191–977.

Malmberg, M., Kleinjan, M., Overbeek, G., Vermulst, A.A., Lammers, J., & Engels, R. (2013). Are there reciprocal relationships between substance use risk personality profiles and alcohol or tobacco use in early adolescence? *Addictive Behaviors, 38,* 2851–9.

Marmorstein, N.R., White, H.R., Loeber, R., Stouthamer-Loeber, M. (2010). Anxiety as a predictor of age at first use of substances and progression to substance use problems among boys. *Journal of Abnormal Child Psychology, 38*, 211–24.

McKenzie, M., Jorm, A.F., Romaniuk, H., Olsson, C.A., & Patton, G.C. (2011). Association of adolescent symptoms of depression and anxiety with alcohol use disorders in young adulthood: findings from the Victorian Adolescent Health Cohort Study. *The Medical Journal of Australia, 195, 3*.

Stanley, L.R., Miller, K.A., Beauvais, F., Walker, P.S., & Walker, R.D. (2014). Predicting an alcohol use disorder in urban American Indian youths. *Journal of Child & Adolescent Substance Abuse, 23*(2), 101-108.

Wolitzky-Taylor, K., Bobova, L., Zinbarg, R.E., Mineka, S., & Craske, M.G. (2012). Longitudinal investigation of the impact of anxiety and mood disorders in adolescence on subsequent substance use disorder onset and vice versa. *Addictive Behaviors, 37*(8), 982-985.

Zimmermann P., Wittchen H.U., Höfler M., Pfister H., Kessler R.C., & Lieb R. (2003) Primary anxiety disorders and the development of subsequent alcohol use disorders: a 4-year community study of adolescents and young adults. *Psychological Medicine, 33,*1211–22.

Studies Finding Cross-Sectional Association Between Adolescent Diet Quality and Depression

(These citations correspond to footnote 36)

Faisal-Cury, A., Leite, M.A., Escuder, M.M.L., Levy, R.B., & Peres, M.F.T. (2022). The relationship between ultra-processed food consumption and internalising symptoms among adolescents from São Paulo city, Southeast Brazil. *Public Health Nutrition, 25(*9), 2498-2506.

Jacka, F.N., Kremer, P.J., Leslie, E.R., Berk, M., Patton, G.C., Toumbourou, J.W., & Williams, J.W. (2010). Associations between diet quality and depressed mood in adolescents: results from the Australian Healthy Neighbourhoods Study. *The Australian and New Zealand Journal of Psychiatry, 44(*5), 435–442.

Korczak, D.J., Perruzza, S., Chandrapalan, M., Cost, K., Cleverley, K., Birken, C.S., & McCrindle, B.M. (2021). The association of diet and depression: an analysis of dietary measures in depressed, non-depressed, and healthy youth. *Nutritional Neuroscience, 25*(9).

Kulkarni, A.A., Swinburn, B.A., & Utter, J. (2015). Associations between diet quality and mental health in socially disadvantaged New Zealand adolescents. *European Journal of Clinical Nutrition, 69*(1), 79–83.

Silva, S.A., do Carmo, A.S., & Carvalho, K. (2021). Lifestyle patterns associated with common mental disorders in Brazilian adolescents: Results of the Study of Cardiovascular Risks in Adolescents (ERICA). *PloS one, 16*(12).

Sinclair, R., Millar, L., Allender, S., Snowdon, W., Waqa, G., Jacka, F., . . . Swinburn, B. (2016). The cross-sectional association between diet quality and depressive symptomology amongst Fijian adolescents. *PloS one, 11*(8).

Zahra, J., Ford, T., & Jodrell, D. (2014). Cross-sectional survey of daily junk food consumption, irregular eating, mental and physical health and parenting style of British secondary school children. *Child: Care, Health and Development, 40*(4), 481–491.

Citations for Studies Included in Substance Use Meta-Analyses

Early Cannabis and Later Psychosis

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