Reviewing Environmental and Genetic Factors Affecting Adolescent Mental Health

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Abstract:

An adolescent's mental health can decline due to various influences, such as environmental and genetic factors. This scoping review focuses on reviewing and synthesizing the existing literature on environmental and genetic factors that are associated with a risk of adolescents developing mental health disorders. Articles were collected from three primary search engines: PubMed, ScienceDirect, and Google Scholar. Using the PCOT Method, the population included adolescents ranging from ages 10-19, outcomes included environmental and genetic risk factors, articles were published within 5 years (2019-2024), and the articles were peer reviewed and in English. Specific articles included primary studies, clinical essays, cross-sectional cohort studies, and longitudinal cohort studies. To review our articles, we primarily utilized the engine Google Sheets for charting, ensuring that the articles chosen had been screened several times for the highest quality research. Originally, we identified 31 articles that we believed would best fit with our criteria. From these, we excluded those that, upon further research, did not discuss the topics in detail (n = 6). Our results from the articles that were specifically curated and thoroughly researched led us to the conclusion that environmental factors and genetic factors have a significant impact upon adolescent mental health.

Key Words: Adolescence, Environmental Factors, Genetic Factors, Adolescent Mental Health, Mental Health

1. Introduction

As defined by the World Health Organization, a mental disorder is characterized by a clinically significant disturbance in an individual's cognition, emotional regulation, or behavior. In 2019, 1 in every 8 people, or 970 million people around the world, were living with a mental health disorder. In adolescents, the most frequent mental health disorders suffered include depression and anxiety, schizophrenia, eating disorders, attention-deficit hyperactivity disorder, and substance use disorders (World Health Organization). With the heavy onset of adolescents that suffer from these disorders comes an onslaught of preventative measures, including therapeutic programs, youth services, emergency helplines, and more. Each disorder requires a different therapy, which can include a variety of medications, psychoeducation, rehabilitation, interventions, and more. These therapies have been researched and thoroughly considered by the research community as the best forms of treatment, which are different from the shock therapy and insulin treatments of the past.

Aside from measures to deal with these disorders, there is current research being conducted to understand which factors influence them. Adolescent mental health can be influenced by a range of different environmental and genetic factors. In order to identify our view and targets on this issue, our research team developed a main objective: to review and synthesize the existing literature on environmental and genetic factors that are associated with a risk of adolescents developing mental health disorders. Within this centralized objective, we developed three specific objectives:

1. To identify the existing literature on the environmental and geographical regions to be studied for this research project
2. To identify the prevalence of mental health disorders in literature (ex: depression, anxiety, bipolar disorder, schizophrenia)
3. To identify if genetic factors are key contributors in mental health disorders in adolescents

Having these objectives allowed us to clearly formulate a hypothesis based on what our data collection would present. Our hypothesis stated, “environmental and genetic factors are significantly associated with an increased risk of adolescents developing mental health disorders.” This led our team to conduct a scoping review on several different articles centered around our overall research question: *How do environmental and genetic factors influence the development of mental disorders in adolescent populations?*

2. Methods

The protocol for this scoping review was developed using the scoping review framework proposed by Tricco et al. (2018). As outlined in a work by Levac et al. (2010), a scoping review, often referred to as ‘mapping’, involves researchers collecting and synthesizing evidence from a wide array of sources to provide a comprehensive overview of a particular topic. This scoping review focuses on the influence of environmental and genetic factors on adolescents.

2.1: Research questions

The eligibility of our research question was determined using the population, context, outcome, and time (PCOT) framework (Tricco et al. 2018; Aslam and Emmanuel 2010).

Based on the PCOT framework, the following primary research question to guide our scoping review was proposed:

How do environmental and genetic factors influence the development of mental disorders in adolescent populations?

2.2: Search strategy

From July 2024 to August 2024, our research team conducted a literature study focusing primarily on studies published within the last five years, from January 2019 to July 2024. This time frame was chosen to ensure the inclusion of the most current and relevant research on the influence of environmental and genetic factors on adolescent mental health. We predominantly utilized three search engines, with each group member responsible for searching the appropriate articles within their assigned database. These databases included PubMed, Google Scholar, and ScienceDirect. Furthermore, the electronic literature search was limited to peer-reviewed articles. No grey literature was included in this review to maintain a focus on peer-reviewed research. To refine our search results, we used a combination of targeted

keywords and Boolean operators (“AND” and “OR”). These keywords consisted of “adolescent,” “teenager,” “mental health,” “mental health disorder,” “environmental”, and “genetic”. We utilized the software Zotero to manage the search results, enabling us to create a spreadsheet to remove duplicates and exclude studies that did not meet our immediate relevance criteria.

2.3: Study selection

Literature selection was based on the inclusion and exclusion criteria, which were collaboratively developed by all three research members, by using the PCOT method.

Inclusion Criteria:
All full-text studies that met the following criteria were eligible and considered:

- **P**opulation: adolescents (age range 10-19)
- **C**ontext: mental health disorders
- **O**utcomes: environmental and genetic risk factors
- **T**ime: articles published within 5 years (2019-2024)
- Peer reviewed articles
- Language: English
- Study Types: Primary studies, Clinical essays, Cross-sectional cohort studies, Longitudinal cohort studies

Exclusion Criteria:

- Other types of articles not specified in the inclusion criteria
    - Systematic reviews
    - Meta-analyses
    - Overviews of overviews
    - Letters to editors
    - Protocols
    - Non-peer reviewed articles

Our screening process was conducted in two stages: (1) title and abstract screening followed by (2) full-text screening. The first screening process consisted of a quick skimming of the title and the abstract for each article by all three members. The second screening process involved each member thoroughly reading the full text body of each individual article to ensure that the articles selected met the inclusion criteria.

2.4: Charting Data

When conducting the extraction of our data, we divided out articles into different categories using the software Google Sheets. For data extraction, we used: (i) ID number, (ii) author, (iii) title, (iv) publication year, (v) study objectives, (vi) study type, (vii) country of research, (viii) tool of data collection, (ix) sample size, and (x) study main results. The information we received from this process was crucial in verifying that the articles we chose were the best and most accurate results to answer our leading Research Question.

2.5: Collating, summarizing, and reporting results

This review's primary outcome was the identification of environmental and genetic factors influencing adolescent mental health and participant gender distribution. All three researchers documented study details consisting of the following: the country of study, publication year, age range of affected adolescents, the specific environmental and genetic factors studied, and any reported impacts on adolescent mental health. At no point were any authors contacted to obtain any additional data.

3. Results

An electronic search identified 555 articles. After title screening, 5 articles were excluded due to duplicate publication. 550 articles were screened for abstract, and 127 articles were sought for full-text review. However, 3 articles were unable to be retrieved. Of the 124 articles assessed for full-text review, 25 studies met the inclusion criteria and were included in the scoping review. The details of the selection process are presented in the flowchart (Figure 1).

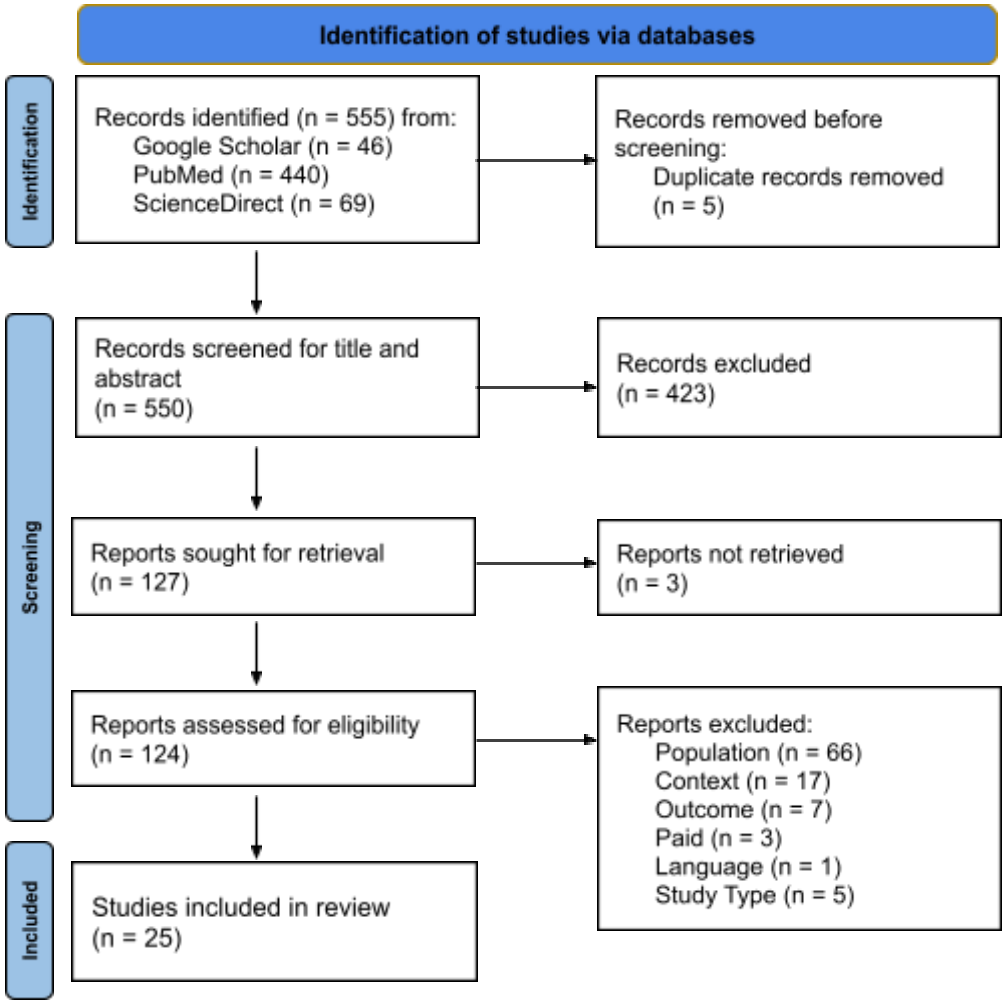

Figure 1. PRISMA flow diagram of study selection.

3.1 Environmental Factors

3.1.a Anxiety and Depression:

Out of the studies conducted on mental health disorders, thirteen studies focused on the onset of a variety of anxiety and depressive disorders affecting adolescent behavior. From these thirteen, we derived four articles that researched how environmental components such as air pollution, noise pollution, and city pollution had a significant role in the declining mental health of adolescents (Thompson et al. 2021; Latham et al. 2021; Rudolph et al. 2019). Aside from these factors, other underlying components such as socioeconomic class, school performance, drug use, physical activity, interpersonal relationships, and sociodemographic variables (including but not limited to race, ethnicity, and gender) were proven to have a substantial role in the decline of adolescence mental health, especially in urban settings (Kieling et al. 2021; Zeng et al. 2021). Additionally, elements of a household, such as the country, rural/urban setting, religion, and community, can significantly impact the mental health of adolescents by shaping their view of themselves (de Castro et al. 2023). In families of different sizes, having multiple kids and being in a specific role from the birth order can raise mental health concerns (Okada et al. 2021). Aside from birth order, the specific style in which the parents raise the adolescent (Wang et al. 2024) as well as the adolescents' perspectives on the parenting styles can have a significant impact on how the adolescent views themselves, which can lead to possible depressive episodes (Chubar et al. 2020). Most of the reviewed research reports focused on adolescent mental health disorders in day to day life, as these are the most prevalent. However, regarding more serious cases, adolescents are also more susceptible to developing mental health disorders within their treatment facilities rather than in their day to day life (Lindgren et al. 2019).

3.1.b Psychiatric Disorders (General):

Two of the included studies discussed general psychiatric disorders, both of which only examined environmental factors. Findings reported factors including exposure to violence and social support along with overall neighborhood context, such as neighborhood disorder and socioeconomic status (Latham et al. 2022; Vaalavuo et al. 2021). The exposure and experience of physical violence, including family violence, sexual abuse, and crime victimization, during the period of adolescence was proved to be associated with a significantly increased prevalence of any psychiatric disorder at the age of eighteen (Latham et al. 2022). On the other hand, it was found that having familial support at eighteen years old mitigated the prevalence of any psychiatric disorder, even when those in question had experienced or been exposed to physical violence in adolescence. Additional environmental factors such as a higher IQ and sibling or maternal warmth during childhood, while considered, were not found to have the same protective effect as family support (Latham et al. 2022). Neighborhood disorder, a factor considered by two different studies, received contrasting results when being associated with psychiatric disorders. According to a study by Latham et al. (2022), living in neighborhoods with high levels of disorder was associated with an increased prevalence in any psychiatric disorder, though these results, after being adjusted for covariates, were not statistically significant; additionally, it was found that the socioeconomic status of a family had very little effect in mitigating or elevating the odds of meeting the criteria for any psychotic disorder. However, according to a study by Vaalavuo et al. (2021), growing up in an advantageous neighborhood

with parents of high education was proved to increase the likelihood of developing psychiatric disorders in comparison to growing up in a disadvantageous neighborhood.

3.1.c Attention-Deficit Hyperactivity Disorder (ADHD):

Two studies focused on the correlation between certain environmental factors and the prevalence of ADHD within adolescent populations. In a study conducted by Rudolph et al. (2019) focusing on environmental noise and its effects on mental health disorders on urban adolescents in the United States, it was found that there was no evidence that pointed to a relation between high environmental noise and the likelihood of developing severe ADHD (0.71, 95% CI = 0.38, 1.31). Similarly, according to a study by Roberts et al. (2019) focusing on the impacts of air pollutants NO_2 and $PM_{2.5}$ on a variety of mental health disorders including ADHD, there were no associations found between the exposure of NO_2 and $PM_{2.5}$ at the age of twelve and the diagnosis of ADHD at the age of eighteen.

3.1.d Eating Disorders:

Environmental factors hold a significant role in the development of eating disorders within the adolescent population. Among the studies included in this review, only two addressed eating disorders, with one specifically discussing the environmental factors associated with the condition. A study by Mora et al. (2022) examined various factors influencing the risk of developing eating disorders in adolescents, focusing on self-esteem, eating and health habits, and the use of new technologies and fashion magazines. The findings revealed that sociodemographic variables such as age, sex, and academic performance did not have a statistically significant relationship with the risk of developing eating disorders (Mora et al. 2022). However, certain eating habits and behaviors, including eating pattern, dieting, and the use of weight loss drugs, were significantly correlated with increased risk (Mora et al. 2022). Additionally, Mora et al. (2022) found that frequent use of the internet, mobile phones, fashion magazines, and game consoles were linked to higher risk of eating disorders. In contrast, adolescents with higher self-esteem were found to be at a lower risk for eating disorders with an OR = 0.910 (CI 95% 0.878–0.943). A one-point increase in the self-esteem dimension lowered the risk of being part of an ED risk group by 9.5% (Mora et al. 2022).

3.1.e Alcohol Use Disorders:

Only a single study examined how environmental factors influence the prevalence of alcohol use disorders. A study by Hildebrand et al. (2023) reveals that shared and nonshared environmental factors contribute to alcohol use disorders (AUDs) in eighteen-year old Swedish twins. The prevalence of potentially hazardous alcohol consumption was higher among females than males, 59.0% and 54.4% respectively, which contradicts previous research findings, suggesting a possible shift in environmental influences on drinking behavior between genders during late adolescence (Hildebrand et al. 2023). The researchers note that different environmental factors likely influence AUDs in males versus females; however, these differentiating environmental factors have not been determined.

3.1.f Conduct Disorder:

One of the studies we reviewed analyzed the effect of environmental factors upon conduct disorder, which, according to Chiocchetti et al. (2022), is a disorder characterized by

aggressiveness and dissocial behavior. In a study by Roberts et al. (2019), which focused on exploring how NO_2 and $PM_{2.5}$ air pollution impacted various mental health disorders including conduct disorder, it was discovered that at the age of eighteen, there was a greater chance of being diagnosed with conduct disorder when having been exposed to higher concentrations NO_2 and $PM_{2.5}$ at twelve years old, although this association was not found to be statistically significant ($PM_{2.5}$: OR = 3.95, 95% CI 0.72–21.76, p = 0.114; NO_2: OR = 5.12, 95% CI 0.68–38.58, p = 0.113). Additionally, in a study conducted by Rudolph et al. (2019), environmental noise and its effects on sleep along with various mental health disorders were studied. It was found that living in high-noise communities was associated with lower odds of behavioral disorders (including conduct disorder and oppositional defiant disorder) (OR = 0.82, 95% CI = 0.31, 2.18).

3.1.g Psychosis/Psychotic Experiences:

A study conducted by Crush et al. (2019) analyzed the association between social support and the likelihood of having psychotic experiences in adolescence. It was found that social support was associated with a decrease in the likelihood of psychotic experiences at the age of eighteen, both in the experiment's entire sample (OR = 0.91, 95% CI 0.89–0.93, p < 0.001) and in a high-risk group exposed to poly-victimization (OR = 0.93; 95% CI 0.88–0.98, p = 0.009). These results suggest that higher perceived social support has a unique buffering effect on the prevalence of adolescent psychotic experiences (Crush et al. 2019).

3.1.h Bipolar Disorder:

Of the studies reviewed, only one was conducted on bipolar disorder (specifically childhood-onset bipolar disorder) and its environmental correlates. According to a study by Barton et al. (2021), of the experiment's sample, approximately 1 in 5 were found to have childhood-onset bipolar disorder. Additionally, childhood-onset bipolar disorder was discovered to have positive associations with factors such as bipolar disorder not otherwise specified (BD-NOS), comorbid ADHD and oppositional defiant disorder (ODD), lifetime police contact, lifetime stimulant treatment, and higher scores on parent-reported emotional lability, family history of depression, suicidal ideation, ADHD, substance use disorder (SUD), alcohol use disorder (AUD), and conduct disorder (CD), and negative associations with lifetime smoking (Barton et al. 2021).

3.1.i Personality Disorders:

One of the studies, conducted by Maclean et al. (2019), covers the role that child maltreatment plays on mental health disorders within adolescent populations. In this study, it was found that in comparison to children without child protection contact, or exposure to abuse, children who had been subjected to substantiated maltreatment had more instances of mental health events and diagnoses. While 5.9% of children without child protection contact experienced mental health related events, 37.4% of children with substantiated maltreatment experienced mental health related events; and while 3.6% of children without child protection contact were diagnosed with a mental health disorder, 20% of children with substantiated maltreatment were diagnosed with a mental health disorder. Of all the mental health disorders included in the study (including substance related disorders, schizophrenia, affective disorders, personality disorders, behavioral disorders, and more), the association between maltreatment and the prevalence of

personality disorders appeared to be particularly strong, at hazard ratio (HR): 6.83 (95% CI 5.81 to 8.04) unadjusted and HR: 3.64 (95% CI 2.94 to 4.52) adjusted (Maclean et al. 2019).

3.2 Genetic Factors

3.1.a Anxiety and Depression:

Out of the studies we reviewed, there were five articles that mentioned specific genes within the human genome that have a direct effect on adolescent mental health. In a report, Serotonergic Multilocus genetic variation with the THP2 gene rs4570625 polymorphism G allele was understood to have an impact with adolescent depressive episodes (Zeng et al. 2023). On a broader scale, the heritability between a child and parents is incredibly important in diagnosing possible anxiety & depressive disorders, especially if the adolescent carries a potential serotonin transporter gene (Held et al. 2022). Regarding heritability from parents, factors such as family history of depression as well as immune and inflammatory markers can lead to an adolescent having mental health disorders (Kieling et al. 2021). Other genetic factors include additive genetic factors which help with zygosity determination using genetic analysis (Wang et al. 2024).

3.1.b Schizophrenia:

There were two included studies that analyzed the genetic factors that contribute to the development of schizophrenia in adolescents. In the study by Luo et al. (2019), it was found that there was an association between putamen volumes in the brain and schizophrenia among an IMAGEN adolescent cohort. The minor T allele, a mutation in the gene SLC39A8, of SNP (single nucleotide polymorphism) rs13107325, was found to be connected with larger volumes of bilateral pumatin. Additionally, the minor G allele of SNP rs7182018 was found to be associated with greater gray matter volumes (GMVs) of two bilateral putamen clusters (Luo et al. 2019). In a Psychiatric Genomics Consortium genome-wide association study (GWAS) in 2014, SNP rs13107325 was seen to have associations with the incidence of schizophrenia, and in the summary-databased Mendelian randomization analysis using Psychiatric Genomics Consortium results, associations between the GMVs of putamen clusters and the incidence of schizophrenia was found as well (Luo et al. 2019). Additionally, a study conducted by Paksarian et al. (2020) considered that residential mobility throughout childhood was associated with serious mental disorders (including schizophrenia, bipolar disorder, and depression) in adolescence as well as substance abuse and criminal conviction and investigated how genetic factors may be liable for this association. However, it was found that the polygenic risk scores (PRS) for schizophrenia were weakly associated with residential mobility from ages ten through fourteen years (one move: OR=1.07, 95%CI=1.00–1.16). Instead, the parents' history of mental disorders was seen to have a more consistent association with residential mobility (one move: OR=2.10, 95%CI:1.65–2.65) (Paksarian et al. 2020).

3.1.c Attention-Deficit Hyperactivity Disorder (ADHD) & Eating Disorders:

Of the included studies, there were three studies covering ADHD and two covering eating disorders; the only article discussing the genetic factors of ADHD and eating disorders, respectively, was a study by Yilmaz et al. (2023) which explored the genetic covariance of

ADHD symptoms and eating disorder symptoms. It was discovered in the experiment that shared genetic factors between the two disorders were present. For female adolescents, the strongest genetic correlation was observed between cognitive/inattention problems and bulimia, with genetic factors accounting for 67% of this association (Yilmaz et al. 2023). In male adolescents, the strongest genetic correlations were found between conduct problems and bulimia and between hyperactivity and bulimia, with genetic factors accounting for 83% and 95% of these associations respectively, suggesting that there are shared genetic influences between ADHD symptoms and certain disordered eating behaviors, particularly bulimia (Yilmaz et al. 2023). When considering ADHD symptoms and eating disorder symptoms separately, cross-twin, within-trait correlations were found to be stronger between monozygotic twins than that between dizygotic twins, which suggested the presence of genetic effects. Then, when considering ADHD and eating disorder symptoms together, it was again found that correlations were stronger between monozygotic twins than between dizygotic twins (Yilmaz et al. 2023). These statistics directly suggest a relationship between genetics and eating disorders.

3.1.d Alcohol Use Disorder:

There was only a single study that fixated on the impact of genetic factors on the prevalence of alcohol use disorders. The study by Hildebrand et al. (2023) found moderate heritability estimates for AUDs across different measures, indicating that genetic factors play a substantial role in the risk for developing alcohol use problems in late adolescence. However, these heritability estimates were lower than what previous studies have reported. Hildebrand et al. (2023) discovered the presence of qualitative sex differences in the genetic influences on AUDs, suggesting that there may be several different genes involved in alcohol use issues for males versus females.

3.1.e Conduct Disorder:

Of the studies analyzed, one study was primarily centered on how genetic factors are associated with conduct disorder. Specifically, it was focused on genome-wide epigenetic methylation patterns within female adolescents with Conduct Disorder (Chiocchetti et al. 2022). According to the study's results, which were measured by the experiment's differential methylation analysis, it was found that increased methylation directly led to an increased expression of the neurite regulator SLITRK5. It was thus proposed that increased methylation inhibits the accessibility of the glucocorticoid receptor which thus leads to increased expression of SLITRK5. This allowed researchers to suggest that the increased expression of SLITRK5 is associated with the diagnosis of conduct disorder within the population of female adolescents (Chiocchetti et al. 2022).

3.1.f Bipolar Disorder:

In a study conducted by Paksarian et al. (2020), the impact of genetic factors on the associations between residential mobility throughout childhood and serious mental disorders (such as schizophrenia, bipolar disorder, and depression) in adolescence were considered. This experiment stated that the Polygenic Risk Scores (PRS) for bipolar disorder were not associated with residential mobility throughout adolescence, unlike the PRS for schizophrenia or clinical depression, which were both weakly associated with childhood mobility (Paksarian et al. 2020).

4. Discussion

The findings from our scoping review highlight the complex interplay between environmental and genetic factors in influencing adolescent mental health. The reviewed studies provide evidence that both sets of factors contribute significantly to the development of various mental health disorders during adolescence, which is a critical period of psychological development.

In terms of environmental factors, studies by Thompson et al. (2021) and Rudolph et al. (2019) emphasize that adolescents are more susceptible to mental health issues when exposed to air pollution, noise pollution, detrimental aspects of their home life, and settings such as psychiatric hospitals and academic institutions. Based on our results, it is reported that most mental health disorders derive from home life and academic institutions, possibly due to the amount of time in an adolescent's day dedicated to these settings. For home life, factors include parenting styles/perceived parenting, socioeconomic factors (such as economical class), demographic characteristics (including race, gender, ethnicity, and religion), child order, and whether they live in an urban or rural setting. These factors can tend to be overwhelming for the adolescent in their daily life, from the moment they wake up at home and come from school. For example, factors such as bullying and overbearing parents can have a direct impact on how the adolescent views their life, promoting the development of mental health disorders. Academic institutions introduce factors such as anxiety derived from self-efficacy, drug use, use of new technologies, interpersonal/social relationships, school performance, and prosocial behavior. Research by de Castro et al. (2023) and Wang et al. (2024) suggests that adolescents from lower socioeconomic backgrounds or those experiencing dysfunctional family relationships are at higher risk for developing mental health disorders. This is supported by existing literature that emphasizes the role of social determinants in mental health outcomes. Our review revealed conflicting evidence regarding the influence of neighborhood context on mental health. Latham et al. (2022) found that living in high-disorder neighborhoods was associated with an increased risk of psychiatric disorders, while Vaalavuo et al. (2021) reported that adolescents from higher socioeconomic backgrounds were more likely to develop psychiatric disorders, suggesting that the relationship between neighborhood environment and mental health may be impacted by other factors. Genetic factors were also identified as important determinants of adolescent mental health, with several studies highlighting the role of specific genes and hereditary factors in the development of disorders such as schizophrenia, attention-deficit hyperactivity disorder, depression, eating disorders, alcohol use disorder, and conduct disorders. For instance, articles such as studies by Held et al. (2022) and Kieling et al. (2021) provided clear evidence that adolescents with a family history of mental health disorders are more likely to inherit similar issues, indicating that genetic predisposition plays a significant role in the transmission of these conditions. Findings by Yilmaz et al. (2023) demonstrated a genetic overlap between ADHD and eating disorders, suggesting that these conditions may share common genetic pathways. However, eating disorders and alcohol use disorder lack studies outlining the specific genes or genetic factors that influence the development of these disorders. In addition, the study by Lindgren et al. (2019) finds conflicting evidence regarding the heritability estimates for alcohol use disorder, highlighting the need for more research about this subject. The findings from this review also highlight the need for more research into the genetic factors related to adolescent mental health disorders, particularly in understanding how genetic and environmental factors interact to influence mental health outcomes.

4.1 Strengths and Limitations:

This review followed PRISMA-ScR guidelines, which enhanced the transparency and thoroughness of the reporting. However, a limitation of this review is the restriction to English-language publications, which led to the omission of relevant studies published in other languages. With the addition of non-English language publications, our research would likely be more centralized and defined. Another limitation within our research is the lack of quality evaluation of the included statistics. With a more in-depth evaluation of the statistics from each article, our final review could be more refined. Additionally, several studies provided inconclusive data from their population which may have interfered with the accuracy of the results.

4.2 Conclusions:

After concluding the research collection process, our team was able to reflect and understand that there were potential areas of improvement within our research. In future research, a more specific exclusion criteria would prove to be more useful while extracting data.

Based on this study, our future goals entail methods of broadcasting the importance of mental health with regards to different environmental and genetic factors to a variety of communities, spanning different countries, households, religions, and geographical locations. We hope this will help to positively impact adolescent lives. We aim to create meaningful change in adolescent lives and positively impact their well-being.

Our research team believes that our hypothesis, which states, ‘environmental and genetic factors are significantly associated with an increased risk of adolescents developing mental health disorders’ was supported. After reviewing the data collected, we believe there is sufficient evidence suggesting that adolescent mental health is strongly influenced by a combination of environmental and genetic factors.

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Author Contributions:

Each author held a key role in the manifestation of this research report. All authors contributed a substantial portion from the topic creation, researching of data, inspection and interpretation, extraction of data, forming the draft, editing and/or reviewing the article, giving the final approval

to be published, and each author has agreed to be accountable for all aspects of this research report.

Conflict of Interest:

The authors declare no conflicts of interest related to the subject of the review.

Appendix 1: Research Equations by Online Database

Search Engine	Research Equations
Pubmed	("adolescent" OR "teenager") AND ("mental health" OR "mental health disorder") AND ("environmental") AND ("genetic")
Google Scholar	("adolescent" OR "adolescents" OR "teenager" OR "teenagers") AND ("mental health disorder" OR "mental health disorders") AND ("environment") AND ("genetics")
Science Direct	("adolescent" OR "teenager") AND ("mental health" OR "mental health disorder") AND ("environmental") AND ("genetic")

Appendix 2: Summary of various study objectives and main results

Id	Author	Publication year	Study objectives	Study type	Sample size	Study main results
40	Lindgren, Maija; Jonninen, Minna; Jokela, Markus; Therman, Sebastian	2019	We wanted to assess whether different types of self-reported psychosis risk symptoms would predict psychiatric service use over the follow-up period of seven years.	Cohort study	819 from questionnaire	Stronger symptoms on any PQ factor as well as the presence of a mood disorder predicted prolonged service use. All of the PQ factors remained significant predictors when adjusted for baseline mood disorder and multimorbidity.
41	Paksarian, Diana; Trabjerg, Betina B.; Merikangas, Kathleen R.; Mors, Ole; Børglum, Anders D.; Hougaard, David M.; Nordentoft,	2020	The goal of this study was to assess whether the associations between residential mobility during early adolescence and subsequent schizophrenia, bipolar disorder and major depressive disorder (MDD) are confounded by genetic liability.	Case cohort study	4207 schizophrenia cases, 1402 bipolar disorder cases, 18 215 MDD cases and 17 582 subcohort members.	Mobility was positively associated with each disorder, with more moves associated with greater risk. Adjustment for PRS produced slight reductions in the magnitude of associations. Adjustment for PRS and parental history of mental disorder together reduced estimates by 5–11%.

	Merete; Werge, Thomas; Pedersen, Carsten B.; Mortensen, Preben B.; Agerbo, Esben; Horsdal, Henriette Thisted					
45	Thompson, Rhiannon; Fisher, Helen L.; Dewa, Lindsay H.; Hussain, Tania; Kabba, Zaina; Toledano, Mireille B.	2022	The aim of this study was to conduct qualitative interviews with UK adolescents to explore their thoughts and feelings about the environment, understand their experiences of contextual environmental issues and inform change by improving our collective understanding of how young people can perceive and respond to these issues.	Cohort study	15 participants in interviews	Participants reported a" sense of feeling overwhelmed or bombarded by numerous features of the urban environment." On the contrary, they felt that nature and fresh air were more soothing.
62	de Castro, Filipa; Cappa, Claudia; Madans, Jennifer	2023	It aims to address two interrelated research questions: 1)To what extent do signs of depression and/or anxiety occur among adolescents with different background characteristics? 2) How are these signs related to difficulties in the domains of seeing, hearing, walking, self-care, learning, remembering, concentrating, making friends, accepting change, and behavioral control?	Cross-sectional analysis	123 975 adolescents	Depression or anxiety signs, and signs of both depression and anxiety, were at least two times and up to three times more prevalent among adolescents with functional difficulties in any other domain compared to those without such difficulties.

74	Mousset, Eliane Saint-Pierre; Lane, Julie; Therriault, Danyka; Roberge, Pasquale	2024	The specific objectives were to: 1) describe adolescent's anxiety symptoms and self-efficacy levels (social and emotional) before participation in the prevention program; 2) explore the association between self-efficacy and anxiety symptoms, while comparing self-efficacy across various groups (high anxiety vs low anxiety) before participation in the prevention program; 3) explore the predictive effect of self-efficacy on anxiety symptoms, while exploring changes in anxiety symptoms from pre- to post-data collection to determine the presence or absence of interaction effects of self-efficacy.	Secondary analysis	1948 adolescents	Results indicate that: adolescents' anxiety symptoms, and the two domains of self-efficacy differ according to gender, family characteristics, and program type; the association between adolescents' anxiety symptoms and levels of total self-efficacy is strong; and total self-efficacy has a predictive effect on adolescents' anxiety symptoms in the context of an anxiety prevention program administered in schools
76	Luo, Qiang; Chen, Qiang; Wang, Wenjia; Desrivières, Sylvane; Quinlan, Erin Burke; Jia, Tianye; Macare, Christine; Robert, Gabriel H.; Cui, Jing; Guedj, Mickaël; Palaniyappan, Lena; Kherif, Ferath; Banaschewski, Tobias; Bokde, Arun L. W.; Büchel, Christian; Flor, Herta; Frouin, Vincent; Garavan,	2019	To identify genetic variants associated with adolescent brain structure and explore psychopathologic relevance of such associations.	Association study	1721 adolescents	We identified a gene that points to a potential new mechanism associated with both ion transporter and immune reaction for development of psychopathology, in particular associated with schizophrenia. This could help with finding a cure to schizophrenia.

	Hugh; Gowland, Penny; Heinz, Andreas; Ittermann, Bernd; Martinot, Jean-Luc; Artiges, Eric; Paillère-Martinot, Marie-Laure; Nees, Frauke; Orfanos, Dimitri Papadopoulos; Poustka, Luise; Fröhner, Juliane H.; Smolka, Michael N.; Walter, Henrik; Whelan, Robert; Callicott, Joseph H.; Mattay, Venkata S.; Pausova, Zdenka; Dartigues, Jean-François; Tzourio, Christophe; Crivello, Fabrice; Berman, Karen F.; Li, Fei; Paus, Tomáš; Weinberger, Daniel R.; Murray, Robin M.; Schumann, Gunter; Feng, Jianfeng					
88	Schaefer, Jonathan D.; Hamdi, Nayla R.; Malone, Stephen M.; Vrieze, Scott; Wilson, Sylia; McGue, Matt; Iacono, William	2021	The purpose of the present study was thus to examine associations between prospectively assessed adolescent cannabis use and young-adult outcomes (psychiatric, cognitive, and	Longitudinal study	3762	Adolescent cannabis use is associated with poorer adult outcomes across multiple domains.

	G.		socioeconomic) in three longitudinal studies of twins			
89	Yilmaz, Zeynep; Quattlebaum, Mary J.; Pawar, Pratiksha S.; Thornton, Laura M.; Bulik, Cynthia M.; Javaras, Kristin N.; Yao, Shuyang; Lichtenstein, Paul; Larsson, Henrik; Baker, Jessica H.	2023	The goal of the present study was to evaluate the phenotypic associations and examine the extent to which genetic and environmental factors are shared and contribute to the associations between ADHD symptom dimensions and symptoms of disordered eating in a large Swedish twin cohort of adolescent girls and boys.	Longitudinal study	470 monozygotic and 349 dizygotic (female), 441 monozygotic and 315 dizygotic (male)	This study provides evidence for shared genetic factors having a significant influence on the association between ADHD symptoms and disordered eating attitudes and behaviors.
106	Okada, Naohiro; Yamamoto, Yu; Yahata, Noriaki; Morita, Susumu; Koshiyama, Daisuke; Morita, Kentaro; Sawada, Kingo; Kanata, Sho; Fujikawa, Shinya; Sugimoto, Noriko; Toriyama, Rie; Masaoka, Mio; Koike, Shinsuke; Araki, Tsuyoshi; Kano, Yukiko; Endo, Kaori; Yamasaki, Syudo; Ando, Shuntaro; Nishida, Atsushi; Hiraiwa-Hasegawa, Mariko; Yokoyama, Charles; Kasai,	2021	To find out if birth order has an effect on the social development of adolescents.	Longitudinal study	3171 pairs	We found that birth order, a non-genetic environmental factor, affects adolescent social development via different neural substrates. The current study provides novel insights into the developmental neuroscience of birth order, enriching the long history of the research field on birth order psychology.

	Kiyoto					
136	Latham, Rachel M.; Kieling, Christian; Arseneault, Louise; Botter-Maio Rocha, Thiago; Beddows, Andrew; Beevers, Sean D.; Danese, Andrea; De Oliveira, Kathryn; Kohrt, Brandon A.; Moffitt, Terrie E.; Mondelli, Valeria; Newbury, Joanne B.; Reuben, Aaron; Fisher, Helen L.	2021	We will test whether the inclusion of childhood air pollution exposure as an additional predictor in Rocha and colleagues' multivariable depression risk prediction model improves the identification of adolescents who are at greatest risk for developing MDD in the UK.	Longitudinal cohort study	2232 British twin children	We found that the odds of developing MDD at age 18 were elevated for those with the highest level of annual exposure to NOX and PM2.5 at age 10. However, inclusion of these ambient air pollution exposure estimates into the risk prediction model produced minimal overall improvement since model specificity increased but model sensitivity decreased.
208	Rudolph, Kara E.; Shev, Aaron; Paksarian, Diana; Merikangas, Kathleen R.; Mennitt, Daniel J.; James, Peter; Casey, Joan A.	2019	We tested the policy-relevant hypothesis that living in communities where environmental noise exceeds the US EPA threshold is associated with worse sleep and higher prevalence of mental health disorders corresponding to the DSM-IV in a nationally representative sample of US urban adolescents.	Cross-sectional study	4508 US urban adolescents	We find evidence for an association between residence in a high-noise area and later bedtimes among urban adolescents but no consistent evidence of such an association with mental health disorders.
233	Roberts, Susanna; Arseneault, Louise; Barratt, Benjamin; Beevers, Sean; Danese, Andrea; Odgers, Candice L.; Moffitt, Terrie E.; Reuben, Aaron; Kelly,	2019	We then explored whether these air pollutants were associated with concurrent and longitudinal mental health problems, and checked the robustness of associations for other important risk factors, including socioeconomic status,	Cohort study	1116 families	We found an increased likelihood of depression and conduct disorder at 18 in those exposed to higher estimated pollution levels (PM2.5 and NO2) at age 12, but no significant association with concurrent depression or conduct disorder symptoms. This may reflect the cumulative effect of chronic exposure to air pollution by age 18, or it could be that air

	Frank J.; Fisher, Helen L.		family psychiatric history, childhood victimization, and smoking, as well as controlling for age-12 symptoms in age-18 analyses.			pollution exposure takes time to impact on the processes underlying such behavioral problems.
250	Chubar, Viktoria; Van Leeuwen, Karla; Bijttebier, Patricia; Van Assche, Evelien; Bosmans, Guy; Van den Noortgate, Wim; van Winkel, Ruud; Goossens, Luc; Claes, Stephan	2020	In this study, we investigate how 274 genes involved in nine neurotransmission systems (serotonin, dopamine, hypothalamic pituitary adrenal [HPA] axis, oxytocin, GABA, glutamate, choline, noradrenergic, and the clock pathway) and perceived parenting behaviors (as environmental exposures) interact in explaining SAS during adolescence.	Case-control study	948 Caucasian adolescents	The results suggest that genes involved in glutamate (SLC1A1), glutathione neurotransmission (GSTZ1), and oxidative stress (CALCRL), in association with harsh punitive parenting, may contribute to social anxiety in adolescence.
358	Vaalavuo, Maria; Kailaheimo-Lönnqvist, Sanna; Kauppinen, Timo M.; Sirniö, Outi	2021	We study whether childhood neighborhood context affects mental health in adolescence in Finland. We also examine heterogeneous effects by family background.	Longitudinal cohort study	115 627 children	Our results show that there is no evidence of a strong association between neighborhood characteristics under study and psychiatric disorder within families.
403	Barton, Jessica; Mio, Megan; Timmins, Vanessa; Mitchell, Rachel H. B.; Goldstein, Benjamin I.	2023	We set out to examine differences in clinical, and familial characteristics among adolescents with childhood- versus adolescent-onset BD.	Cohort study	195 adolescents	Approximately one-fifth of participants had childhood-onset BD (n = 35; 17.9%). A number of clinical and familial factors were significantly associated with childhood-onset BD. However, there were no significant differences in depressive and manic symptom severity. In multivariate analyses, the variables most strongly associated with childhood-onset were police contact, and family history of suicidal ideation. Smoking and psychiatric hospitalization were

						associated with adolescent-onset.
404	Hildebrand Karlén, Malin; Lindqvist Bagge, Ann-Sophie; Berggren, Ulf; Fahlke, Claudia; Andiné, Peter; Doering, Sabrina; Lundström, Sebastian	2023	To investigate the heritability of AUDs in a nation-wide sample of male and female twins in late adolescence (18 years)	Univariate sex-limitation twin analyses	8,330 18-year-old Swedish monozygotic (MZ) and dizygotic (DZ) twins from the Child and Adolescent Twin Study (Sweden)	Prevalence of potential hazardous alcohol consumption/active alcohol use was 57.1%, and for potentially harmful alcohol use prevalence was 26.5%. Prevalence was higher among females (59.0% and 31.1% respectively) than males (54.4% and 20.0% respectively). Overall, the results of the univariate model fitting indicated that there were qualitative sex differences in the genetic and environmental influences on AUDs, with generally moderate heritability estimates ranging between 0.37 and 0.50.
415	Mora, Fernando; Alvarez-Mon, Miguel A.; Fernandez-Rojo, Sonia; Ortega, Miguel A.; Felix-Alcantara, Miriam P.; Morales-Gil, Isabel; Rodriguez-Quiroga, Alberto; Alvarez-Mon, Melchor; Quintero, Javier	2022	The aim of this study is to analyze the relationship between sociodemographic and behavioral factors, as well as self-esteem, in students of the first cycle of middle school and the probability of belonging to the risk group of eating disorders (ED) measured through the EAT-26 scale.	Cohort study	656 students belonging to eight educational centers in Madrid	A significant relationship was observed between self-esteem and belonging to an ED risk group, with an OR = 0.910 (CI 95% 0.878−0.943). Hence, each one-point increase on the self-esteem dimension decreased the risk of belonging to an ED risk group by 9.5%. In the variables considered in the area of dysfunctional feeding patterns, the variables ‘number of meals’ ($p < 0.01$), ‘dieting’ ($p < 0.01$), and ‘drug consumption to lose weight’ ($p < 0.01$) were found to be related to the risk of belonging to the ED group.

428	Maclean, Miriam Jennifer; Sims, Scott Anthony; O'Donnell, Melissa	2019	To determine mental health outcomes for children with a history of child protection system involvement, accounting for pre-existing adversity, and to examine variation in risk across diagnostic groupings and child protection subgroups.	Longitudinal, population-based record-linkage study	All children in Western Australia (WA) with birth records between 1990 and 2009	Compared with children without child protection contact, children with substantiated maltreatment had higher prevalence of mental health events (37.4% vs 5.9%) and diagnoses (20% vs 3.6%). After adjusting for background risks, all maltreatment types were associated with an almost twofold to almost threefold increased hazard for mental health events. Multivariate analysis also showed mental health events were elevated across all child protection groups, ranging from HR: 3.54 (95% CI 3.28 to 3.82) for children who had entered care to HR: 2.31 (95% CI 2.18 to 2.46) for unsubstantiated allegations. Maternal mental health, aboriginality, young maternal age and living in socially disadvantaged neighbourhoods were all associated with an increased likelihood of mental health events. The increase varied across diagnostic categories, with particularly increased risk for personality disorder, and frequent comorbidity of mental health and substance abuse disorders.
437	Zeng, Zihao; Peng, Liyi; Liu, Shuangjin; Yang, Qin; Wang, Hongcai; He, Zhen; Hu, Yiqiu	2023	To examine the interactions between serotonergic multilocus genetic profiles and environmental factors, such as interpersonal relationships and insomnia, to understand their effects on adolescent depression	Cohort study	760 students from junior high school in Hunan, China	(1) interpersonal relationship predicted adolescent depressive symptoms; (2) insomnia mediated the effect of interpersonal relationships on adolescent depressive symptoms; (3) the THP2 gene rs4570625 polymorphism G allele was a key risk factor for depressive symptom, and the MGPS moderated the effects of teacher-student relationship and insomnia on adolescent depressive symptom. Specifically, as the MGPS

						increased, the effects of insomnia on adolescent depressive symptom were enhanced; further, when the MGPS score increased, the effect of teacher-student relationship on depression showed a similar phenomenon with an increased slope and enhanced prediction; and (4) the results of sensitivity analysis showed that multilocus genetic interaction with the environment had a better explanatory power and stability for depression than single polymorphism studies.
478	Held, Leslie K.; Vink, Jacqueline M.; Vitaro, Frank; Brendgen, Mara; Dionne, Ginette; Provost, Lysandre; Boivin, Michel; Ouellet-Morin, Isabelle; Roelofs, Karin	2022	To investigate the genetic and environmental aetiology of freezing	Longitudinal cohort study	662 pairs of twins	Freezing was found to be moderately heritable (45% of the variance accounted for by genetic factors). The remaining variance was explained by unique environmental factors, including measurement error. No significant contribution of shared environmental factors was noted. Additionally, shorter freezing was associated with more internalizing symptoms in adolescence at trend level, a pattern that was significant for depressive but not anxiety symptoms.
486	Kieling, Christian; Buchweitz, Claudia; Caye, Arthur; Manfro, Pedro; Pereira, Rivka; Viduani, Anna; Anés, Maurício; Battel, Lucas; Benetti, Silvia; Fisher, Helen L.; Karmacharya, Rakesh; Kohrt, Brandon A.; Martini, Thais;	2021	In this report, we present the rationale, methods, and baseline characteristics of the Identifying Depression Early in Adolescence Risk Stratified Cohort (IDEA-RiSCo), a study designed for in-depth examination of multiple neurobiological, psychological, and environmental measures associated with the risk of developing and with the presence of	Cohort study	7720 adolescents	Across a variety of measures of psychopathology and exposure to negative events, there was a clear pattern in which either the MDD group or both the HR and the MDD groups exhibited worse indicators in comparison to the LR group.

	Petresco, Sandra; Piccin, Jader; Rocha, Thiago; Rohde, Luis Augusto; Rohrsetzer, Fernanda; Souza, Laila; Velazquez, Bruna; Walsh, Annabel; Yoon, Leehyun; Zajkowska, Zuzanna; Zonca, Valentina; Swartz, Johnna R.; Mondelli, Valeria		depression in adolescence, with a focus on immune/inflammatory and neuroimaging markers.			
492	Wang, Fangyi; Ma, Xingshun; Zhao, Liansheng; Li, Tao; Fu, Yixiao; Zhu, Wenfen	2024	To explore the influence of genetic and environmental factors on adolescent anxiety	Cohort study	196 adolescent twins	Structural equation modeling was performed to evaluate the effects of additive genetic factors (A), common environmental factors (C), and individual-specific environmental factors (E) on adolescent anxiety. The estimates of A and E on adolescent anxiety were 0.34 (95% CI = 0.12–0.53) and 0.66 (95% CI:0.47–0.89), respectively. The environment played an important role in adolescent anxiety. Adolescent anxiety was significantly positively correlated with peer relations ($r = 0.606$, $p < 0.05$) and negatively correlated with prosocial behavior ($r = 0.207$, $p < 0. 05$). No sex differences were observed. Adolescent anxiety was influenced by both genetic and environmental factors. The individual-specific environmental factors played an important role.

501	Chiocchetti, Andreas G.; Yousaf, Afsheen; Waltes, Regina; Bernhard, Anka; Martinelli, Anne; Ackermann, Katharina; Haslinger, Denise; Rotter, Björn; Krezdorn, Nico; Konrad, Kerstin; Kohls, Gregor; Vetro, Agnes; Hervas, Amaia; Fernández-Rivas, Aranzazu; Freitag, Christine M.	2022	To explore the epigenetic signature of females with CD and its relation to psychosocial and environmental risk factors	Cohort study	99 female adolescents	We identified a 12% increased methylation 5' of the neurite modulator SLITRK5 (FDR = 0.0046) in cases within a glucocorticoid receptor binding site. Functionally, methylation positively correlates with gene expression in lymphoblastoid cell lines. At systems-level, genes (uncorr. P < 0.01) were associated with development of neurons, neurite outgrowth or neuronal developmental processes. At gene expression level, the associated gene-networks are activated perinatally and during early childhood in neocortical regions, thalamus and striatum, and expressed in amygdala and hippocampus. Specifically, the epigenetic signatures of the gene network activated in the thalamus during early childhood correlated with the effect of parental education on CD status possibly mediating its protective effect. The differential methylation patterns identified in females with CD are likely to affect genes that are expressed in brain regions previously indicated in CD. We provide suggestive evidence that protective effects are likely mediated by epigenetic mechanisms impairing specific brain developmental networks and therefore exerting a long-term effect on neural functions in CD.
544	Crush, Eloise; Arseneault, Louise; Danese, Andrea; Jaffee, Sara R.; Fisher, Helen L.	2020	This study aims to utilize the discordant twin design in a longitudinal cohort to consider the relative family-wide v. unique environmental effects of social support on	Longitudinal cohort study	2232 British twin children	The association between greater perceived social support and a reduced likelihood of psychotic experiences in adolescence appears to be extremely robust.

			adolescent psychotic experiences and control for earlier psychopathology.			
548	Latham, Rachel M.; Arseneault, Louise; Alexandrescu, Bianca; Baldoza, Saffron; Carter, Alysha; Moffitt, Terrie E.; Newbury, Joanne B.; Fisher, Helen L.	2022	We examined how personal experience of severe physical violence and living in areas with high levels of neighbourhood disorder during adolescence combine to associate with mental health at the transition to adulthood and which factors mitigate this.	Longitudinal cohort study	2232 British twin children	Personal experience of severe physical violence during adolescence was associated with elevated odds of age-18 psychiatric disorder regardless of neighborhood disorder exposure. Cumulative effects of exposure to both were evident for internalizing and thought disorder, but not externalizing disorder. For adolescents exposed to severe physical violence only, higher levels of perceived social support (including from family and friends) were associated with lower odds of psychiatric disorder. For those who also lived in areas with high neighborhood disorder, only family support mitigated their risk.

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