



POPULATION STUDY ARTICLE

Behavior problems in adolescence and subsequent mental health in early adulthood: results from the World Trade Center Health Registry Cohort

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BACKGROUND: The present study examined the association between 9/11-related adolescent behavioral problems on mental health outcomes in early adulthood.

METHODS: Data from enrollees of the World Trade Center Health Registry, who completed at least one adolescent (2006–2007 or 2011–2012) and adult survey (2011–2012 or 2015–2016), were analyzed. Adolescent behavioral difficulties were assessed using the adolescent-reported Strengths and Difficulties Questionnaire (SDQ). Adult mental health outcomes included binge drinking, smoking status history, 9/11-related post-traumatic stress disorder (PTSD), depression, and the self-reported number of physician mental health diagnoses. Multivariable regression was used to estimate associations of SDQ scores with mental health outcomes.

RESULTS: Of the 297 enrollees, 16.8% ($n = 50$) had abnormal/borderline SDQ scores as an adolescent. Binge drinking was not associated with adolescent SDQ scores. Enrollees with abnormal/borderline SDQ scores as an adolescent were more likely to be a consistent smoker (odds ratio (OR): 5.6, 95% confidence interval (CI): 1.2–25.2), have probable PTSD (OR: 3.5, 95% CI: 1.3–9.8), depression (OR: 6.2, 95% CI: 2.7–13.9), and to have two or more self-reported physician-diagnosed mental health conditions as an adult (OR 5.6, 95% CI: 2.0–12.5).

CONCLUSIONS: The findings of this study underscore the need to intervene early with children exposed to traumatic events so as to avert later adolescent and adult problem behaviors.

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INTRODUCTION

Studies of the long-term development of adolescent emotional and behavioral problems are essential for predicting adult psychopathology and for planning early interventions and prevention. In addition, the period of emerging adulthood is a particularly important time of life when mental health and behavior problems can disrupt stage-salient transitions in education, employment, and relationships.¹ Although the existing literature documents different methods of measurement of adolescent behavior problems and adult psychopathology, the findings are consistent. Studies have identified associations between behavioral problems in adolescence and anxiety and depression later on in adulthood.^{2–6} One study found an association between adolescent problem behavior and major depressive disorder in adulthood.⁴ Antisocial behavior in adolescence has been related to anxiety/depression in adulthood.⁷

In addition to mental health disorders in adulthood, other studies have assessed the role of behavior problems in adolescence and subsequent risk behaviors as an adult. Behavior problems in adolescence were related to a broad range of adult risk behaviors including alcohol use and abuse, illicit drug use, and nicotine dependence.^{2,7–11}

Childhood exposure to traumatic events can predict behavioral outcomes in adolescence. Though findings are mixed,¹² studies have found that childhood exposure to violence at home¹³ and witnessing school or community violence^{14–16} have been linked to

higher behavior problems in adolescence. Exposure to violence and subsequent disruptive behavior can also impact academic achievement in children.^{17,18}

Few studies have evaluated the consequences of “single-incident traumas,” such as Hurricane Katrina, the World Trade Center terrorist attacks on 11 September 2001, and school shootings, or have evaluated the consequences using longitudinal data. Literature suggests that exposure as a child to the events of 11 September 2001, such as being caught in the dust cloud, witnessing horrific events, and having a family member killed in the attacks has been associated with poor outcomes as an adolescent including substance use,^{19,20} poor school-functioning,^{19,21} and behavioral problems.^{22,23} However, there is a paucity of research on the extent to which the effects of these adolescent behavior problems relate to a “single-incident trauma” in childhood impact early adulthood. Understanding this will be key to post-disaster development of interventions and treatment planning for children. An estimated 25,000 children were living or attending school in lower Manhattan on 11 September 2001 and were exposed to the World Trade Center (WTC) terrorist attacks. Over 3,000 of these children enrolled as participants in the WTC Health Registry (Registry), thereby enabling analysis of the long-term health of those exposed to 9/11 as adolescents and adults.²⁴

The current study uses longitudinal data from the Registry to study the relationship between 9/11-related adolescent behavior problems and mental health outcomes in adulthood. Several

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mental health and substance use outcomes were assessed among adults who were exposed to 9/11 as children: binge drinking, smoking, report of mental health disorder diagnoses, and screening positive for depression or post-traumatic stress disorder (PTSD).

METHODS

Study sample and study design

The Registry's study design and enrollment methods have been previously described.²⁴ Briefly, the Registry is a prospective longitudinal cohort of 71,431 persons exposed to the WTC terrorist attacks on 9/11/2001. Children under 18 years were recruited through their parents and were eligible for enrollment if they resided or were enrolled in school in Manhattan south of Canal Street or were present south of Chamber Street on the morning of 9/11. In 2007–2008 and 2011–2012 enrollees between 11 and 17 years of age at the time of survey and their parent or guardian were surveyed separately.

The current study design included Registry enrollees who completed at least one adolescent survey (age 11–17 years) and at least one adult survey (≥ 18 years). Adolescent surveys were from 2006–07 or 2011–12 and the adult survey that was closest in time to the adolescent survey, either from 2011–12 or 2015–16 was used. After excluding enrollees without behavior measures or outcome measures, the final sample size was 297 enrollees. The Registry and the protocol used in the study were approved by the Institutional Review Board of the New York City Department of Health and Mental Hygiene.

Adolescent Strengths and Difficulties Questionnaire

The main independent variable of interest was adolescent behavioral problems that were assessed using the adolescent-reported Strength and Difficulties Questionnaires (SDQ), a 25-item adolescent behavioral screening instrument. A difficulties score (0–40) was categorized as normal (0–15) or borderline/abnormal (16–40) based on the normative US data.²⁵ The SDQ has been demonstrated as a psychometrically sound measure of child mental health problems.²⁵

Adult mental health and substance use outcomes

All outcome measures were collected from the adult surveys. Probable adult PTSD in the last 30 days was assessed using the PTSD Checklist-Stressor Specific Version (PCL-17) with questions specific to 9/11. The PCL-17 is a self-reported, 17-item scale corresponding to the Diagnostic and Statistical Manual of Mental Disorders (4th ed., DSM-IV) criteria that are commonly used in epidemiologic research.²⁶ Cases of probable 9/11-related PTSD were defined using a score of 44 or higher on the PCL-17.²⁶

An 8-item Patient Health Questionnaire (PHQ-8) assessed adult depression in the last 2 weeks. The PHQ-8 consists of eight of the nine criteria on which a diagnosis of DSM-IV depression is based.²⁷ Scores for each item were summed (range 0–24) and respondents with a PHQ-8 score of 10 or greater were considered to have depression.

On the adult surveys, enrollees were asked whether they have ever been diagnosed by a healthcare provider with the following mental health conditions: PTSD, depression, or anxiety. The responses were summed and categorized into 0, 1, or 2+.

Substance use outcomes were binge drinking and smoking. Binge drinking was defined as having five or more drinks for men or four or more drinks for women on a single occasion in the last 30 days.²⁸ Using both the adolescent and adult surveys, a four-level variable was developed for a smoking habit: (1) consistent ("yes" on adolescent and adult survey), (2) former ("yes" on adolescent and "no" on adult survey), (3) new ("no" on adolescent and "yes" on adult survey), and (4) never ("no" on both adolescent and adult survey).

Sociodemographic variables

Sociodemographic variables collected from the adolescent survey included age from adolescent survey, gender, race/ethnicity, tobacco use, and if someone smoked in the home. Variables collected from the corresponding parent survey included parent education, household income, and number of adults in the household.

Data analysis

All the analyses were performed using SAS 9.4. Bivariate association between study variables and SDQ score categories were assessed by Pearson's chi-square test. Fisher's exact test was used for cells with five or fewer observations. Separate models were run for each outcome. Multivariable logistic regression was used to estimate association between SDQ score and outcome variables: probable adult PTSD, depression, and binge drinking. Multinomial regression was used to estimate the association between SDQ score and outcome variables: number of mental health conditions and smoking habit. All regression models were adjusted for sociodemographic variables found to be significant in the bivariate analysis.

RESULTS

Descriptors

A total of 50 enrollees (16.8%) of 297 had abnormal/borderline SDQ scores on their adolescent survey (Table 1). The average age of enrollees on their adolescent survey was 14.6 years, 56.6% were female and 54.2% were white non-Hispanic (Table 1). Fifteen percent reported ever smoking cigarettes and 4.4% had probable 9/11-related PTSD on their adolescent survey. The majority (81.5%) lived with two or more adults in the household, 55.5% had a household income of $> \$75,000$, and 83.3% had a parent with some college or higher education.

On the adult survey 8.7% had probable 9/11-related PTSD, 17.3% had probable depression, and 15.6% had two or more mental health condition diagnoses (Table 2). Each of the mental health outcomes was associated with SDQ scores in the bivariate analyses. Over half of the adults reported binge drinking at least once in the last 30 days. Only 3.7% of enrollees reported smoking on both the adolescent and adult survey (consistent smoker), while the majority (78.5%) were never smokers. Neither binge drinking nor smoking habit was associated with SDQ scores in the bivariate analyses.

Mental health outcomes

In the adjusted analysis, enrollees with abnormal/borderline SDQ scores on their adolescent survey were 3.5 times more likely (95% confidence intervals (CI): 1.3–9.8) to have probable 9/11-related PTSD as an adult compared to those who had normal SDQ scores (Table 3). Enrollees with abnormal/borderline SDQ scores on their adolescent survey were six times more likely (95% CI: 2.7–13.9) to have depression as an adult compared to those who had normal SDQ scores. Compared to those with 0 mental health conditions diagnosis, the adjusted odds ratio (AOR) of having 2 or more mental health conditions diagnoses was higher among those with abnormal/borderline SDQ scores as an adolescent compared to those with a normal SDQ scores (AOR: 5.0, 95% CI: 2.0–12.5).

Substance use outcomes

Although not statistically significant, the point estimate is above one, suggesting that enrollees with abnormal/borderline SDQ scores on their adolescent survey were more likely to have at least one episode of binge drinking as an adult compared to those who had normal SDQ scores (Table 4). Compared to the never smoked group, the AOR of being a consistent smoker was higher among those with abnormal/borderline SDQ scores as an adolescent compared to those with a normal SDQ scores (AOR: 5.6, 95% CI: 1.2–25.2).

Table 1. Characteristics of adolescents aged 11–17 years reported in adolescent survey by SDQ status, 2007–2012

| | All | | Normal | | Abnormal/ borderline | | <i>p</i> -value ^a |
|--|--------------|------|--------------|------|-------------------------|------|------------------------------|
| | No. | (%) | No. | (%) | No. | (%) | |
| Total | 297 | 100 | 247 | 83.2 | 50 | 16.8 | |
| Adolescent's report | | | | | | | |
| Age, years | | | | | | | |
| Mean (Std. Dev.) | 14.60 (1.76) | | 14.56 (1.76) | | 14.80 (1.80) | | 0.3862 |
| Gender | | | | | | | |
| Male | 129 | 43.4 | 109 | 44.1 | 20 | 40.0 | 0.5911 |
| Female | 168 | 56.6 | 138 | 55.9 | 30 | 60.0 | |
| Race/ethnicity | | | | | | | |
| White | 161 | 54.2 | 141 | 57.1 | 20 | 40.0 | 0.0270 |
| Non-White | 136 | 45.8 | 106 | 42.9 | 30 | 60.0 | |
| Someone smokes in home | | | | | | | |
| No | 266 | 89.9 | 225 | 91.1 | 41 | 83.7 | 0.1234 ^a |
| Yes | 30 | 10.1 | 22 | 8.9 | 8 | 16.3 | |
| Adolescent smoking status | | | | | | | |
| No | 250 | 84.7 | 214 | 87.0 | 36 | 73.5 | 0.0162 |
| Yes | 45 | 15.3 | 32 | 13.0 | 13 | 26.5 | |
| Probable adolescent PTSD | | | | | | | |
| No | 281 | 95.6 | 245 | 99.2 | 36 | 76.6 | <0.0001 ^a |
| Yes | 13 | 4.4 | 2 | 0.8 | 11 | 23.4 | |
| Parent's report | | | | | | | |
| Number of adults in household | | | | | | | |
| One adult | 53 | 18.5 | 36 | 15.2 | 17 | 34.0 | 0.0018 |
| Two or more | 234 | 81.5 | 201 | 84.8 | 33 | 66.0 | |
| Household gross income | | | | | | | |
| ≤\$75,000 | 122 | 44.5 | 91 | 40.4 | 31 | 63.3 | 0.0036 |
| >\$75,000 | 152 | 55.5 | 134 | 59.6 | 18 | 36.7 | |
| Parental education | | | | | | | |
| High school graduate or less | 48 | 16.7 | 35 | 14.7 | 13 | 26.0 | 0.0514 |
| Some college or higher | 240 | 83.3 | 203 | 85.3 | 37 | 74.0 | |
| Child's unmet health care needs in the last 12 months | | | | | | | |
| No | 264 | 93.6 | 220 | 94.8 | 44 | 88.0 | 0.1033 ^a |
| Yes | 18 | 6.4 | 12 | 5.2 | 6 | 12.0 | |
| Talked to professional about the child's mental and emotional problem in the last 12 month | | | | | | | |
| No | 202 | 71.6 | 178 | 76.7 | 24 | 48.0 | <0.0001 |
| Yes | 80 | 28.4 | 54 | 23.3 | 26 | 52.0 | |

^aFisher's exact test for overall, if indicated. Otherwise chi-squared test. Numbers may not sum to total due to missing values

Table 2. Mental health/substance use outcome prevalence in adulthood (2011–2016) by adolescent SDQ status (2007–2012)

| | All | | Normal | | Abnormal/ borderline | | <i>P</i> -value |
|---|-----|------|--------|------|-------------------------|------|---------------------|
| | No. | (%) | No. | (%) | No. | (%) | |
| Total | 297 | 100 | 247 | 83.2 | 50 | 16.8 | |
| Probable adult 9/11-related PTSD in last 12 months (PCL ≥ 44) | | | | | | | |
| No | 264 | 91.3 | 226 | 93.4 | 38 | 80.9 | 0.0099 ^a |
| Yes | 25 | 8.7 | 16 | 6.6 | 9 | 19.1 | |
| Depression in last 2 weeks (PHQ ≥ 10) | | | | | | | |
| No | 234 | 82.7 | 209 | 87.8 | 25 | 55.6 | <0.0001 |
| Yes | 49 | 17.3 | 29 | 12.2 | 20 | 44.4 | |
| Number of physician diagnosed mental health conditions ^b | | | | | | | |
| 0 | 218 | 73.9 | 190 | 77.2 | 28 | 57.1 | 0.0043 |
| 1 | 31 | 10.5 | 25 | 10.2 | 6 | 12.2 | |
| 2+ | 46 | 15.6 | 31 | 12.6 | 15 | 30.6 | |
| Binge drinking at least once in the last 30 days | | | | | | | |
| No | 113 | 46.1 | 96 | 46.4 | 17 | 44.7 | 0.8521 |
| Yes | 132 | 53.9 | 111 | 53.6 | 21 | 55.3 | |
| Change in smoking habit | | | | | | | |
| Never smoker | 233 | 78.5 | 198 | 80.2 | 35 | 70.0 | 0.0947 ^a |
| New smoker | 19 | 6.4 | 17 | 6.9 | 2 | 4.0 | |
| Former smoker | 34 | 11.4 | 25 | 10.1 | 9 | 18.0 | |
| Consistent smoker | 11 | 3.7 | 7 | 2.8 | 4 | 8.0 | |

^aFisher's exact test for overall, if indicated. Otherwise chi-squared test.

^bMental health conditions include physician-diagnosed PTSD, depression, and anxiety.

adulthood. This study is among the few that have looked at "single-incident traumas," such as the 9/11 terrorist attacks, and the long-term impact on exposed children.²⁹ Unlike the current study, which is on persons directly exposed to the events of 9/11, studies after the 1995 Oklahoma City bombing focused on children and adolescents who were indirectly exposed.^{30,31} In those studies, middle and high school students who reported hearing or feeling the blast and those who had high levels of bomb-related television viewing were more likely to have post-traumatic stress symptoms.

In our sample of directly exposed children, we found that behavior problems in adolescence were associated with several mental health outcomes: having probable PTSD, depression, and 2 or more mental health diagnoses as an adult. These findings are consistent with other longitudinal epidemiological studies showing that behavior problems in adolescence were associated with depression and anxiety in adulthood.^{2–7} In addition, adolescent behavior problems were associated with higher odds of being a consistent smoker, but not with being a new smoker in adulthood or with binge drinking. This is also consistent with existing literature showing that adolescent behavior problems are associated with alcohol abuse and nicotine dependence.^{2,7–11} Many of these earlier studies use different measurements and definitions of behavior problems, differing both from the current study and from each other, which makes direct comparison difficult. The behavior problems measured in different studies include: various juvenile criminal or delinquent activities, tobacco use, alcohol use, illicit drug use, sexual intercourse, measures of antisocial behavior, as well as screening tools such as the Child Behavior Checklist, and Youth Self Report.^{2,5,7,9} Regardless of the

DISCUSSION

This study's goal was to assess the relationship between putative 9/11-associated behavior problems in adolescence with mental health in adulthood. Using data collected over a 9-year period, we found that 9/11-associated behavior problems in adolescence were associated with a higher risk of adverse outcomes in

Table 3. Adjusted odds ratios for mental health outcomes in adulthood (2011–2016) by adolescent SDQ (2007–2012)

| | Probable 9/11-related PTSD ^a | Depression ^a | Number of physician-diagnosed mental health conditions ^b | |
|-------------------------|---|-------------------------|---|----------------------|
| | | | 2+ | 1 |
| | Adjusted OR (95% CI) | Adjusted OR (95% CI) | Adjusted OR (95% CI) | Adjusted OR (95% CI) |
| Normal SDQ | Reference | Reference | Reference | Reference |
| Abnormal/borderline SDQ | 3.5 (1.3, 9.8) | 6.2 (2.7, 13.9) | 5.0 (2.0, 12.5) | 1.8 (0.6, 5.4) |

^aThe model was adjusted for age at adolescent survey, gender, race/ethnicity, household gross income, someone smokes at home, and adolescent smoking
^bThe model was adjusted for age at adolescent survey, gender, race/ethnicity, household gross income, someone smokes at home, adolescent smoking, and number of adults in household

Table 4. Adjusted odds ratios for substance use outcomes in adulthood (2011–2016) by adolescent SDQ (2007–2012)

| | Binge drinking ^a | Smoking habit ^b | | |
|-------------------------|-----------------------------|----------------------------|----------------------|----------------------|
| | | New smoker | Former smoker | Consistent smoker |
| | Adjusted OR (95% CI) | Adjusted OR (95% CI) | Adjusted OR (95% CI) | Adjusted OR (95% CI) |
| Normal SDQ | Reference | Reference | Reference | Reference |
| Abnormal/borderline SDQ | 1.4 (0.6, 3.3) | 0.7 (0.1, 3.4) | 2.3 (0.8, 6.6) | 5.6 (1.2, 25.2) |

^aThe model was adjusted for age at adolescent survey, gender, race/ethnicity, household gross income, someone smokes at home, and adolescent smoking
^bThe model was adjusted for age at adolescent survey, gender, race/ethnicity, household gross income, and someone smokes at home

specific problem behavior measured, the findings are consistent across the field. The findings from this study support the general nature of risk for mental health disorders and underscore the prognostic significance of adolescent behavior problems.

This study found that single-incident trauma-related behavior problems, as measured by total SDQ score, in adolescence predicted several poor mental health outcomes as an adult. One interesting observation was that adolescent behavior problems were associated with reporting diagnoses of 2 or more mental health conditions, but not with reporting one diagnosis. While this could be attributed to sample size, when the categories were regrouped to compare 0–1 mental health diagnosis to 2 or more, it was found that adolescents with behavior problems had statistically significant higher odds of having 2 or more mental health diagnoses compared to having 0–1 mental health diagnosis. Most other studies focus on one diagnosis or mental health outcome, not the number of mental health outcomes. One study by Fergusson et al.² found that children with conduct problems had a significantly higher number of mental health problems or substance dependence as young adults compared to children with no conduct problems.² Further research into this observation is needed.

Previous research has shown that behavior problems in adolescents are associated with initiation of smoking³² and that both behavior problems and early nicotine use in adolescence are predictive of later nicotine dependence in adulthood.³³ In this present study, we examined how adolescent behavior problems are associated with smoking habits into early adulthood. We found that adolescent behavior problems were associated with being a consistent smoker (report of smoking as both an adolescent and adult), but not with only smoking as an adolescent (former smoker) or only as an adult (new smoker). These results indicate that behavior problems exhibited in adolescence have a role in continued nicotine use from adolescence into young adulthood.

Although we did not observe a statistically significant relationship between adolescent behavior problems and binge drinking as an adult, the point estimate was in the same direction as previous studies, which found that later alcohol use was related to

earlier problem behavior.^{7,8,10,11} One study by Fergusson et al.⁹ also did not find a statistically significant association between alcohol use and conduct or attention problems in adolescence.⁹ The reasons for these discrepancies are not clear and further exploration of this is warranted.

Although our findings demonstrate a link between adolescent problem behavior and adult psychopathology after exposure to a "single-incident trauma", they do not explain the causal basis for this association. There are hypotheses in the literature on this relationship. One is that by disrupting normal developmental processes, adolescent problem behavior directly increases the risk for adult psychopathology.³⁴ Others have hypothesized that the link between adolescent problem behavior and adult psychopathology owes to a common liability that may be inherited.³⁵ Despite the uncertainty of the pathway for this causal relationship, our findings do have implications for prevention. The appearance of behavior problems in adolescence after a disaster can help in detecting a group that is at a high risk of developing mental health and/or substance use disorders later in life. Moreover, since the type of adolescent behavior problems within the literature are broad and the adult outcomes are variable, interventions or prevention strategies targeted at single behaviors may not fully mitigate the risk of psychopathology among exposed youth.⁴

LIMITATIONS

This study is subject to several limitations. First, the study findings relate to a particular cohort with a specific trauma, therefore the findings may not be generalizable. Second, the outcome measures were either self-reported mental health disorder, substance use, or symptoms. Research supports the validity of self-reported substance use. Self-reported behaviors may provide more extensive coverage of problems since formal diagnoses of substance abuse only captures the most severe cases, therefore only providing a limited estimate of prevalence. Also, the majority of alcohol users do not meet the diagnostic criteria for abuse or dependence disorders, but still exhibit elevated risk of adverse outcomes.⁷ The assessment of PTSD and depression were based on a self-administered questionnaire of symptoms that are

commonly used in epidemiologic studies and considered to have good diagnostic efficiency.^{26,27} Third, the small sample size could have resulted in a lack of power to detect some relationships. Finally, this paper does not report on the overall functioning of the adult respondents nor does it examine additional traumas experienced between the two surveys.

CONCLUSIONS

This study demonstrated a relationship between adolescent 9/11-related behavior problems and adult mental health conditions and substance use. Continued longitudinal studies, such as the World Trade Center Health Registry, are important for the continued monitoring of the long-term effects of 9/11 on children as they continue to age. Long-term access to trauma-related services is needed for a subset of children exposed to 9/11. This study's findings underscore the need to intervene early with children exposed to traumatic events so as to avert later adolescent and adult problem behaviors. It also demonstrates the importance of healthcare providers obtaining the developmental history of an adult's individual emotional and behavioral problems in the assessment of psychopathology.

DISCLAIMER

The contents of this publication are solely the responsibility of the authors and do not necessarily represent the official views of NIOSH-CDC or the Department of Health and Human Services.

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ADDITIONAL INFORMATION

Competing interests: The authors declare no competing interests.

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