Original Research

Adverse Childhood Experiences as Predictors of Perceived Health: Assessing the ACE Pyramid Model Using Multiple-Mediation

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Abstract

Background

Adverse Childhood Experiences (ACEs) have been shown to contribute to a litany of mental and physical health problems, including several chronic diseases and death, via a model known as the ACE pyramid. Many of the results of ACEs in the ACE pyramid are known contributors to poor perceived health, which has significant health implications. Despite these results, a possible link between ACEs and perceived health has not been examined to date. Based on the temporal order of the ACE pyramid, we believe any relationship between ACEs and perceived health will be mediated by other components of the model.

Methods

We conducted an analysis of the 2010 Behavioral Risk Factor Surveillance System (BRFSS) data for 4 states (Hawaii, Nevada, Vermont and Wisconsin).The Adverse Childhood Experiences Scale (11 questions) and Physical Health Days (days out of the last 30 where physical health was not good) were the primary predictor and outcome variables, respectively. The PHQ-8, a depression measure, served as a first-level mediator, while body mass index, Sleep Days (days out of the last 30 that sleep was poor) and average monthly alcohol consumption served as second-level mediators. We conducted a multiply-mediated regression using PROCESS (Hayes, 2018).

Results

The analysis included 6,060 respondents. ACEs were associated with an increase of 0.28 additional days of poor perceived health days per ACE through increases in depression and poor sleep.

Conclusions

Adverse childhood experiences may influence perceived health through multiple intermediary factors, including depression and poor sleep quality. We discuss several theoretical and clinical implications, and future directions are proposed that take advantage of the multiply-mediated model.

Keywords

adverse childhood experiences; perceived health; depression; mediation; sociological factors; child abuse; domestic violence; health behavior; psychological stress

Introduction

Adverse Childhood Experiences (ACEs) refer to distressing, often traumatic, events that could happen in a child's life, such as physical, sexual and emotional abuse, neglect and family environment factors, such as domestic abuse and divorce.[1] Unfortunately, ACEs are not an uncommon phenomenon. The 2016 National Survey of Children's Health found that 45% of children have experienced at least one ACE, while 20% of children have experienced two or more.[2] Children who experience one or more ACE are at risk for a variety of negative health outcomes.[1,3–5]

The ACE Pyramid

The ACE pyramid, originally proposed in 1998, is a theoretical model that demonstrates the path by which the health of a child who has experienced ACEs may be significantly diminished.[1] The model proposes that ACEs lead to the development of biopsychosocial abnormalities, which increase the likelihood of health risk behaviors, contributing to the onset of chronic disease and ultimately culminating in death.[1] In the time since the initial ACE study, much work has been done to examine and support the stages of the ACE pyramid. Regarding psychosocial abnormalities, ACEs have been linked with an increased risk of coincident and future depression and suicide.[6–12] The lasting effects of ACEs can later be seen through the development of risky health behaviors, including the use of alcohol, tobacco and illicit substances, such as prescription opioids.[7,11,13,14] Other health risk factors, including poor sleep and an unhealthy body mass index (BMI), have been linked to ACEs as well.[15–18] Finally, ACEs have been linked to countless chronic health conditions, such as autoimmune disease, heart disease, liver disease and cancer.[19–22] In total, the existing literature provides ample evidence to support the ACE pyramid as a theoretical model and to demonstrate that ACEs affect a wide range of mental and physical health outcomes. However, no study to date has examined the impact of ACEs on perceived health.

ACEs and Perceived Health

Perceived physical health refers to an individual's thoughts regarding their own health. While understandably associated with objective health, perceived health is distinct in that it is a subjective experience that can differ from measures of objective health. Some studies suggest that objective health may not even be the primary determinant of perceived health, with other factors such as life satisfaction, spirituality and close relationships playing a larger role in determining perceived health.[23–25] Perceived health is also associated with mortality independently from objective health, as patients who perceive their health as being poor experience health declines faster than their peers who are of similar objective health.[23,26,27] For example, studies have shown that the impact of poor perceived health has a substantial impact on survival rates for cancer patients.[28] This influence on survival lends itself to including

poor perceived health in the ACE pyramid model, as the capstone for the pyramid is death.[1] While the traditional focus of the ACE pyramid has been on the chronic health conditions that directly contribute to mortality, it stands to reason that a factor shown to have a pronounced impact on mortality beyond chronic illness may also be an important component of the ACE pyramid model. Furthermore, many of the factors that are commonly included as early outcomes in the ACE pyramid are associated with increases in poor perceived health. There is an established link between depression and poor perceived physical health.[25,29,30] Other studies have shown that poor perceived health is associated with poor sleep,[31–33] excess alcohol consumption[34–36] and BMI.[24,37,38] With many of the very risk factors that ACEs increase also being associated with poor perceived health, it reasons then that ACEs may indirectly contribute to poor perceived health as mediated by those factors.

Multiple-Mediation Model

When examining the ACE pyramid and the effects of ACEs on health outcomes, much of the work conducted has been done using a single-mediation model.[39,40] While more thorough than a non-mediational model, the use of a single mediation pathway fails to account for the complexity involved in the intersection of biological and psychological phenomena. Using a single-mediation does not provide sufficient explanation of the underlying mechanisms of the ACE pyramid model as it was proposed as a single-mediation collapses several of the model's casual layers into one, reducing the depth of knowledge gained from the study. We propose that the unique levels of the ACE pyramid, when available, should be used as additional mediation levels in order to capture the nature of the phenomena in question more fully.

This Study

The ACE pyramid conceptually outlines how ACEs contribute to depression, health risk behaviors and chronic disease. We aim to expand this theoretical model to include a psychological component of health by examining the association between the ACE pyramid model and perceived health. Previous work on ACEs has only used single-mediated models primarily aimed at assessing the effects of ACEs on
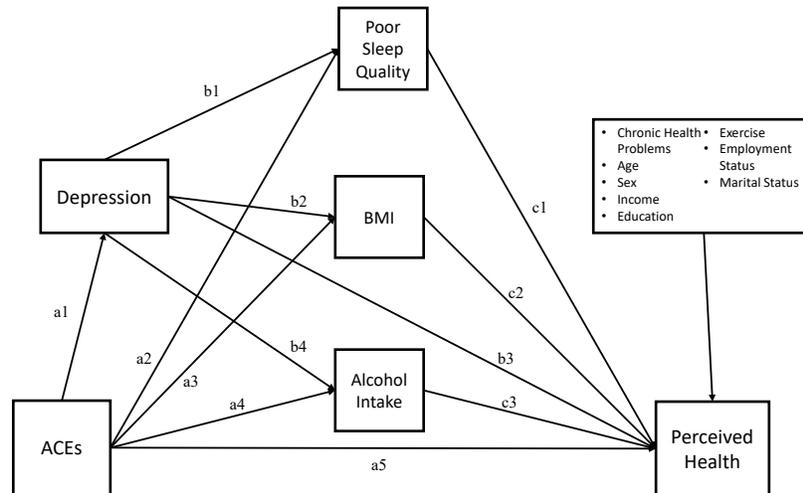
Figure 1. Theoretical Multiple-Mediation Model for Poor Perceived Physical Health. Proposed theoretical model linking Adverse Childhood Experiences to Perceived Health. Paths can be combined to describe mediating paths. For example, ACEs to BMI (Path a3) and BMI to Perceived Health (c2) shows ACEs' effect on Perceived Health through Path a3c2.

chronic health problems. The current study examines the ACE pyramid model with a multiple-mediation model to further expand the understanding of the wide-reaching influences of ACEs. (**Figure 1**) Specifically, we expect that ACEs will be indirectly associated with an increase in poor perceived health as mediated by depression and health-related risk factors.

Methods

Participants and the Procedure
Data from the 2010 Behavioral Risk Factor Surveillance Survey (BRFSS) was used, as this was the most recent year in which questions relating to both ACEs and depression were included. The BRFSS is an annual telephone survey conducted by the CDC designed to be representative of the United States population.[41] The BRFSS includes core health questions administered to every participant, as well as optional modules on a per-state basis.[41] The modules assessing ACEs and depression are both optional modules, and were last administered together in the 2010 BRFSS across four states (Hawaii, Nevada, Vermont and Wisconsin). As a result, data for this study was limited to those 4 states (Possible n = 6,081, 62% female).

Measures
The Adverse Childhood Experiences Scale was used as a measure of challenges during childhood.[41] The ACEs Scale consists of 11 questions related to the 8 ACEs defined in the original

ACE study.[1,41] While there are various validated methods that can be used to score and subscale the ACEs Scale,[1,21] we have opted to use the entirety of the scale as a 1-factor "child maltreatment" scale as demonstrated by Ford and colleagues.[42] The reliability of the ACEs Scale was good (Cronbach's α = 0.78).

Perceived poor physical health (PPPH) was assessed by a single-item from the Healthy Days portion of the HRQOL-4:[41,43] "Now thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good?" While perceived health is commonly assessed on a likert-type question, such as "How would you rate your health?", a review by the CDC found that the HRQOL-4's Physical Healthy Days had strong construct validity as a measure of perceived health, as well as offering several advantages over the more traditional likert-type question.[43]

Depression was assessed via the Patient Health Questionnaire-8 (PHQ-8), which is an 8-question screening tool that has been repeatedly validated and is derived from the PHQ-9 frequently used in clinical settings.[44] Questions are scored from 0 to 14, indicating the number of days out of the last 2 weeks the participant has experienced each of the 8 symptoms, resulting in a score ranging from 0 to 112 symptom days. The reliability of the PHQ-8 was good (Cronbach's α = 0.86).

The remaining mediating variables were assessed with single-item measures. Sleep quality was measured by the question, "How many days did you not get enough sleep in the past 30 days?"[41] BMI is a calculated variable in the BRFSS derived from self-reported height and weight. Average monthly alcohol consumption was assessed with the question, "During the last 30 days, on days when you drank, about how many drinks did you drink on average?"[41]

In addition to our primary measurers, several covariates were included to account for known health risk factors. The covariates included age, income, education, sex, exercise, employment and marital status, all of which were categorical with the exception of age (continuous) and sex (binary). Additionally, a cumulative measure of chronic health problems was included to account for several indicators of objective poor health, including diabetes, heart attack, heart disease, stroke and current asthma as reported to the patient by their doctor. Objective health measures were included as a covariate as a means to further isolate the impact of ACEs on the perception of health rather than the existence of health conditions.

Statistical Analysis

As a preliminary analysis, we conducted bivariate correlations between ACEs, depression, sleep quality, BMI, alcohol consumption, chronic health problems and perceived poor physical health (PPPH). Out of the total sample of 6,081, 21 participants were excluded from the main analysis due to missing data (Final n= 6,060, 0.5% missing). For the main analysis, we analyzed a multiple mediation model using the PROCESS v3 macro in SAS 9.4 under the current assumptions for mediation.[45–47] As we used observational data without a pre-existing temporal relationship between the variables, we selected the direction of the proposed paths in the model based on the theoretical flow of the ACE pyramid.[1] The PROCESS v3 procedure uses bootstrapping (k= 5,000) to create 95% confidence intervals for the estimated indirect effects as a measure of significance instead of the Sobel test, as is recommended in current mediation literature.[45–47] Finally, in preparation for our OLS regression-based analyses, we conducted an assessment of multicollinearity that revealed no multicollinearity concerns between

the variables and covariates based on all variance inflation factors (VIFs) being below 2.5.

Results

Participants ranged in age from 18–99 (M = 56.3, SD = 16.05). The sample was primarily White (72.4%) with 3.5% Black, 7.8% Multiracial, 3.85% Hispanic and 11.6% other. The mean ACE score was 2.0 (SD = 2.29). For all descriptive statistics, see **Table 1**. In our preliminary analysis of correlations, ACEs were associated with increases in all mediating variables ($p < 0.0001$) as well as increases in PPPH ($r = 0.08$, $p < 0.0001$). Additionally, almost all mediating variables were associated with increases in PPPH (**Table 2**) with alcohol consumption being the only exception; it was associated with a decrease in PPPH ($r = -0.08$, $p < 0.0001$). All covariates were significantly correlated with the outcome measure ($p < 0.05$) and were, therefore, included in the final model.

In the main analysis, the number of ACEs experienced were significantly associated with increases in depression scores (Path a1 = 2.5, $p < 0.0001$), BMI (Path a3 = 0.13, $p = 0.0009$) and alcohol consumption (Path a4 = 0.05, $p = 0.0002$). However, the number of ACEs experienced were not related to poor sleep (path a2, $p = 0.59$). The first mediator, the depression score, was associated with increases in both poor sleep (Path b1 = 0.24, $p < 0.0001$) and BMI (Path b2 = 0.02, $p < 0.0001$), but it was not related to alcohol consumption (Path b3, $p = 0.61$).

The multiple-mediation model for PPPH was significant ($F_{16,6043} = 129.4$, $p < 0.0001$) and accounted for 26% of the variance in PPPH. The direct effect of ACEs on PPPH was not significant (Path a5 = 0.026, $p = 0.66$). However, the total indirect effect of ACEs was significantly associated with an increase in PPPH (Total Indirect Effect = 0.28, 95%CI = 0.238–0.333) via 2 mediation paths (**Figure 2**). For the first mediation path, ACEs were associated with an increase in depression score, which were then associated with an increase in PPPH (Path a1b3 = 0.24, 95%CI = 0.200–0.293). In the second path, the significant ACEs-depression path was associated with an increase in poor sleep, which was then associated with an increase

Table 1. Descriptive Statistics of Primary Variables and Demographics

	N= 6,081
Primary Variables, Mean (SD)	
Poor Perceived Health	10.75 (10.83)
ACEs	2.01 (2.29)
Depression	19.78 (23.01)
Sleep Quality	9.64 (10.69)
BMI	27.95 (6.52)
Alcohol Intake*	1.12 (1.99)
Age, Mean (SD)	56.28 (16.1)
Sex = Female, N (%)	3770, (62.0)
Chronic Health Problems, Mean (SD)	0.37 (0.69)
Race/Ethnicity, N (%)	
White	4,403 (72.4)
Black	210 (3.5)
Other	704 (11.6)
Multiracial	474 (7.8)
Hispanic	234 (3.9)
Education Level, N (%)	
Education < HS	419 (6.9)
Education > HS	5,662 (93.1)
Monthly Exercise, N (%)	
Yes	4,394 (72.3)
No	1,687 (27.77)
Income, N (%)	
Income < 35K	1,738 (28.6)
Income ≥ 35K	4,343 (71.4)
Employment Status**, N (%)	
Employed	3,278 (54.0)
Unemployed	1,053 (17.34)
Retired	1,740 (28.66)
Marital Status***, N (%)	
Married	3,244 (53.42)
Previously Married	1,795 (29.56)
Single/Never Married	847 (13.95)
Currently Dating	187 (3.08)

*For Alcohol Intake, N = 6,077
**For Employment Status, N = 6,071
***For Marital Status, N= 6,073

Table 2. Bivariate Correlations Between Primary Variables

	ACE	Depression	Sleep Quality	BMI	Alcohol Intake	Perceived Health
ACE Scale	1					
Depression	0.34***	1				
Sleep Quality	0.20***	0.52***	1			
BMI	0.08***	0.13***	0.12***	1		
Alcohol Intake	0.08***	0.01	0.02	-0.02	1	
Perceived Health	0.08***	0.35***	0.20***	0.09***	-0.08***	1

Note: *p < 0.05 **p < 0.001, ***p < 0 .0001, ACE= Adverse Childhood Experience Scale

in PPPH (Path a1b1c1 = 0.049, 95% CI= 0.032–0.067). Additionally, ACEs were also indirectly associated with a decrease in PPPH mediated by alcohol consumption (Path a4c3 = -0.007, 95% CI = -0.013–−.0002). (**Table 3**)

Discussion

This study aimed to support and expand upon the ACE pyramid model by demonstrating that ACEs exhibit a multiply-mediated association with perceived physical health. We found that ACEs were indirectly associated with poor perceived health via associated increases in the depression score followed by an associated increased in poor sleep. The lack of a significant direct association between ACEs and poor perceived health suggests that this association is fully mediated, which is consistent with the ACE pyramid model.[1] While it is plausible that ACEs could have directly altered an individuals' later perceptions, the implication of mediation allows for a more gradual, natural progression from experiencing ACEs to altered health perception.

Our results provide novel support for the ACE pyramid model by expanding upon prior findings in several key ways. First, this study provides evidence that ACEs are associated with perceived physical health, a construct known to increase mortality rates, but as of yet unexamined in ACEs research. This evidence suggests

that ACEs may be a clinically significant factor to consider, even in late-life healthcare, due to the known impact of poor perceived health on decreased survival rates. Second, our study highlights the intertwining of psychosocial and physiological health by demonstrating that components of the ACE pyramid model can have an impact beyond biological health in the form of health perception. Finally, this study empirically demonstrates support for the ACE pyramid functioning as a model of multiple-mediation, and future studies should seek to use models that reflect the multi-layered nature of the ACE pyramid. These novel contributions provide several new avenues for ACEs research and interventions.

Perceived Physical Health

From a clinical perspective, this finding provides support for utilizing ACE scores in 2 new ways. First, ACE screening holds potential as an additional intervention area for pre-existing chronic health problems. As it stands, ACE screenings are used primarily as an aid in preventing poor health outcomes. Our findings suggest that ACE screenings can be used after the poor health outcome has occurred as a means to inform treatments targeted at improving perceived health. Second, our findings suggest an alternative avenue for prevention using ACE screenings for patients who do not yet have chronic health problems. In addition
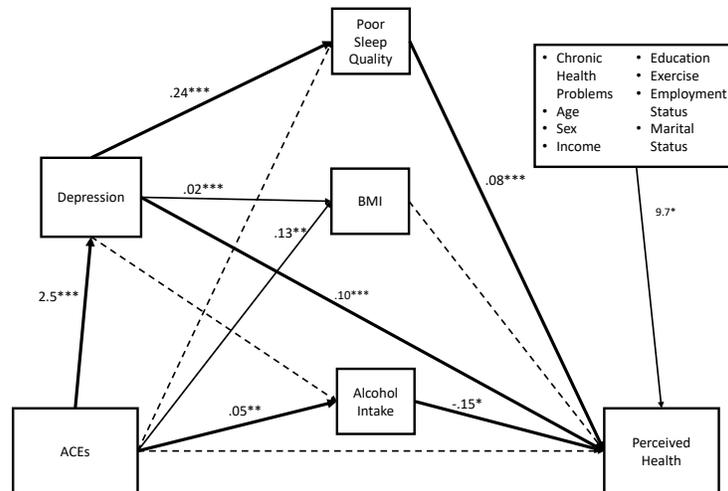
Figure 2. Computed Multiple-Mediation Model for Poor Physical Health.
Note: *p < 0.05, **p < 0.01, ***p < 0.001; Dashed lines indicate paths that are not statistically significant. Bolded paths indicate paths of mediation. Total indirect effect of ACEs = 0.28 (95% CI = 0.238–0.333). Significant Covariates includes chronic health problems, age, education > HS, sex = F, did not exercise in the past month, being unemployed and being retired.

to the standard practice of using ACE scores to understand and address risky health behaviors, clinicians should also offer evidence-based interventions designed to improve perceived health, such as the use of mindfulness meditation.[48,49] Future studies should seek to further examine the proposed link between ACEs, poor perceived health and survival rates as well as the efficacy of interventions, such as mindfulness for decreasing the effect of ACEs on perceived health.

We believe the link between ACEs and perceived health is troubling and worth serious consideration from a theoretical perspective as well. This finding, in conjunction with the existing body of literature, suggests that ACEs may pose a dual threat to the health of an individual. Much research has demonstrated that ACEs increase the likelihood that an individual develops one or more chronic health problems.[1,3,4] Our findings suggest that ACEs are associated with increases in the likelihood that those same individuals perceive their health as poor. Given that perceived poor health is a risk factor known to decrease survival rates,[23,26–28] it is plausible that ACEs may first contribute to making someone sick and then reduce their odds of survival by diminishing their perception of their health. Future research is needed to evaluate the role of perceived health in the ACE pyramid model as it relates to mortality.

Multiple-Mediation and ACEs

Our results showed that the relationship between ACEs and perceived health is multiply mediated via several associative pathways. ACEs were associated with an increase in the number of drinks a person has on average per month and their depression score. The increased depression score was then associated with the increase of days a person sleeps poorly. The increased depression score and the elevated incidence of poor sleep were associated with an increase in the number of days per month that person perceives their health to be poor. Additionally, the increased average number of drinks per month was associated with a slight decrease in the perceived poor health days per month. While the first 2 pathways are congruent with our hypotheses and the ACE pyramid in general, we believe the counterintuitive relationship between alcohol consumption and perceived health requires further examination and may be due in large part to 2 factors. First, our sample had a relatively low average number of drinks per month (M = 1.1, SD = 2.0), indicating that a strong majority of our sample did not drink with great frequency. This low number may indicate that the majority are using alcohol in social settings or as a self-care coping strategy, both of which could serve as protective factors for perceived health.[50–54] Second, our sample's drinking habits fall within the acceptable moderate drinking range of the

Table 3. Regression Estimates for Poor Perceived Health

	Estimate	SE	t	p	Lower CI (95%)	Upper CI (95%)
Intercept	-2.20	1.13	-1.91	0.06	-4.37	0.05
Primary Variables						
ACEs	0.03	0.06	0.44	0.66	-0.09	0.14
Depression	0.10	0.01	14.40	<.0001	0.09	0.11
Poor Sleep Quality	0.08	0.01	6.17	0.0001	0.06	0.11
BMI	0.00	0.02	0.12	0.91	-0.03	0.04
Alcohol Intake	-0.15	0.06	-2.41	0.02	-0.27	-0.03
Demographics						
Age	0.12	0.01	10.43	<.0001	0.09	0.14
Sex = Female	-1.01	0.26	-3.90	<.0001	-1.51	-0.50
Education < HS	--	--	--	--	--	--
Education > HS	-1.20	0.49	-2.47	0.01	-2.16	-0.25
Exercise	--	--	--	--	--	--
No Monthly Exercise	3.95	0.28	13.90	<.0001	3.40	4.51
Chronic Health Problems	0.96	0.19	5.15	<.0001	0.59	1.32
Income <35K	--	--	--	--	--	--
Income ≥ 35K	-0.54	0.31	-1.75	0.08	-1.14	0.06
Employment Status						
Employed	--	--	--	--	--	--
Unemployed	5.10	0.38	13.41	<.0001	4.36	5.85
Retired	1.78	0.37	4.86	<.0001	1.06	2.49
Marital Status						
Married	--	--	--	--	--	--
Previously Married	0.13	0.31	0.41	0.68	-0.48	0.73
Single/Never Married	0.30	0.39	0.78	0.43	-0.46	1.07
Currently Dating	0.76	0.71	1.07	0.28	-0.63	2.16

Note: Parameter estimates for the model predicting days of poor perceived health. Reference groups for categorical variables signified by --.

United States dietary guidelines.[55] We believe that individuals who engage in healthy drinking practices may also be mindful of other dietary guidelines, resulting in greater perceived health. Additionally, mild to moderate drinking has been shown to have a protective effect against a myriad of health problems.[52,56–58] Future studies should seek to examine this link in further detail.

We propose that the multiply-mediated nature of ACEs provides several potential opportunities for intervening between when an individual experiences ACEs and their development of

poor health. For instance, several school-level interventions have been shown to be effective at reducing depression rates,[59] but our results suggest such interventions have the potential to offer long-term health benefits as well. In addition to interventions targeted at adolescents, we believe our findings support an opportunity to mitigate the increased health risks associated with ACEs in elderly patients. We propose that counseling or psychotherapy may be beneficial for the elderly as a means to boost their longevity, especially as their health declines, as it could serve to sever the mediation between ACEs and perceived health.

Future ACEs studies should seek to examine alternative, multiple-mediation avenues, such as the mediating roles of anxiety and nutrition. Multiple-mediation analysis provides an enhanced understanding of the mechanisms that underlie the relationship between ACEs and poor health that are otherwise left to conjecture. This enhanced understanding is crucial for developing new approaches to preventing chronic illness as well as aiding in the continued understanding of the relationships between mental and physical health.

Limitations

Our study had multiple limitations. First, our sample was a cross-sectional epidemiological survey, which limited our ability to make causal inferences. Specifically, while we attempted to control for a myriad of confounding factors, the potential for confounding factors cannot be ruled out in our study. Other factors that were unaccounted for may have a significant impact on both ACEs and PPPH, such as the parenting style the individual was raised with, the neighborhood they live in and various policy-level factors. Furthermore, most of the data was categorical in nature due to the formatting of the survey, and, therefore, we were limited in the level of specificity we could achieve with several measures. Finally, while we do not believe the impact of ACEs to be changing over time, it is worth noting that our data was somewhat older.

Second, while our use of the PROCESS methodology provided many advantages, it was unable to accommodate the weighting variables provided by the BRFSS.[47] The BRFSS uses a complex survey design, including raking by strata, and they include several weights to account for the potential design effects of the survey.[41] We were not able to adjust for these design effects, meaning our sample was biased in its construction. As a result, caution must be used in generalizing our findings to the general population.

Third, our application of the multiple-mediation methodology relies heavily on the theoretical assumptions of the ACE pyramid. For example, we modeled the effect of depression on poor sleep as the ACE Pyramid dictates that poor psychosocial health is the antecedent of problematic health behaviors. As a result, our proposed model does not accommodate the potential for reciprocal relationships, such as depression increasing poor sleep and poor sleep exacerbating depressive symptoms. While our model is informed by theory, it is plausible that misspecification of the mediational pathways occurred, resulting in biased estimates. Future studies should seek to further examine the proposed pathways using a longitudinal study.

Conclusion

Adverse childhood experiences are related to perceived health through multiple intermediary factors, including depression and poor sleep quality. Given the protective role of perceived health in patients with chronic conditions, screening for ACEs in those patients may be of clinical value. Furthermore, the mediational components of our model provide new insight for intervention opportunities relating to ACEs. Future research should further explore the integration of perceived health into the ACE pyramid.

Conflicts of Interest

The authors declare they have no conflicts of interest.

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