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The impact of adverse childhood experiences on health problems: evidence from four birth cohorts dating back to 1900

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Abstract

Background. We examined the relationship of the number of adverse childhood experiences (ACE score) to six health problems among four successive birth cohorts dating back to 1900 to assess the strength and consistency of these relationships in face of secular influences the 20th century brought in changing health behaviors and conditions. We hypothesized that the ACE score/health problem relationship would be relatively "immune" to secular influences, in support of recent studies documenting the negative neurobiologic effects of childhood stressors on the developing brain.

Methods. A retrospective cohort study of 17,337 adult health maintenance organization (HMO) members who completed a survey about childhood abuse and household dysfunction, as well as their health. We used logistic regression to examine the relationships between ACE score and six health problems (depressed affect, suicide attempts, multiple sexual partners, sexually transmitted diseases, smoking, and alcoholism) across four successive birth cohorts: 1900–1931, 1932–1946, 1947–1961, and 1962–1978.

Results. The ACE score increased the risk for each health problem in a consistent, strong, and graded manner across four birth cohorts ($P < 0.05$). For each unit increase in the ACE score (range: 0–8), the adjusted odds ratios (ORs) for depressed affect, STDs, and multiple sexual partners were increased within a narrow range (ORs: 1.2–1.3 per unit increase) for each of the birth cohorts; the increase in risk for suicide attempts was stronger but also in a narrow range (ORs: 1.5–1.7).

Conclusions. Growing up with ACEs increased the risk of numerous health behaviors and outcomes for 20th century birth cohorts, suggesting that the effects of ACEs on the risk of various health problems are unaffected by social or secular changes. Research showing detrimental and lasting neurobiologic effects of child abuse on the developing brain provides a plausible explanation for the consistency and dose–response relationships found for each health problem across birth cohorts, despite changing secular influences.

Keywords: Childhood abuse; Household dysfunction; Health behaviors; Secular trends

Over the past century, advances in medicine and public health reduced morbidity and increased life expectancy in the United States [1,2]. In the early half of the 1900s, infectious diseases such as tuberculosis and pneumonia were the leading causes of death; currently, chronic diseases account for the majority of deaths in the United States [3]. From about 1950 to the present, research about health behaviors, which are risk factors for multiple types of chronic diseases, and many infectious diseases that are currently public health problems [2,4–7] has proliferated. Although these efforts have provided vast information on lifestyle and behavioral risk factors for disease, the *underlying* determinants of such risk factors and lifestyles remain poorly understood. For example, most persons are aware that smoking causes lung cancer and heart disease, but why do some people become smokers and what explains differences in ability to quit [8]?

An expanding body of research suggests that childhood abuse can lead to a variety of negative health outcomes and behaviors, such as substance abuse, suicidal behaviors, and

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depressive disorders [9–17]. The Adverse Childhood Experiences (ACE) Study is a large-scale epidemiological study that assesses the impact of various forms of childhood abuse and household dysfunction on a wide variety of health behaviors and outcomes from adolescence to adulthood. Because these types of experiences rarely occur in isolation and are highly interrelated [18,19] the ACE Study uses a cumulative stressor model to assess the relationship between the total number of these childhood exposure (ACE score) and various health outcomes. Recent publications from this study have repeatedly shown a strong, graded relationship between the ACE score and high-priority health and social problems such as smoking [19], unintended pregnancies [20], sexually transmitted diseases [21], male involvement in teen pregnancy [22], adult alcohol problems [23,24], attempted suicides [25], illicit drug use [26], and leading causes of death in the United States [18].

Many health behaviors and outcomes that are important in medicine and public health and that have been a focus of the ACE Study have been influenced by secular, social, and/or economic changes, as well as evolving medical and public health initiatives to alter them. For instance, certain psychiatric disorders have increased in prevalence over the past several decades [27–30]; suicides and suicide attempts have increased among younger cohorts [30,31] as is the case when examined cross-culturally [32]. Economic [30,32] and societal influences [28], as well as campaigns to increase screening for depressive disorders [33] have been postulated as reasons for these secular trends.

Sexual behaviors have also changed due to social influences [34]. Over the past several decades a trend for younger age at first intercourse [34,35], later age for first marriage [34,36], and higher rates of divorce [36,37] have emerged. These trends likely contributed to increases in the number of sexual partners over a lifetime as well as the increased risk for STDs, especially among adolescents [34,36].

The prevalence of alcohol and tobacco use have changed considerably over the past century [38]. For example, the NLAES study also found that alcohol use in early adulthood (ages 20 through 24) was less than 50% for those born between 1894 and 1937 (pre-World War II), whereas it was 75% for those born between 1968 and 1974 (Vietnam War era) [39]. Trends in cigarette smoking are among the most notable of these secular influences, due to factors such as changing attitudes about the social desirability of smoking, sales taxes, and the dissemination of information about their health effects. Per capita cigarette consumption in the United States was very low from 1900 untill 1917, peaked in 1960, and has declined significantly since the Surgeon General's report in 1964 [40,41].

In this study we examine the graded relationship between the ACE score and six health problems among four successive birth cohorts dating back to 1900 to assess the strength and consistency of this relationship in the face of powerful secular influences. Because of recent studies documenting the negative and lasting neurobiologic effects of childhood trauma/stressors on the developing brain [42,43] we hypothesized that the ACE score/health problem relationship would be resistant or "immune" to secular influences, such as changing social attitudes and the dissemination of health information that primarily exert their influence on adolescents and adults. Specifically, we assessed the strength and consistency of the relationships between the ACE score and depressed affect, suicide attempts, multiple sexual partners, sexually transmitted diseases smoking, and alcoholism for the following successive birth cohorts: 1900–1931, 1932–1946, 1947–1961, and 1962–1978. We reasoned that if the ACE score increased the risk for each of these health problems across birth cohorts in a consistent and graded manner, this would suggest that these types of childhood experiences exert an effect irrespective of the social, economic, political, and secular influences specific to the era in which these persons were born and raised.

Methods

The ACE Study is a collaboration between Kaiser Permanente's Health Appraisal Center (HAC) in San Diego, California, and the U.S. Centers for Disease Control and Prevention. The ACE Study was approved by the institutional review boards of Kaiser Permanente, Emory University, and the U.S. Department of Health and Human Services. Potential participants were sent letters that accompanied the ACE Study questionnaire informing them that their participation was voluntary and their answers would held in strictest confidence and would never become part of their medical record.

Study population

The study population was drawn from the HAC, which provides standardized medical, psychosocial, and preventive health evaluations to adult members of Kaiser Health Plan in San Diego County. In any 4-year period, 81% of the adult members obtain this service and over 50,000 members are evaluated yearly. Thus, data from the HAC represents the experiences and health of a majority of adult Kaiser members in San Diego. Additionally, their visit to the HAC is primarily for the purposes of complete health assessments, rather than symptom or illness-based care.

All persons evaluated at the HAC complete a standardized questionnaire, which includes health histories and health-related behaviors, a medical review of systems, and psychosocial evaluations. This information was included in the ACE Study database.

Two weeks after their HAC evaluation, each person who was evaluated at the HAC between August 1995 and March 1996 (wave 1) and June and October 1997 (wave 2) received the ACE Study questionnaire by mail. The questionnaire collected detailed information about ACEs (e.g.,

abuse), household dysfunction (e.g., domestic violence), and health-related behaviors from adolescence to adulthood. Wave 2 respondents were asked detailed questions about health topics than analysis of wave 1 data had shown to be important [18]. The response rate for both survey waves combined was 68%, for a total of 18,175 responses.

We excluded 754 respondents who coincidentally underwent examinations during the time frames for both survey waves. The unduplicated total number of respondents was 17,421. After exclusion of 17 respondents with missing information about race and 67 with missing information about educational attainment, the final study sample included 95% of the respondents (17,337/18,175) (Wave I=8,708, Wave II=8,629).

Assessment of representativeness, and response or reporting bias

In Wave I, the HAC questionnaire data were abstracted for both respondents and *nonrespondents* to the ACE Study questionnaire, enabling a detailed assessment of the representativeness of respondents in terms of demographic characteristics and health-related issues. Results of this analysis have been published elsewhere [44]. Briefly, nonrespondents tended to be younger, less educated, or from racial/ethnic minority groups. After controlling for demographic differences, health behaviors such as smoking, alcohol or drug abuse, and health conditions such as heart disease, hypertension, obesity, and chronic lung disease *did not differ* between respondents and nonrespondents. Thus, there was no evidence that the general health of respondents and nonrespondents differed.

In addition, questions allowed assessment of the strength of the relationship between childhood sexual abuse and health behaviors, diseases, and psychosocial problems; the strength of these relationships was virtually identical for respondents and nonrespondents [44]. Thus, there was no evidence that respondents to the ACE Study questionnaire were biased toward attributing their health problems to childhood experiences such as sexual abuse [44].

Definitions of adverse childhood experiences (ACEs)

Questions used to define ACEs are listed in Table 1. All questions about ACEs pertained to the respondents' first 18 years of life (≤18 years of age). For questions adapted from the Conflict Tactics Scale (CTS) [45] there were five response categories: "never," "once or twice," "sometimes," "often," or "very often." We defined three types of childhood abuse: emotional abuse (two questions), physical abuse (two questions), or contact sexual abuse (four questions) by Wyatt [46]. In addition, we defined five exposures to household dysfunction during childhood: exposure to substance abuse (defined by two questions) [47], mental illness (two questions), violent treatment of mother or stepmother (four questions) [45], criminal behavior in the household (one question), and parental separation or divorce (one question). Respondents were defined as exposed to a category if they responded "yes" to one or more of the questions in that category. The total number of these exposures (range: 0–8) was summed to create the ACE score. Due to small sample sizes, ACE scores of 4 or more were combined into one category (≥4). Thus, analyses were conducted with the summed score as four dichotomous variables (yes/no) with 0 experiences as the referent.

Definition of birth cohorts

The four birth cohort groups were based on respondents' age at entry into the study using 15-year increments, with the exception of the cohort dating from 1900 to 1931. Due to small sample sizes we combined 1900–1915 and 1919–1931. The four cohort groups have been used in prior reports from the ACE Study that examined the associations of the ACE score on male involvement in teen pregnancy and illicit drug use by birth cohort [26,48].

Definition of selected health behaviors and health outcomes

Mental health

Depressed affect. Depressed affect was defined as a "yes" response to the question that was included in both ACE Study survey waves "Have you had or do you now have depression or feel down in the dumps?" We compared the measure of depressed affect to a validated screening tool developed by the Rand Corporation for lifetime prevalence of major depression or dysthymia (which was available for ACE survey Wave I only) [49]. In this comparison (2×2 table), lifetime depressed affect was significantly associated with the validated measure [49] ($X^2 = 1476$, $df = 1$; $P < 0.0001$); the sensitivity, specificity, and predictive value positive for lifetime depressed affect were 83, 60, and 87%, respectively.

Lifetime suicide attempt (ever attempting suicide). Attempted suicide was defined as a "yes" response to the question "Have you ever attempted to commit suicide?" Using data available from Wave II only, the mean number of suicide attempts (standard deviation) was 1.6 (.91); the range was 1–4 times; 75th and 95th percentiles were 2 and 4, respectively. Number of attempts did not differ between men and women or according to the ACE Score.

Sexual health

Multiple sexual partners. Defined as having 30 or more sexual partners over a lifetime.

Sexually transmitted diseases. A "yes" response to the HAC question: "Have you ever been treated for or told you had any venereal disease?"

Table 1
Definition and prevalence of each category of adverse childhood experience and ACE score by sex

Childhood abuse	Women (N = 9,367)	Men (N = 7,970)	Total (N = 17,337)
Emotional	13.1	7.6	10.6
(Did a parent or other adult in the household. . .)			
1. Often or very often swear at you, insult you, or put you down?			
2. Sometimes, often, or very often act in a way that made you that you might be physically hurt?			
Physical	27.0	29.9	28.3
(Did a parent or other adult in the household. . .)			
1. Often or very often push, grab, slap, or throw something at you?			
2. Often or very often hit you so hard that you had marks or were injured?			
Sexual	24.7	16.0	20.7
(Did an adult or person at least 5 years older ever. . .)			
1. Touch or fondle you in a sexual way?			
2. Have you touch their body in a sexual way?			
3. Attempt oral, anal, or vaginal intercourse with you?			
4. Actually have oral, anal, or vaginal intercourse with you?			
Household dysfunction			
Substance abuse	29.5	23.8	26.9
1. Live with anyone who was a problem drinker or alcoholic?			
2. Live with anyone who used street drugs?			
Mental Illness	23.3	14.8	19.4
1. Was a household member depressed or mentally ill?			
2. Did a household member attempt suicide?			
Mother treated violently	13.7	11.5	12.7
(Was your mother (or stepmother)):			
1. Sometimes, often, or very often pushed, grabbed, slapped, or had something thrown at her?			
2. Sometimes, often, or very often kicked, bitten, hit with a fist, or hit with something hard?			
3. Ever repeatedly hit over at least a few minutes?			
4. Ever threatened with or hurt by a knife or gun?			
Incarcerated household member	5.2	4.1	4.7
1. Did a household member go to prison?			
Parental separation or divorce	24.5	21.8	23.3
1. Were your parents ever separated or divorced?			
Number of adverse childhood experiences (ACE Score)			
0	34.5	38.0	36.1
1	24.5	27.9	26.0
2	15.5	16.4	15.9
3	10.3	8.6	9.5
≥4	15.2	9.2	12.5

Substance use and abuse

Ever been a cigarette smoker. The following question defined this behavior: "Have you smoked at least 100 cigarettes in your entire life?" A "yes" response defined ever being a smoker. The median age at initiation for smoking was 18 years for birth cohorts 1900–1931, 1932–1946, and 1947–1961 and 17 years for 1962–1978.

Self-reported alcoholic. A "yes" response to the question "Have you ever considered yourself to be an alcoholic?" defined self-reported alcoholism [47]. "Assessment of the methodological studies indicate that for the general population, self-reports of alcohol use are fairly accurate" [50]. Furthermore, assuring respondents of the confidentiality of their responses (which was part of the ACE Study protocol) and providing responses in a private setting (mail survey in the home for the ACE Study) also enhance the accuracy of self-reported alcohol abuse [50,51]. The prevalence we found for self-reported alcoholism, 6.5%, is similar to previously reported data on alcohol dependence [52].

Statistical analysis

All analyses were conducted using SAS (version 8.2). Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were obtained from multiple logistic regression models that estimated the likelihood of the selected health behavior or outcome with the ACE score stratified by birth cohort. Covariates in all models were included on a priori reasoning rather than using stepwise selection and included age (continuous variable), sex, race, and education (high school diploma, some college, or college graduate versus less than high school). We had no a priori hypotheses about interaction between demographic variables and the ACEs to examine. Using SAS regression diagnostics, we found no evidence of collinearity. In the data that we present herein,

Table 2
Prevalence and adjusted odds ratios[a] for the relationship between the ACE score and mental health variables stratified by birth cohort

	1900–1931			1932–1946			1947–1961			1962–1978		
ACE Score	*N*	%	Odds ratio	*N*	%	Odds ratio	*N*	%	Odds ratio	*N*	%	Odds ratio
						Depressed affect						
0	2625	16.7	1.0 (referent)	1936	17.8	1.0 (referent)	1279	21.6	1.0 (referent)	415	21.6	1.0 (referent)
1	1540	19.2	1.2 (1.1–1.4)	1473	26.3	1.7 (1.4–2.0)	1082	31.3	1.6 (1.3–1.9)	419	27.2	1.3 (1.0–1.8)
2	765	26.9	1.9 (1.6–2.3)	901	36.9	2.7 (2.2–3.2)	776	37.5	2.1 (1.7–2.6)	316	34.4	1.9 (1.4–2.7)
3	356	28.1	2.0 (1.5–2.5)	555	38.9	2.8 (2.3–3.5)	526	45.1	2.7 (2.2–3.4)	213	41.3	2.4 (1.7–3.4)
≥4	302	43.1	3.8 (2.9–4.9)	669	47.5	3.7 (3.1–4.6)	831	51.5	3.5 (2.9–4.3)	358	51.1	3.6 (2.6–5.0)
Total[b]	5588	20.9	1.3 (1.3–1.4)	5534	28.9	1.3 (1.3–1.4)	4494	35.0	1.3 (1.2–1.3)	1721	34.1	1.3 (1.2–1.3)
						Suicide attempts						
0	2625	0.6	1.0 (referent)	1936	1.3	1.0 (referent)	1279	1.2	1.0 (referent)	415	2.2	1.0 (referent)
1	1540	0.9	1.5 (0.8–3.2)	1473	1.8	1.4 (0.8–2.4)	1082	3.1	2.7 (1.5–5.1)	419	4.5	2.1 (0.9–4.7)
2	765	2.0	3.4 (1.7–6.9)	901	4.3	3.2 (1.9–5.4)	776	5.5	4.8 (2.7–8.8)	316	5.1	2.3 (1.0–5.3)
3	356	4.2	7.1 (3.4–14.7)	555	5.6	3.9 (2.3–7.0)	526	3.4	2.8 (1.4–5.7)	213	8.9	4.1 (1.8–9.2)
≥4	302	7.0	10.9 (5.5–21.4)	669	13.8	9.4 (5.9–14.9)	831	14.7	13.2 (7.6–22.8)	358	19.8	10.2 (5.0–20.9)
Total[b]	5588	1.5	1.7 (1.5–1.9)	5534	3.9	1.6 (1.5–1.7)	4494	5.2	1.5 (1.4–1.6)	1721	7.8	1.5 (1.4–1.7)

[a] All odds ratios adjusted for sex, race, education, and age at survey.
[b] Odds ratio in this row represents test for trend ($P < .05$), with ACE score as an ordinal variable.

persons with incomplete information about an ACE were considered not to have had that experience. To assess the potential effect of this assumption, we repeated our analysis after excluding any respondent who had missing information on any ACE and found no substantial difference in the results.

To test for a trend (graded relationship) between the ACE score and the risk of each selected health outcome by birth cohort, we entered ACE score as an ordinal variable into logistic models, with adjustment for the demographic covariates (sex, age, race, and education). We used this test to assess the consistency of the association between the ACE score and each health problem among four birth cohorts by examining for overlapping 95% CIs.

Support for our methodology is found in an epidemiological perspective on cohort analyses as described in Rothman (1998) [53]. Specifically, birth cohort analyses provide a means to examine etiologic hypotheses. Toward the end of the 19th century it was accepted that disease rates could be strongly influenced by events occurring early in life [53]. Thus, we examine how traumatic experiences during childhood, as reported in four consecutive birth cohorts born between 1900 and 1978, affected the risk of various health problems.

Results

Characteristics of study population

The study population included 9367 women (54%) and 7970 men (46%). The mean age (standard deviation) was 56 (15.2) years. Seventy-five percent of participants were white, 39% were college graduates, 36% had some college education, and 18% were high school graduates. Only 7% had not graduated from high school.

Adverse childhood experiences

The prevalence of each individual ACE and of the ACE scores is shown in Table 1. Women were more likely than men to report ACEs, with exception of physical abuse (Table 1). Sixty-four percent of respondents reported at least 1 ACE. We found no substantial difference in prevalence of ACEs between Waves 1 and 2; after adjusting for base age, educational attainment, sex, and race the mean ACE score was 1.5 for both waves.

Risk for health behaviors and outcomes by birth cohort

In Table 2 we present data for mental health outcomes for each of four birth cohorts. As the ACE score increased, there was a graded increase in the likelihood of reporting depressed affect and suicide attempts for all cohorts. Compared to 0 ACEs there was a 4-fold increased likelihood of depressed affect for any of the cohorts that reported 4 or more ACEs ($p < .05$). For suicide attempts there was a 9-fold to 13-fold increase for any of the cohorts if persons had reported 4 or more ACEs compared to persons with no ACEs ($P < .05$).

Similarly, as the ACE score increased, the likelihood of having multiple sexual partners and reporting sexually transmitted diseases increased in a graded manner for all cohorts ($P < .05$) (Table 3). Comparing all cohorts with an ACE score of 4 or more to those who reported no ACE,

Table 3
Prevalence and adjusted odds ratios[a] for the relationship between ACE score and multiple sexual partners and sexually transmitted diseases, stratified by birth cohort

	1900–1931			1932–1946			1947–1961			1962–1978		
ACE Score	*N*	%	Odds ratio	*N*	%	Odds ratio	*N*	%	Odds ratio	*N*	%	Odds ratio
Multiple sexual partners (≥30 over a lifetime)												
0	2625	2.1	1.0 (referent)	1936	4.9	1.0 (referent)	1279	6.3	1.0 (referent)	415	3.6	1.0 (referent)
1	1540	4.4	1.9 (1.3–2.7)	1473	5.4	1.1 (0.8–1.6)	1082	6.8	1.1 (0.8–1.5)	419	3.6	0.9 (0.4–1.9)
2	765	5.9	2.7 (1.8–4.1)	901	8.8	2.0 (1.4–2.7)	776	7.7	1.3 (0.9–1.9)	316	7.0	2.1 (1.1–4.1)
3	356	4.5	2.1 (1.2–3.8)	555	11.2	2.9 (2.1–4.2)	526	9.9	1.9 (1.3–2.8)	213	7.0	2.4 (1.1–5.1)
≥4	302	6.6	3.6 (2.1–6.2)	669	10.0	3.1 (2.2–4.4)	831	14.2	3.7 (2.7–5.0)	358	8.1	2.8 (1.4–5.5)
Total[b]	5588	3.6	1.3 (1.2–1.4)	5534	6.9	1.3 (1.2–1.4)	4494	8.6	1.3 (1.2–1.4)	1721	5.6	1.2 (1.1–1.4)
Sexually transmitted diseases												
0	2625	3.0	1.0(referent)	1936	4.7	1.0(referent)	1279	9.6	1.0 (referent)	415	9.6	1.0 (referent)
1	1540	3.3	1.1 (0.8–1.6)	1473	7.7	1.8 (1.3–2.4)	1082	13.0	1.4 (1.1–1.8)	419	15.0	1.6 (1.1–2.5)
2	765	4.8	1.6 (1.1–2.5)	901	7.4	1.7 (1.2–2.4)	776	15.3	1.7 (1.3–2.2)	316	17.7	2.0 (1.3–3.2)
3	356	5.3	2.0 (1.2–3.3)	555	11.5	2.9 (2.0–4.0)	526	15.8	1.8 (1.3–2.4)	213	25.8	3.3 (2.1–5.2)
≥4	302	8.6	3.4 (2.1–5.5)	669	10.2	2.6 (1.9–3.7)	831	21.9	2.9 (2.2–3.7)	358	22.1	2.7 (1.8–4.1)
Total[b]	5588	3.8	1.3 (1.2–1.4)	5534	7.3	1.2 (1.2–1.3)	4494	14.4	1.2 (1.2–1.3)	1721	17.0	1.2 (1.1–1.3)

[a] All odds ratios adjusted for sex, race, education, and age at survey.
[b] Odds ratio in this row represents test for trend ($P < .05$), with ACE score as an ordinal variable.

there was a three-fold increased likelihood of having a sexually transmitted disease ($P < .05$).

There was a graded increase for each cohort in the likelihood for ever smoking cigarettes and self-reported alcoholism as the ACE score increased (Table 4). In all cohorts of the 20th century, when we compared those with an ACE score of 4 or more to those with no ACE, the adjusted ORs for self-reported alcoholism ranged from 5.1 to 10.9 ($P < .05$).

Statistical test for a trend between ACE score and health outcomes in each birth cohort

We performed a test for trend between the ACE score and each health problem for persons born in each cohort: 1900–1931, 1932–1946, 1947–1961, and 1962–1978. The four ORs for depressed affect were 1.3 for each cohort (Table 2). These results suggest that for every increase in the ACE score the risk of depressed affect increased by

Table 4
Prevalence and adjusted odds ratios[a] for the relationship between substance use/problems and the ACE score, stratified by birth cohort

	1900–1931			1932–1946			1947–1961			1962–1978		
ACE Score	*N*	%	Odds ratio	*N*	%	Odds ratio	*N*	%	Odds ratio	*N*	%	Odds ratio
Ever smoked												
0	2625	49.4	1.0 (referent)	1936	47.3	1.0 (referent)	1279	34.6	1.0 (referent)	415	19.3	1.0 (referent)
1	1540	56.6	1.3 (1.1–1.5)	1473	55.2	1.3 (1.2–1.5)	1082	37.4	1.1 (0.9–1.3)	419	26.5	1.4 (1.1–2.0)
2	765	61.7	1.6 (1.4–1.9)	901	58.9	1.6 (1.3–1.9)	776	45.2	1.6 (1.3–1.9)	316	29.8	1.6 (1.1–2.3)
3	356	61.5	1.7 (1.3–2.2)	555	60.5	1.7 (1.4–2.1)	526	48.9	1.8 (1.5–2.3)	213	40.4	2.7 (1.8–3.9)
≥4	302	68.2	2.4 (1.8–3.1)	669	64.6	2.1 (1.8–2.6)	831	56.1	2.6 (2.2–3.2)	358	46.4	3.1 (2.2–4.4)
Total[b]	5588	54.9	1.2 (1.2–1.3)	5534	54.7	1.2 (1.1–1.2)	4494	42.8	1.2 (1.2–1.3)	1721	31.2	1.3 (1.2–1.3)
Alcoholism												
0	2625	2.0	1.0 (referent)	1936	3.1	1.0 (referent)	1279	3.1	1.0 (referent)	415	1.2	1.0 (referent)
1	1540	3.7	1.8 (1.2–2.6)	1473	5.9	1.9 (1.4–2.7)	1082	6.3	2.0 (1.3–3.0)	419	4.1	3.1 (1.2–8.8)
2	765	4.8	2.4 (1.5–3.6)	901	9.7	3.3 (2.4–4.7)	776	8.6	2.8 (1.9–4.2)	316	4.4	3.5 (1.2–9.9)
3	356	7.6	4.0 (2.5–6.5)	555	11.5	4.3 (2.9–6.1)	526	12.9	4.5 (3.0–6.9)	213	7.0	6.0 (2.1–17.0)
≥4	302	13.9	5.1 (3.1–8.3)	669	16.4	7.0 (5.0–9.9)	831	17.6	7.3 (5.0–10.6)	358	12.9	10.9 (4.2–28.1)
Total[b]	5588	3.6	1.5 (1.3–1.6)	5534	7.4	1.5 (1.4–1.5)	4494	8.7	1.4 (1.3–1.5)	1721	5.6	1.4 (1.3–1.6)

[a] All odds ratios adjusted for sex, race, education, and age at survey.
[b] Odds ratio in this row represents test for trend, with ACE score as an ordinal variable.

30%. For suicide attempts, the ordinal ORs were 1.5 to 1.7; the risk of suicide attempts increased by 50–70% for every unit increase in the ACE score.

For multiple sexual partners and sexually transmitted diseases the ordinal ORs for the test for trend was between 1.2 and 1.3; a 20 to 30% increased likelihood for these two outcomes exists for every increase in the ACE score, in all four birth cohorts (Table 3).

The test for trend showed a 20–30% increased risk for smoking and a 40–50% increased risk for self-reported alcoholism when examining all cohorts (Table 4).

There was no significant difference in the ordinal ORs between each of the four birth cohorts for any of the health problems that we examined. Thus, the test for trend assessed the strength of the relationship between the ACE score and health problems for each birth cohort; the overlapping 95% CIs indicated that there was no meaningful difference in these relationships according to birth cohort.

Discussion

The risk of depressed affect, suicide attempts, multiple sexual partners, sexually transmitted diseases, ever smoking cigarettes, and alcoholism increased in a graded manner as the ACE score increased in each of four successive birth cohorts from 1900 to 1978. Furthermore, the strength of these graded relationships did not differ substantially or in a statistically significant manner *between* successive birth cohorts. The difference in the overall prevalence for health behaviors observed in each birth cohort is consistent with varied secular influences. However, the focus of the present analyses was to examine how increasing ACE scores affect the risk (adjusted OR) of these behaviors within successive birth cohorts. The remarkably consistent relationships between the ACE score and the risk of a variety of health behaviors and outcomes suggest that the mechanisms by which these stressful experiences exert their effect are resistant to, or unaffected by, the many and changing influences on health and behavior such as those that occurred throughout the 20th century.

The graded or "dose–response" relationship between the burden of ACEs and the risk of the six health outcomes for successive birth cohorts dating back to 1900 is consistent with emerging information about the neurobiological effects of early traumatic experiences on the developing brain of infants and young children. Neurological development during early childhood is the foundation on which experiences, positive or negative, are organized and processed. Home and family environments and the characteristics of the parents and persons to whom children are exposed are powerful determinants of emotional, behavioral, cognitive, social, and physiologic functioning later in life [42,43]. Specifically, child abuse and neglect can adversely affect the developing brain in ways that result in emotional, social, and cognitive impairments, increasing the risk for substance abuse, depression, suicide, and a variety of other problems [54–57]. Thus, the strong association in successive 20th century birth cohorts between the ACE score and the six health outcomes offers compelling evidence that the impact of ACEs on multiple types of health problems is a *consistent phenomenon* that may have its roots in the inherent biologic effects of traumatic stressors (ACEs) on the developing nervous system of children.

Physiological and anatomical changes in the brains of individuals who experienced childhood abuse are progressively being documented and provide biological plausibility for our findings. For example, Teicher et al. conducted electroencephalograms (EEGs) to measure limbic irritability [58] and found the percentage of clinically significant brain-wave abnormalities to be higher among individuals who had a history of early trauma versus those who did not experience early trauma [58]. Magnetic resonance imaging (MRI) has revealed reductions in hippocampal volumes among severely sexually abused women and reductions in the intracranial and cerebral volumes among maltreated children compared to nonabused individuals [59,60]. Although the effects cannot be defined to any specific area of the brain, it has been shown that the limbic system, which is responsible for emotional response, is adversely affected. Studies such as these document the anatomic and functional neurological changes among persons who experienced one or more forms of abuse compared to nonabused individuals [54,58–60]. Because ACEs rarely occur in isolation [18,19], the cumulative effect of multiple ACEs likely has an even more powerful negative effect on a young child's developing brain via repeated and/or chronic activation of the stress response. We speculate that in this scenario, the inherent human stress response [61] and effects of the adrenal release of catecholamines and corticosteroids on developing neurons and neural networks may provide a biological explanation for these findings.

Other explanations for the strong and consistent relationships found between adverse childhood experiences and multiple health problems across birth cohorts may be that childhood abuse and neglect result in negative psychological and social consequences. For example, abuse and neglect in childhood were shown to be associated with poor self-esteem, conflicted relationships, and severe life events in adulthood, in turn, acting as risk factors for depression and other adverse health consequences [62].

There are several potential limitations with retrospective reporting of childhood experiences and self- reporting of the outcome measures. In both cases, underreporting of ACEs and the health outcomes may have occurred. For example, respondents may have difficulty recalling certain events or may choose not to disclose health-related behaviors. Longitudinal follow-up of adults whose childhood abuse was documented has shown that their retrospective reports of childhood abuse are likely to *underestimate* actual occurrence [63,64]. Difficulty recalling childhood events likely results in misclassification (classifying persons truly ex-

posed to ACEs as unexposed) that would bias our results toward the null [52]. Thus, this potential weakness probably resulted in underestimates of the true strength of the relationships between ACEs and the six outcomes we examined.

Our data cannot provide certainty about the temporal relationship between the exposure (ACEs) and the six health outcomes studied. For some respondents it is possible that the outcomes may have occurred before the ACEs. However, the majority of suicide attempts (68%) occurred during adulthood [25]. Alcoholism typically takes multiple years to become fully manifest [65]. Cumulating 30 or more sexual intercourse partners would likely require multiple years of sexual activity. Our assessment of depressed affect included a lifetime history, which makes it likely that most reports included problems with depressive disorders during adulthood. Based on the finding presented, future studies may be able to build on the knowledge about depressed affect by including detailed instruments that focus on the assessment of affective symptoms in adulthood. Finally, the median age of onset of smoking was in the late teens for all birth cohorts, making it likely that ACEs antedated the initiation of smoking for most respondents. Thus, for the six health outcomes studied it is likely that the ACEs occurred before the onset of the health problems.

The prevalence of childhood exposures we report is nearly identical to those reported in surveys of the general population. We found that 16% of the men and 25% of the women met the case definition for contact sexual abuse; a national telephone survey of adults in 1990 conducted by Finkelhor et al. using similar criteria estimated that 16% of men and 27% of women and had been sexually abused [66]. As for physical abuse, 28% of the men from our study had experienced this as boys, which closely parallels the percentage found (31%) in a recent population-based study of Ontario men that used questions from the same scales [67]. The similarity of the estimates from the ACE study to those of population-based studies suggests that our findings are likely to be applicable in other settings.

Our data offers compelling evidence that behaviors known to increase the risk of chronic diseases have had their origins in childhood regardless of the changing influences of the 20th century. Recent findings from the neurosciences provide biologic plausibility for both the “dose–response” relationship of the ACE score to health outcomes and the apparent “immunity” of this relationship to powerful and varied secular influences on health and behavior. Studies that have shown the social and psychological consequences due to the effects of early adverse experience also support our findings. This information challenges the disciplines of medicine and public health to address both the primary prevention and secondary prevention of ACEs in the 21st century. Primary prevention of child abuse using early life family-based intervention has shown promise [68]. Because these experiences are common, early detection and intervention may be an effective means in preventing or mitigating the myriad sequelae of ACEs. Furthermore, educating health care providers about the long-term effects of early stressful or traumatic childhood experiences on adolescents and adults may increase their ability to help patients recover from the effects of these childhood experiences.

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