HHS Public Access

Author manuscript

Ann Epidemiol. Author manuscript; available in PMC 2017 July 01.

Published in final edited form as:

Ann Epidemiol. 2016 July ; 26(7): 488–492.e5. doi:10.1016/j.annepidem.2016.06.003.

Adverse childhood experiences and later life adult obesity and smoking in the United States

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Abstract

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COMPETING INTERESTS: None.

BACKGROUND—Prior work demonstrates associations between physical abuse, household alcohol abuse and household mental illness early in life with obesity and smoking. Studies, however, have not generally been in nationally representative samples and have not conducted analyses to account for bias in the exposure.

METHODS—We used data from the 1979 U.S. National Longitudinal Survey of Youth to test associations between measures of adverse childhood experiences with obesity and smoking and used an instrumental variables approach to address potential measurement error of the exposure.

RESULTS—Models demonstrated associations between childhood physical abuse and obesity at age 40 years (OR 1.23, 95% CI 1.00-1.52) and ever smoking (OR 1.83, 95% CI 1.56-2.16), as well as associations between household alcohol abuse (OR 1.53, 95% CI 1.31-1.79) and household mental illness (OR 1.29, 95% CI 1.04-1.60) with ever smoking. We find no evidence of association modification by gender, socioeconomic position or race/ethnicity. Instrumental variables analysis using a sibling's report of adverse childhood experiences demonstrated a relationship between household alcohol abuse and smoking, with a population attributable fraction of 17% (95% CI 2.0% to 37%) for ever smoking and 6.7% (95% CI 1.6% to 12%) for currently smoking.

CONCLUSIONS—Findings suggest long-term impacts of childhood exposure to physical abuse, household alcohol abuse and parental mental illness on obesity and smoking, and that the association between household alcohol abuse and smoking is not solely due to measurement error.

Keywords

obesity; smoking; life course; measurement

INTRODUCTION

Obesity and smoking are two of the greatest contributors to morbidity and mortality (1). Understanding the underlying causes of obesity and smoking is critical for long-term prevention and treatment strategies. There is accumulating evidence for the importance of structural factors in the environment, including neighborhood and household context, as contributors to these outcomes (2-4). In addition, a large body of evidence exists for the role of childhood maltreatment within the household, including physical and emotional abuse, and risk of obesity in children and adults. A frequent metric for measuring this domain of exposures is a scale of Adverse Child Experiences (5). A recent meta-analysis of 41 studies concluded that there was an overall association between childhood maltreatment and risk of later obesity; a finding that was consistent across different types of childhood adverse experiences (6). The extent of this evidence has resulted in recommendations for pediatricians to include child maltreatment within the household as a risk factor for obesity (7, 8). The literature examining the relationship between childhood maltreatment and adult smoking is more limited, yet studies suggest that experience of childhood maltreatment increases risk of both smoking initiation and duration (9, 10). There is some evidence to support gender differences with stronger effects of adverse child experiences on smoking for women (11).

There are, however, four important limitations in the literature that are critical to address in order to establish the importance of these factors for contributing to population prevalence of obesity and smoking. First, of the 41 studies included in the recent review of adverse childhood experiences and obesity (12), only three are from nationally representative samples (13-15). Only two studies on adverse childhood experiences and smoking were done in a nationally representative populations (11, 16). Additional investigations in nationally representative samples are necessary to fully understand the population impact of adverse childhood experiences on adult obesity and smoking. A second limitation to the current literature is that no studies have rigorously examined potential association modification by gender, socioeconomic position and race/ethnicity. While almost half of the 41 studies included in the meta-analysis tested for gender interactions or stratified by gender, only two examined interactions by race/ethnicity and only one by socioeconomic position (6). Given the potential for type 1 error in the reporting of interactions selective reporting of significant findings may have occurred (17). Third, most studies had limited or no data on socioeconomic characteristics in early life, so could not adequately control for confounding by socioeconomic position in childhood (6). Fourth, prior studies have relied on individual report of adverse exposure or used administrative records. Of the 41 studies reviewed examining associations of childhood adversity with later life obesity, 32 used self-report data recalled by the adult subject and 9 used administrative records (6). Though administrative data are observed and collected prospectively, there is evidence that only the most severe instances of maltreatment are captured, leading to under-reporting of events (18). The validity and reliability of retrospective measurement of child maltreatment has been debated (19), raising the question whether measuring the recalled exposure, child adversity, from adults who have already achieved the outcome, in this case, obesity or smoking in midlife, will produce recall bias, leading to error in the estimate of association.

The purpose of our study was therefore twofold. First, we investigated whether childhood physical abuse, household alcohol abuse and household mental illness early in life contribute to obesity and smoking later in early and middle adulthood in a nationally representative population, controlling for early life sociodemographic factors. We specified *a priori* to test whether results differed by gender, socioeconomic position and race/ethnicity. Secondly, we addressed potential recall bias due to individual self-report by using siblings' reports of within household adverse childhood experiences. We applied an instrumental variable approach where we use siblings report as an instrument for an individual's exposure to adverse childhood experiences.

METHODS

STUDY SAMPLE

We used data from the National Longitudinal Survey of Youth 1979, a nationally representative survey of U.S. men and women who were 14-22 years old in 1979, and followed up annually until 1986 and subsequently every other year (20). We use baseline data for all of our control variables, data from the wave when the respondent was closest to age 25 and age 40 for our two measures of BMI, and data from when the respondent was closest to age 40 for our measures of current and ever smoking. Data on the retrospective

reporting of adverse childhood events was collected in 2012. The sampling was household based and the survey collected data on all eligible siblings who were residing in the selected households. Black and Hispanic individuals were oversampled. The total sample size was 12,686 at baseline and 7,301 at the 2012 wave of data collection. Data were missing on physical abuse (n=35, 0.5 percent), parental alcohol abuse (n=25, 0.3 percent) and parental mental illness (n=32, 0.4 percent). Data were also missing on outcomes (n=1879, 26 percent of BMI at age 25; n=858, 12 percent of BMI at age 40; n=178, 2.4 percent of smoking status over follow-up) and control variables, resulting in a final analytic sample sizes of 7266 for models of physical abuse, 7276 for models of parental alcohol abuse and 7269 for models of parental mental illness. Our analysis was approved by the University of California, Berkeley Committee for the Protection of Human Subjects.

EXPOSURE ASSESSMENT

Assessment of exposure to childhood physical abuse, alcohol abuse and mental illness in the household was determined through participant self-report on questions administered in the 2012 wave of the survey, when participants were between the ages of 47 and 54 years old. All three questions were selected from the Adverse Childhood Experiences questionnaire (5). Physical abuse was assessed by the question, "Before age 18, how often did a parent or adult in your home ever hit, beat, kick or physically harm you in any way? Do not include spanking. Would you say never, once, or more than once?" We recoded this as "yes" if more than once and "no" if never or once. Childhood adversity in the household was measured by two questions: "Before age 18, did you live with anyone who was depressed, mentally ill, or suicidal?" and "Before age 18, did you live with anyone who was a problem drinker or alcoholic?", with responses as "yes" or "no" to each question. In our sample, response to the physical abuse question was moderately associated with the questions assessing alcohol intake in the household ($r=0.28$) and mental illness in the household ($r=0.22$). Mental illness and alcohol intake were also moderately correlated ($r=0.22$).

OUTCOMES

We calculated BMI by dividing self-reported weight by the temporally closest assessment of self-reported height squared, using the survey year in early adulthood (closest to age 25) and midlife (closest to age 40). We examined two different ages since the impacts of the exposures on obesity may differ depending on duration of time since exposure. Since weight and height were self-reported, we used regression-calibration of measures developed from the Third National Health and Nutrition Examination Survey where height and weight are both self-reported and measured to account for bias within strata of race/ethnicity and gender (21). We examined obesity (BMI ≥ 30) at ages 25 and 40 and Class II obesity (BMI ≥ 35) at age 40 only, as Class II obesity at age 25 was rare (fewer than 100 individuals in our analytic sample).

Respondents were asked to self-report their current and past smoking behavior. From these data, we created two variables to capture smoking behaviors: whether an individual had ever smoked (defined as whether they ever responded "yes" to smoking more than 100 cigarettes in their lifetime) and whether an individual was currently smoking daily (based on 2010 self-report).

COVARIATES

Models included the following covariates, all collected by self-report, that based on prior knowledge were potential confounders of the relationships between childhood adverse experience measures and our selected outcomes: race/ethnicity (Hispanic, Black, Asian, and White), maternal education (less than high school or high school diploma), birthplace in the Southern United States, childhood in an urban area, and birthplace outside of the United States.

STATISTICAL MODELS

To investigate the associations between our measures of adverse childhood experiences and obesity and smoking later in life, we used logistic regression. All logistic regression models accounted for survey weights and the complex survey design using the survey package in R (22). All analyses were done using a combined study custom sampling weight and inverse probability of censoring weights to account for study sampling design and differential loss to follow up (23). The treatment/missingness model used in the estimators were based on main terms in the logistic regression model including the covariates described previously. We present odds ratios from the logistic regression models which approximate risk ratios because the odds ratios are close to one and the exposures we examine are not common (24).

In order to examine the extent to which estimates of association may be biased by an individual's self-report, we fit instrumental variable models using a sibling's report of adverse childhood experiences as an instrument for that individual's exposure. For individuals with more than one sibling in the data we used the sibling who was closest in age. We could not use additional sibling reports because of the large number of missing data that would result for individuals with only one sibling. We explain a general background for our motivation for and use of an instrumental variable approach in the Supplemental Material. We use a multiplicative generalized method of moments instrumental variable estimator that has been shown to be more robust to specification error than alternative models and is appropriate for estimating probabilities of dichotomous outcomes (25). The models were implemented using the "ivpois" command in Stata version 11 (26, 27). We had moderate first stage power for physical abuse (F-test=9), and household mental illness (F-test=9). We had substantially greater power for household alcohol abuse, with an F-test statistic of 26.

For findings from our instrumental variable models where the 95% confidence interval did not include the null, we calculated a population attributable fraction using the equation: $[P_{\text{pop}} \times (RR-1)] / [P_{\text{pop}} \times (RR-1) + 1]$ where P_{pop} is proportion of the population with the exposure and RR is the relative risk (here approximated by the odds ratio) calculated from the instrumental variable model.

RESULTS

Table 1 shows the distribution of childhood exposure to physical abuse, household alcohol abuse and household mental illness by demographic characteristics. Percents shown are by row and are specific to each type of adversity. Seventeen percent of women and 13 percent

of men reported physical abuse, 23 percent of women and 16 percent of men reported household alcohol abuse, and 11 percent of women and 5 percent of men reported household mental illness. Individuals who were obese and smoked reported higher levels of physical abuse and parental alcohol abuse.

Table 2 presents the logistic regression estimated odds ratios of association between physical abuse, household alcohol abuse and household mental illness with obesity and smoking outcomes. Physical abuse was associated with significantly higher odds of all three measures of obesity and both smoking outcomes in the total population. After stratifying on gender, physical abuse was significantly associated with obesity at age 25 and both lifetime and current smoking for women, and obesity at age 40 and ever smoking and currently smoking for men. Exposure to household alcohol abuse during childhood was associated with higher odds of ever smoking and currently smoking in the total population, among women, and among men. Household mental illness was associated only with higher odds of ever smoking, in the total population, and among women.

We also tested for association modification ($P < 0.05$, double sided) by gender, maternal education, black and Hispanic (shown in online supplementary tables S2, S3, S4 and S5). We found no association modification by gender. We found some evidence of association modification for maternal education with weaker relationships between household alcohol and obesity at age 40 among households with higher maternal education. Overall, we found only five instances where the P -value < 0.05 among 60 tests of interaction, where three would be expected to be found by chance, suggesting little evidence for association modification of the exposure by gender, race or education.

To address potential recall bias of childhood household exposures, we conducted an instrumental variable analysis in the sub-cohort of sample adults with siblings who were also surveyed ($n=5923$). Table 3 presents estimated odds ratios of exposure to physical abuse, household alcohol abuse and household mental illness among individuals with a sibling, enabling a comparison between coefficients estimated using logistic regression and instrumental variable approaches. In the logistic regression models physical abuse and alcohol abuse were significantly associated with ever smoking and currently smoking and household mental illness was associated with currently smoking. While these results differ from those in Table 2 in terms of statistical significance of associations for physical abuse and obesity, odds ratios are of a similar magnitude and confidence intervals overlap, indicating estimates are not markedly different in this subsample compared to the full sample. Overall, using the instrumental variable approach based on siblings self-report, we find a relationship between exposure to household alcohol consumption and reports in later life of ever smoking and current smoking. Estimated odds ratios for physical abuse and ever or currently smoking were nearly identical between the logistic regression and instrumental variable models.

The estimated population attributable fraction of ever smoking from physical abuse was 17% (95% confidence interval 2.0% to 37%) and for currently smoking was 6.7% (95% confidence interval 1.6% to 12%).

DISCUSSION

We found meaningful associations between three measures of adverse childhood experiences and obesity and smoking in adulthood. These results support prior findings in the literature; however, our study is unique in controlling for potentially confounding regional and socioeconomic variables in a diverse, nationally representative sample of the U.S. population. We found little evidence of association modification by gender, race-ethnicity or early life socioeconomic position. When we applied an instrumental variable approach to address possible self-report bias, the associations between household alcohol consumption and household mental illness in childhood with later life smoking in the logistic regression analysis persisted, suggesting that links of exposure to household alcohol problems during childhood and both current or ever smoking are not due to measurement error that could be caused by reporting bias.

Our results overall are generally consistent with the recent meta-analysis of 41 studies that showed that there was overall an association between a range of adverse childhood experiences and risk of later obesity (6). However, in our sample, findings were specific to the exposure to physical abuse, with little association between household alcohol consumption or household mental illness on obesity. Unlike prior studies, we were also able to show that impacts were generally similar at age 25 and age 40, consistent with the theory that associations with early life environments persist across the life course due to either physiologic changes or patterns of behavior independent of biology (28). In contrast with the literature, our findings showed that there was a greater consistency of association, and greater magnitude of association, between adverse childhood experience with ever or current cigarette smoking as compared to obesity (12).

While our study was the first to validate reports of early childhood adverse environments using an instrumental variable strategy approach, an alternative approach has been to compare retrospective self-report measures with administrative data (18, 29, 30). Generally agreement has been quite low between the two measures, with studies finding a large number of false negatives (18) and kappa values of agreement under 0.4 (30). Our findings for smoking suggest that rather than this lack of agreement being explained by self-report bias, this validation approach can be problematic because such records only capture the most severe instances of abuse (18).

There are important limitations to our study. First, outcomes in our study were self-reported, with the potential for measurement error in both the exposure and outcomes. We do not have comprehensive measures of child adverse experience for example neglect or sexual abuse (6). In addition, our analyses of the association between household alcohol use and smoking may be confounded by the fact that adults in the household who abuse alcohol may be more likely to be smokers, and that may affect their childrens' smoking. In this case, efforts to reduce smoking among the parents may be more impactful than reducing alcohol abuse, as parental smoking is the true underlying cause. Finally, the exposure measures are retrospectively recalled and self-reported at the most recent wave of study when the adult health outcomes had already occurred. The possibility that this potential limitation applies to

our analyses was the basis for our conducting the alternative instrumental variable approach to address measurement error.

The instrumental variable approach has the potential to address two fundamental limitations of the traditional regression approach: unmeasured confounding and measurement error of the exposure variable, but has four fundamental characteristics that must be met for valid inference (31). First, the instrument must be adequately correlated with the exposure variable of interest. Sibling report of physical abuse and sibling report of household mental illness are at the border of adequate power, thus they may not be adequate estimators, even if they are unbiased. A second consideration is the fact that an instrumental variable is not valid if it has any direct effects on the outcome of interest. There is some documentation that witnessing violence toward a sibling results in increased risk of anxiety and depression for an individual (32). A third limitation to the instrumental variable approach is that the identification of effects in the population is dependent on those individuals whose exposure is changed by the instrument. Our particular instrumental variable approach is not likely to have this limitation as we are actually dealing with the same exposure of interest. A final limitation is that there are likely shared confounding factors that determine the response of both the sibling and the subject.

Implications from our findings are clearest for the exposures and outcomes where we have consistent findings between the traditional regression results and the instrumental variable results – that parental alcohol abuse in childhood is associated with higher rates of ever and current smoking in adulthood. Past public health interventions have shown that reducing maternal alcohol exposure impacts a number of child health outcomes (33); our current findings suggest that such interventions may also decrease long term smoking behavior in adulthood, a critical determinant of morbidity and mortality. Our calculations of population attributable fraction are consistent with a meaningful proportion of smoking being caused by early life adversity, and that policies and programs to address smoking cessation should take this potential cause into consideration.

Although we did not obtain statistically significant findings from our instrumental variable models for exposure to household mental illness or physical abuse and adult obesity and smoking, we emphasize that our results do not call in to question any of the current public policy efforts to reduce physical abuse or treat severe mental illness for parents with children in the household. Children should always be safe from violence and neglect.

Given this, our findings should be considered in the following two ways. First, given the body of prior literature, our logistic regression findings, and the similarity of point estimates from the instrumental variable approach, both these childhood exposures should be seriously considered as contributing to later life health issues. Even if future studies do not confirm effects on long-term health, social policy should protect every child from experiencing adverse circumstances. Second, however, given the inconsistent evidence with the instrumental variable findings, there should be additional emphasis on studies that use validation approaches to retrospective recall adverse childhood experiences in order to most accurately determine the magnitude with which these factors contribute to later life obesity and smoking.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

ACKNOWLEDGEMENTS

None.

FUNDING: This research was supported by grant number R01MD006104 from the National Institute on Minority Health and Health Disparities. DHR was supported by grant number K01AG047280 from the National Institute of Aging.

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Table 1

Distribution (Percents) of Physical Abuse, Parental Alcohol and Mental Illness by Demographic Characteristics, Obesity and Smoking

	Physical Abuse		Parent Alcohol		Parent Mental	
	No	Yes	No	Yes	No	Yes
Total	85	15	80	20	92	8
Gender						
Women	83	17	77	23	89	11
Men	87	13	84	16	95	5
Race/ethnicity						
Black	89	11	86	14	96	4
White	84	16	80	20	91	9
Hispanic	83	17	83	17	95	5
Maternal Education						
< High school diploma	84	16	79	21	93	7
High school diploma	85	15	80	20	92	8
> High school diploma	87	13	85	15	90	10
Region at birth						
Northeast	86	14	82	18	92	8
Midwest	85	15	81	19	92	8
South	87	13	83	17	92	8
West	81	19	74	26	92	8
Foreign born						
Yes	79	21	82	18	91	9
No	85	15	81	19	92	8
Urban in childhood						
Yes	85	15	80	20	92	8
No	85	15	82	18	92	8
Obesity						
Age 25 years (Class I)	80	20	79	21	91	9
Age 40 years (Class I)	83	17	81	19	92	8
Age 40 years (Class II)	82	18	78	22	91	9
Smoking						
Ever	82	18	78	22	91	9
Age 40 years	79	21	76	24	92	8
Total Number	6188	1078	5936	1340	6756	513

Table Notes: Percents are by row and separately by type of adversity. All percents are calculated using survey weights. Total numbers are actual number of individuals with and without exposure.

Table 2

Logistic Regression Estimated Associations Between Physical Abuse, Household Alcohol Abuse and Household Mental Illness Among Individuals, National Longitudinal Survey of Youth 1979, 1979-2012.

	Physical Abuse		Household Alcohol		Household Mental	
Total	OR	95% CI	OR	95% CI	OR	95% CI
Obesity age 25	1.56	1.20, 2.02	1.11	0.88, 1.39	1.09	0.74, 1.61
Obesity age 40	1.23	1.03, 1.48	1.04	0.88, 1.23	1.01	0.78, 1.31
Obesity II age 40	1.33	1.04, 1.70	1.17	0.93, 1.48	1.20	0.84, 1.70
Smoking, Ever	1.83	1.52, 2.21	1.53	1.28, 1.83	1.29	1.02, 1.64
Smoking, Current	1.69	1.40, 2.05	1.49	1.24, 1.79	1.12	0.87, 1.45
Women						
Obesity age 25	1.87	1.30, 2.69	1.21	0.90, 1.62	1.09	0.69, 1.74
Obesity age 40	1.18	0.92, 1.52	1.09	0.86, 1.37	1.03	0.75, 1.39
Obesity II age 40	1.33	0.99, 1.80	1.20	0.92, 1.55	1.21	0.79, 1.85
Smoking, Ever	2.01	1.59, 2.53	1.67	1.34, 2.09	1.37	1.05, 1.80
Smoking, Current	1.68	1.29, 2.19	1.34	1.02, 1.76	1.10	0.81, 1.51
Men						
Obesity age 25	1.21	0.82, 1.80	0.97	0.65, 1.46	1.14	0.56, 2.33
Obesity age 40	1.31	1.00, 1.73	0.97	0.77, 1.22	1.00	0.62, 1.60
Obesity II age 40	1.35	0.87, 2.09	1.12	0.76, 1.66	1.19	0.58, 2.43
Smoking, Ever	1.64	1.23, 2.19	1.37	1.07, 1.75	1.14	0.76, 1.69
Smoking, Current	1.73	1.28, 2.33	1.71	1.29, 2.27	1.14	0.71, 1.83

Note: Sample size for models for the total population are n=7266 for Physical Abuse, n=7276 for Household Alcohol abuse and n=7269 for Household Mental illness. Odds ratios are calculated from weighted logistic regression models.

Table 3

Logistic Regression and Instrumental Variable Estimated Associations Between Physical Abuse, Household Alcohol Abuse and Household Mental Illness Among Individuals With a Sibling (n=5923), National Longitudinal Survey of Youth 1979, 1979-2010.

	Physical Abuse		Household Alcohol		Household Mental	
	OR	95% CI	OR	95% CI	OR	95% CI
Logistic regression						
Obesity age 25	1.43	0.91, 2.26	1.02	0.71, 1.45	0.92	0.44, 1.95
Obesity age 40	1.08	0.76, 1.53	0.96	0.72, 1.27	0.72	0.46, 1.14
Obesity II age 40	1.13	0.72, 1.79	1.09	0.77, 1.56	0.89	0.49, 1.60
Smoking, Ever	1.65	1.20, 2.26	1.51	1.14, 1.99	1.41	0.83, 2.38
Smoking, Current	1.84	1.30, 2.60	1.41	1.05, 1.89	1.67	1.01, 2.75
Instrumental Variable	OR	95% CI	OR	95% CI	OR	95% CI
Obesity age 25	0.76	0.10, 5.50	0.69	0.35, 1.36	0.34	0.09, 1.21
Obesity age 40	1.39	0.69, 2.79	0.77	0.56, 1.07	0.45	0.13, 1.53
Obesity II age 40	1.59	0.46, 5.50	0.83	0.52, 1.33	ID	
Smoking, Ever	1.63	0.95, 2.80	1.36	1.08, 1.71	2.90	0.31, 2.73
Smoking, Current	1.84	0.31, 10.90	2.01	1.01, 3.98	ID	

Table notes: ID indicates insufficient data to estimate the coefficient. Instrumental variable 95% confidence intervals did not account for the primary sampling unit clustering of the sample.