



# Adverse Childhood Experiences, Protective Factors, and Childhood Obesity: Comparing the Effectiveness of Three Resilience Frameworks

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## Abstract

While rates of childhood obesity continue to rise in the United States, multiple studies have linked childhood obesity to adverse childhood experiences (ACEs). ACEs researchers have begun to develop frameworks that identify protective factors that build resilience against ACEs. However, these frameworks have a limited evidence base. Utilizing data from the 2018–2020 National Survey of Children’s Health, this study compared the effectiveness of the National Scientific Council on the Developing Child (NSCDC), Health Outcomes from Positive Experiences (HOPE), and cumulative positive childhood experiences (PCEs) frameworks in mitigating the impact of ACEs on childhood obesity. Based on hierarchical logistic regression conducted on data from 46,672 children between the ages of 10 and 17 years old, this study found that both the NSCDC and HOPE frameworks were associated with childhood obesity, with each framework explaining a similar amount of variance in childhood obesity across analyses. The cumulative PCEs framework did not strengthen the association between either framework and childhood obesity. Across analyses, strong self-regulation, mastery/after-school activities, and living in a supportive neighborhood had the strongest association with childhood obesity. The findings suggest that the most salient protective factors may be those most closely associated with the direct causes of childhood obesity, with the need to identify factors across ecological levels. Future research is needed to validate these frameworks further and explore these frameworks with other outcomes. The findings have important implications for future ACEs research and ACEs interventions.

**Public Relevance** By understanding which resilience frameworks and protective factors have the strongest relationship with childhood obesity among children who experienced ACEs, interventions can potentially be developed using these findings to mitigate the harmful impact of ACEs on childhood obesity.

**Key Findings** This study found that the National Scientific Council on the Developing Child (NSCDC) and Health Outcomes from Positive Experiences (HOPE) frameworks were associated with childhood obesity after controlling for adverse childhood experiences (ACEs) in a sample of children between the ages of 10 and 17 years old. The strongest protective factors against childhood obesity were strong self-regulation, mastery/after-school activities, and living in a supportive neighborhood. Given the relationship between these protective factors along with several covariates in the study with childhood obesity, future ACEs interventions should potentially target these protective factors and other social determinants of health to reduce the negative impact of ACEs on childhood obesity.

**Keywords** Resilience · Adverse childhood experiences · Protective factors · Childhood obesity

Childhood obesity is an increasingly serious public health issue that has been associated with poorer short- and long-term health outcomes (Keramat et al., 2021; Ogden et al., 2020; Sahoo et al., 2015; Sanyaolu et al., 2019). While the causes of childhood obesity are complex and multifaceted (Boonpleng et al., 2013; Sahoo et al., 2015; Williams et al., 2018), increased exposure to adverse childhood experiences

(ACEs), categories of childhood maltreatment and household dysfunction, has been associated with a higher risk of childhood obesity (Davis et al., 2019). To mitigate the harmful impact of ACEs, researchers have begun to identify possible protective factors from previous resilience research, but studies have predominantly examined these protective factors in isolation (Areba et al., 2021; Crouch et al., 2019b; Hornor, 2017; Ortiz, 2019). In contrast, previous resilience research has found that resilience and protective factor are

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context dependent and are best understood when considering how they interrelate with one another (Masten, 2018; Wright et al., 2013). Fortunately, three resilience frameworks have recently emerged in the literature that describe how protective factors possibly work together to build resilience to overcome childhood adversity, which may include ACEs. These frameworks include the National Scientific Council on the Developing Child (NSCDC) framework (NSCDC, 2015), Health Outcomes from Positive Experiences (HOPE) framework (Sege & Harper Browne, 2017), and cumulative positive childhood experiences (PCEs) framework (Bethell et al., 2019). However, each framework utilizes a different approach and has a limited evidence base with no known studies comparing their relative effectiveness. Further, the limited studies that examined each framework inconsistently included ACEs and only one known study examined childhood obesity (Crouch et al., 2022). Given the importance of mitigating the impact of ACEs on childhood obesity and other outcomes, the purpose of this study was to compare the relationship between childhood obesity and each of these resilience frameworks and associated protective factors before and after controlling for ACEs to better inform future childhood obesity ACEs interventions and future research on ACEs resilience frameworks.

## Childhood Obesity

From 2017 through 2020, 41.9% of adults in the United States (U.S.) were considered obese (Stierman et al., 2021). Adults who are obese are at increased risk of chronic disease and earlier death (Greenberg, 2013; Keramat et al., 2021; Steele et al., 2017). Childhood obesity has been linked to adult obesity (Sanyaolu et al., 2019). From 2107 to 2018, 19.5% of children between 2 and 19 years old in the U.S. were obese, with rates continuing to rise in the U.S. (Ogden et al., 2020; Stierman et al., 2021). Childhood obesity has been linked to childhood diabetes, asthma, sleep apnea, depression, lower self-esteem, eating disorders, and other negative outcomes (Sahoo et al., 2015; Sanyaolu et al., 2019). While males and females have similar childhood obesity rates, Hispanic and Black/African American populations have the highest childhood obesity rates, along with children from lower-income households (Stierman et al., 2021). Childhood obesity rates also increase with age (Ogden et al., 2020).

## Adverse Childhood Experiences

One factor associated with childhood obesity is ACEs (Davis et al., 2019; McKelvey et al., 2019). In the seminal ACEs study, ACEs were identified as categories of childhood maltreatment and household dysfunction that had a dose-wise association with risky health behaviors and poorer health outcomes (Felitti et al., 1998). Multiple studies have replicated and built on the findings of the original ACEs study by establishing a dose-wise association between ACEs and behavioral issues, psychosocial issues, and negative health outcomes (Brown et al., 2009; Campbell et al., 2016; Petrucelli et al., 2019). Children who experienced ACEs are also at increased risk for poorer school, mental health, and health outcomes, including obesity (Bellis et al., 2018; Crouch et al., 2019a; Davis et al., 2019; Meeker et al., 2021).

Compared to youth who did not experience ACEs, youth who experienced 4 ACEs were 1.6 times more likely to be obese and 1.9 times more likely to be severely obese; youth who experienced 6 ACEs were 2.0 times more likely to be obese and 4.2 times more likely to be severely obese (Davis et al., 2019). Children who experienced 4 or more ACEs before 3 years old were also found to be 2.7 times more likely to be obese at 11 years old than those who did not experience ACEs (McKelvey et al., 2019). With 46.3% of U.S. children experiencing at least one ACE and 21.7% of children experiencing multiple ACEs (Bethell et al., 2017), ACEs have the potential to significantly contribute to childhood obesity in the U.S. Thus, identifying protective factors that can build resilience to mitigate the impact of ACEs on childhood obesity is one promising approach to reducing childhood obesity. Fortunately, previous resilience research has identified multiple protective factors that may also be applicable to mitigating the negative impact of ACEs (Masten, 2018).

## Resilience and Protective Factors

Based upon reviews of historic resilience research conducted by Masten (2018) and Wright et al. (2013), early resilience research began by identifying protective factors that allowed individuals to exhibit resilience — the ability to adapt and succeed — despite exposure to trauma and adversity. However, Wright et al. (2013) identified that later waves of resilience research recognized that resilience is often context dependent and that protective factors are best understood when considering how they relate to one another. Building on the findings of the original ACEs study (Felitti et al., 1998), researchers, educators, clinicians, and others have begun to try to identify ways to improve outcomes among children and adults who have experienced ACEs. These

ACEs researchers and practitioners have recently begun to adopt protective factors from previous resilience research (Hornor, 2017; Ortiz, 2019; Sciaraffa et al., 2017). However, research has not yet established how many of these protective factors can promote resilience specifically against ACEs (Traub & Boynton-Jarrett, 2017). While some studies have begun to explore the effectiveness of these protective factors in isolation (Areba et al., 2021; Crouch et al., 2019a, 2019b), frameworks and models that describe how protective factors work together to build resilience are needed to inform future interventions. While having a limited evidence base, three promising ACEs resilience frameworks have recently emerged in the literature: the National Scientific Council on the Developing Child (NSCDC) framework, the Health Outcomes from Positive Experiences (HOPE) framework, and the cumulative positive childhood experiences (PCEs) framework.

### **National Scientific Council on the Developing Child Framework**

The NSCDC framework posits that prolonged or repeated exposure to childhood adversity may result in toxic stress, which has a physiological impact that can result in negative long-term outcomes. However, building on previous resilience research, the NSCDC framework suggests that the presence of four specific, modifiable protective factors is associated with more positive outcomes among those experiencing childhood adversity. The strongest of those protective factors is at least one supportive, caring, and stable adult relationship (i.e., resilience-building adult relationship). The other protective factors include strong self-regulation/executive functioning, mastery in some area, and a supportive, affirming, hopeful cultural or faith tradition (NSCDC, 2015). The individual protective factors from the NSCDC framework are based on previous resilience research (Masten, 2018) with some evidence of the effectiveness of individual protective factors in building resilience against ACEs (Bellis et al., 2017; Sparks et al., 2021; Yamaoka & Bard, 2019). The only known study exploring the effectiveness of this framework among children who experienced ACEs found that the NSCDC framework was associated with a lower likelihood of childhood mental health issues among children experiencing 4 or more ACEs (Keane & Evans, 2022). Despite the promise of this study, a more extensive evidence base is needed to validate the effectiveness of this framework and to determine whether it is associated with a lower risk of other negative outcomes, including childhood obesity.

### **Health Outcomes from Positive Experiences Framework**

While the NSCDC framework seeks to identify the four strongest protective factors, the HOPE framework identifies four broad categories of protective factors. The HOPE framework also recognizes that health encompasses several domains, with resilience being the byproduct of factors at multiple ecological levels. Resilience against ACEs is developed through factors in the following four broad categories during childhood: having relationships that are nurturing and supportive; being in environments that are protective, equitable, and stable; having opportunities to engage in social activities that are constructive and promote connectedness; and developing emotional and social competencies (Sege & Harper Browne, 2017). Compared to the NSCDC framework, the HOPE framework has a slightly larger evidence base, with four known studies exploring the framework (Crouch et al., 2022, 2021a, 2021b; Elmore et al., 2020). One HOPE framework study found that a single protective factor, living in a supportive neighborhood, was associated with a lower likelihood of children experiencing 2 or more ACEs being overweight or obese. However, the overall effectiveness of the framework was not examined (Crouch et al., 2022). Other studies identified specific HOPE framework protective factors associated with better school outcomes (Crouch et al., 2021b) and childhood depression (Elmore et al., 2020). Only one study examined the framework's overall effectiveness but did not consider ACEs (Crouch et al., 2021b). Thus, research is needed to validate the framework's overall effectiveness and compare it to other resilience frameworks among children who experienced ACEs.

### **Cumulative Positive Childhood Experiences Framework**

Unlike the NSCDC and HOPE frameworks, the cumulative PCEs framework seeks to maximize the number of protective factors rather than target the most important factors. According to the cumulative positive childhood experiences (PCEs) framework, categories of positive experiences in childhood have a graded, dose-wise association with fewer adverse outcomes among individuals who have experienced ACEs (Baglivio & Wolff, 2020; Bethell et al., 2019). Researchers have borrowed PCEs from historic resilience research with inconsistencies in the specific protective factors and terminology used across studies (Bethell et al., 2019; Crandall et al., 2020; Crouch et al., 2021a, 2021b; Robles et al., 2019). Nevertheless, studies have found cumulative PCEs were associated with lower levels of mental health issues, risky sexual behaviors, and substance abuse in adulthood after controlling for ACEs (Bethell et al., 2019; Crandall et al., 2020). Exposure to more PCEs was also a

protective factor against recidivism and delinquency among youth who experienced multiple ACEs (Baglivio & Wolff, 2020; Novak & Fagan, 2022). However, no known studies have examined the association between the cumulative PCEs framework and childhood obesity; the one adult study exploring this framework found that an above-median PCEs score was associated with a lower likelihood of obesity and other health outcomes. However, unlike other study outcomes, the association between PCEs and obesity was no longer significant after controlling for ACEs (Kuhar & Zager Kocjan, 2021). Thus, while preliminary evidence has linked the cumulative PCEs framework to better outcomes among those who experienced ACEs, additional research is needed to explore the link with childhood obesity and to compare the framework with other frameworks.

## Comparison of the Resilience Frameworks and Protective Factors

Each of these three resilience frameworks has a different approach to identifying protective factors that build resilience. While the NSCDC framework identifies the specific, modifiable protective factors associated with resilience to overcome toxic stress (NSCDC, 2015), the HOPE framework identifies four broad categories of protective factors in which the specific protective factors are not prescribed (Sege & Harper Browne, 2017). The cumulative PCEs framework seeks to maximize the number of protective factors to build resilience without specifying the protective factors and inconsistencies in protective factors across studies (Bethell et al., 2019; Crandall et al., 2020; Robles et al., 2019).

When comparing each framework's protective factors, the NSCDC framework protective factors were based upon alignment with the framework and those used in the only known National Survey for Children's Health (NSCH) NSCDC framework study (Keane & Evans, 2022; NSCDC, 2015). Due to the lack of specificity provided by the framework, the HOPE framework protective factors were based on those consistently identified in previous HOPE framework studies using the NSCH (Crouch et al., 2022, 2021a, 2021b.). While there was an overlap between the NSCDC and HOPE framework protective factors in this study, there were some distinct differences. The NSCDC framework protective factor of a resilience-building adult relationship only considers the presence of at least one supportive, stable adult relationship (either parent/caregiver or other adult relationship) while the HOPE framework category of supportive and nurturing relationships is much broader, considering mentor relationships, peer relationships (not measured on the NSCH), or any supportive family relationships measured by family resilience on the NSCH (Crouch et al., 2021a; Keane & Evans, 2022; NSCDC, 2015). Likewise, the NSCH

protective factor of strong self-regulation overlaps and could be included in the HOPE framework category of learning emotional and social competencies (NSCDC, 2015; Sege & Harper Browne, 2017). However, learning emotional and social competencies is broader as it extends to consider social and communication skills within interpersonal relationships (Sege & Harper Browne, 2017). Consequently, previous HOPE framework studies (Crouch et al., 2022, 2021a, 2021b) used an item related to communicating about "things that really matter" with a parent/caregiver rather than the self-regulation item of "staying calm and in control when faced with a challenge" used by the NSCDC framework (Keane & Evans, 2022). While the items on the NSCH for mastery and opportunities for social engagement/developing connections were similar, the two frameworks conceptualize these differently. The NSCDC factor of mastery involves having a sense of control or competence over areas of one's life. Mastery may be context specific and align with self-efficacy (NSCDC, 2015, n.d.). Given the link between extracurricular activities and master/self-efficacy (Forgeard & Benson, 2019; Griffiths et al., 2021; Reverdito et al., 2017), this study used participation in extracurricular, community services, or volunteer opportunities as a proxy measure like a previous study (Keane & Evans, 2022). While the HOPE framework category of opportunities for social engagement/developing connections used similar items, this category emphasizes the benefits of extracurricular activities being the development of connectedness and social engagement rather than developing mastery (Sege & Harper Browne, 2017). While the NSCDC protective factor of a supportive, affirming, hopeful cultural or faith tradition could potentially be integrated into the HOPE framework, the HOPE framework does not explicitly refer to this protective factor (NSCDC, 2015; Sege & Harper Browne, 2017). Likewise, while the NSCDC (2015) has suggested interventions using ecological approaches, only the HOPE framework has included a category that addresses protective factors at the neighborhood or community level (Sege & Harper Browne, 2017).

When considering the specific cumulative PCEs framework protective factors, they have differed widely across studies with no clear theoretical framework. Therefore, the cumulative PCE scores in this study were calculated using the NSCDC and HOPE framework protective factors consistent with a previous study (Crouch et al., 2021a). Thus, while there are similarities in the protective factors identified in this study across frameworks, there are distinct differences in how they interrelate. The NSCDC framework identifies the four strongest protective factors, the HOPE framework identifies four broad categories considering ecological levels with less specificity, and the cumulative PCE framework seeks to maximize the protective factors. These



varying approaches can have important implications when considering future ACEs interventions.

## The Current Study

Building on the previously discussed research, this study addresses four gaps in the literature. First, while historic resilience research has identified several protective factors (Masten, 2018; Wright et al., 2013), few studies have explored their effectiveness among those who have experienced ACEs (Traub & Boynton-Jarrett, 2017). Since protective factors are context specific (Wright et al., 2013), this study filled this gap by exploring the effectiveness of these protective factors among children who experienced ACEs. Second, resilience is best understood within the context of how protective factors interrelate to build resilience (Wright et al., 2013). While three resilience frameworks were identified (Bethell et al., 2019; NSCDC, 2015; Sege & Harper Browne, 2017), each has a limited evidence base, with few studies exploring the effectiveness of these frameworks. This study explored the efficacy of all three frameworks related to childhood obesity. Third, this is the first known study to compare the effectiveness of the NSCDC, HOPE, and cumulative PCE frameworks. Finally, while ACEs have been linked to childhood obesity (Davis et al., 2019; McKelvey et al., 2019), few studies have examined the association between protective factors and childhood obesity among children experiencing ACEs (Crouch et al., 2022). Thus, this study identified which protective factors had the strongest association with childhood obesity among children who experienced ACEs. Taken together, these findings provided a fuller understanding of how resilience frameworks and protective factors are associated with childhood obesity to guide future interventions.

The first aim of this study was to determine whether the NSCDC or HOPE framework was associated with a lower likelihood of childhood obesity. The second aim was to determine whether a cumulative PCE score strengthened the link between each framework and childhood obesity. The third aim was to identify which protective factors within each framework had the strongest association with childhood obesity. The fourth aim was to determine whether the previously identified associations were the same after controlling for the number of ACEs.

One criticism of the original ACEs study was that all ACEs were given equal weight, but some traumatic events having a greater influence based on the timing, severity, and a myriad of other factors (Lacey & Minnis, 2020). Likewise, not all PCEs are likely to be equal. Consequently, the researchers hypothesized that frameworks that emphasize the most salient protective factors would have a stronger association with childhood obesity than a framework that

weighted all protective factors equally. Thus, the researchers hypothesized that the NSCDC and HOPE frameworks would be associated with a lower likelihood of childhood obesity, but the addition of a cumulative PCEs score would not strengthen either framework. Further, the NSCDC framework identifies the four strongest protective factors while the HOPE framework focuses on four broad categories to build resilience (NSCDC, 2015; Sege & Harper Browne, 2017). As mentioned previously, the researchers used the same protective factors in each framework as previous NSCH studies to build on previous research. When considering the protective factors within each framework, the NSCDC framework has an increased emphasis on resilience-building adult relationships and self-regulation (NSCDC, 2015). Previous studies have found that supportive adult relationships were associated with better outcomes among those who experienced ACEs (Bellis et al., 2017; Yamaoka & Bard, 2019). Further, Keane and Evans (2022) found that a supportive parent relationship and self-regulation were the strongest protective factors against mental health issues among children with 4 or more ACEs. Thus, due to the increased emphasis on these two protective factors and how the protective factors were measured/conceptualized using the HOPE framework, the researcher hypothesized that the NSCDC framework would have the strongest association with childhood obesity. Further, based on the strongest factors identified in the only previous NSCDC study (Keane & Evans, 2022) and a HOPE framework study examining childhood obesity (Crouch et al., 2022), the researchers hypothesized that a supportive parent/caregiver relationship, self-regulation, and a supportive neighborhood would be the strongest protective factors. Finally, all three resilience frameworks theorize that protective factors or PCEs are associated with better outcomes despite exposure to ACEs or other forms of adversity (NSCDC, 2015; Bethell et al., 2019; Sege & Harper Browne, 2017). Consequently, consistent with other studies that considered PCEs and ACEs (Bethell et al., 2019; La Charite et al., 2023), the researchers hypothesized that the same frameworks and protective factors would still be associated with a lower likelihood of childhood obesity after controlling for the association between ACEs and childhood obesity.

## Methods

### Data and Sample

Data came from the 2018–2020 NSCH, a national survey of childhood health and well-being conducted by the U.S. Maternal and Child Health Bureau (U.S. Census Bureau, 2020b). The NSCH sample was drawn from U.S. Census Master Address File utilizing stratified sampling. The first

level of stratification was based on whether administrative records linked the child to the home (approximately 85% had a confirmed government record, approximately 15% had a probabilistic link to a child in the home, and less than 2% had no clear link to a child in the home). Further, the sample maximized the surveys per state while ensuring survey reliability; census block data was used to ensure higher poverty groups were included proportionally. Each selected household was mailed a screener questionnaire requesting demographic information and information about children in the home. For households completing the screener questionnaire with children, the NSCH randomly selected one child in the household for the parent/caregiver to complete one of three topical questionnaires based on the age of the child (0–5 years old, 6–11 years old, or 12–17 years old). The survey intentionally oversampled children between 0 and 5 years old and children with special needs. Parents/caregivers completed the surveys in either English or Spanish online, on paper, or through a phone interview. Households were assigned to various incentive treatment conditions. All incentives were nonconditional with approximately 90% of household receiving an incentive up to \$5 in the initial mailing for each of the two surveys. Multiple mailings were sent to increase the likelihood of participation (U.S. Census Bureau, 2021b). The screener survey response rates ranged from 37.2 to 40.3%. Between 35.3 and 36.9% of eligible households completing the screener survey completed the topical surveys, which included the data used in this study (U.S. Census Bureau, 2019b, 2020b, 2021b). Based on analysis conducted by the NSCH, the NSCH has somewhat higher response rates among households with higher income, households outside metropolitan areas, and respondents who are college graduates or non-Hispanic, Caucasian. Nevertheless, based on statistical analysis, the NSCH concluded that there was “no strong or consistent evidence of nonresponse bias” on the 2018, 2019, or 2020 NSCH (U.S. Census Bureau, 2019a, 2020a; 2021a).

Of the three topical survey versions, only the versions for children between 6 and 17 years old included all the applicable ACEs and protective factor items. The NSCH only provided BMI categories for children 10 to 17 years old. Multiple years were combined to ensure adequate sample sizes for all subgroups. The final sample consisted of all children between 10 and 17 years old who were not missing any of the variables of interest on the 2018–2020 NSCH. Of the 102,740 responses to the 2018–2020 NSCH, 53,787 (52.4%) were children between 10 and 17 years old. Of those responses, 46,672 (86.8%) of children were in the final sample, missing none of the variables of interest. Of those missing data, 45.5% were missing ACEs variables, 52.4% were missing NSCDC protective factors, 41.7% were missing HOPE protective factors, and 26.0% were missing BMI data; there was no missing demographic data. When

comparing the final sample to those missing data, the final sample was less diverse, had higher educational attainment, had higher household income, and was more likely to have completed the survey during the COVID-19 pandemic. Further, the final sample experienced fewer ACEs (53.6% zero ACEs, 23.4% one ACE, 16.1% two to three ACEs, and 6.9% four or more ACEs) compared to those excluded from the sample due to missing data (49.3% zero ACEs, 26.4% one ACE, 16.6% two to three 3 ACEs, and 7.7% four or more ACEs,  $X^2 = 29.96$ ,  $p < 0.001$ ). Nevertheless, the final sample (13.6% with BMI  $\geq$  95th percentile) did not significantly differ from those missing data (13.8% with BMI  $\geq$  95th percentile,  $X^2 = 0.321$ ,  $p = 0.631$ ) regarding children who were obese. Since there were no differences in the outcome variable, the data was determined to be missing at random. Since data was missing at random, there was a sufficiently large sample size, and the missing variables were protective factors, ACEs scores, and obesity; listwise deletion was used for the final sample (Allison, 2009).

## Measures

### Adverse Childhood Experiences

The 2018–2020 NSCH shared eight ACE items (household mental illness, household substance abuse, household domestic violence, parent/guardian divorce or separation, parent/guardian death, parent/guardian incarceration, neighborhood violence, and discrimination) that were dichotomized (“yes” or “no”) indicating the child had experienced that ACE. Like previous studies (Crouch et al., 2019a; Keane & Evans, 2022), a ninth ACE, economic hardship, was coded “yes” if the respondent reported they “very often” or “somewhat often” had problems paying for necessities since the child’s birth. Like another study (Bethell et al., 2019), ACEs were grouped by risk level (0 ACEs, 1 ACE, 2–3 ACEs,  $\geq$  4 ACEs) to simplify reporting and differentiate the high (2 or 3 ACEs) and highest risk groups ( $\geq$  4 ACEs).

### Childhood Weight Status

Data on the child’s height and weight were not available in the public dataset. However, the public NSCH dataset provided four BMI percentile groups (“less than 5th percentile,” “5th percentile to less than 85th percentile,” “85th percentile to less than 95th percentile,” and “equal to or greater than the 95th percentile”) based on their age, height, and weight. Consistent with the criteria for childhood obesity (Centers for Disease Control and Prevention [CDC], 2021), children were obese if their BMI was “equal to or greater than the 95th percentile.”

## NSCDC Framework Protective Factors

In Table 1, five items captured the four NSCDC protective factors consistent with the previous NSCDC study (Keane & Evans, 2022). To facilitate analysis and evaluation of the cumulative PCE score, all responses were dichotomized (“yes” or “no”) based on whether the child had that protective factor. A supportive adult relationship was based on two items: parent/caregiver relationship and other adult relationship. The child had a supportive parent/caregiver relationship (“yes”) if the respondent answered “very well” or “somewhat well.” A response of “yes” indicated a supportive other adult relationship. If the respondent answered “all of the time” or “most of the time” to the self-regulation item, the child had strong self-regulation (“yes”). If the child participated in any of the mastery activities, the child had mastery in some area (“yes”). If the respondent answered “all of the time” or “most of the time” to the hopeful/affirming cultural tradition, they possessed this protective factor.

## HOPE Framework Protective Factors

This study built on previous HOPE framework studies by utilizing the same NSCH items used by previous researchers (Crouch et al., 2022, 2021a, 2021b). Thus, there was some overlap with the NSCDC protective factors with differences in how those items were conceptualized in each framework. In Table 2, seven items captured the four HOPE framework protective factor categories based on previous studies (Crouch et al., 2022, 2021a). To allow for analysis and evaluation of cumulative PCE scores, each item was coded based on whether the child had that protective factor (“yes” or “no”). For supportive and nurturing relationships, the child had a mentoring relationship, which was also measured in the NSCH framework, based on a response of “yes” and had family resilience based on responses of “all of the time” or “most of the time” to all four items. For stable,

safe, equitable, and protective environments, the child had a supportive neighborhood based on at least one “definitely agree” response with responses of at least “somewhat agree” for the other items; the child had a safe neighborhood based on a response of “definitely agree” or “somewhat agree.” For opportunities for social engagement and developing connections, the child was determined to have participated in after-school activities based on a response of “yes” to any of the three items and exhibited volunteerism based on a response of “yes” to the one item. The HOPE framework items for social engagement and developing connections were similar to the NSCH framework protective factor of mastery, except the HOPE framework separated volunteerism from other extracurricular activities. For learning emotional and social competencies, children shared ideas based on a response of “somewhat well” or “very well.” This item was the same as a supportive parent/caregiver relationship using the NSCDC framework. However, the HOPE framework interpreted this item as the child developing the skills to express challenges and feelings with others while the NSCDC framework utilized this item as an indication of a supportive parent/caregiver relationship (Keane & Evans, 2022; Sege & Harper Browne, 2017).

## Cumulative PCE Scores

To determine whether a cumulative PCE score strengthened each framework, a cumulative PCE score was calculated using the HOPE or NSCDC framework. For the cumulative HOPE PCE score, the score was calculated by adding the number of previously identified HOPE framework protective factors that the child possessed consistent with a previous study (Crouch et al., 2021a). The cumulative HOPE PCE scores were separated into low (0 to 2 PCEs), moderate (3 to 5 PCEs), and high (6 to 7 PCEs) to simplify comparisons and conclusions (Bethell et al., 2019). The same approach was used for the cumulative

**Table 1** NSCDC framework items on the 2018–2020 National Survey of Children’s Health

1. Parent/Caregiver Relationship<sup>a</sup>: How well can you and this child share ideas or talk about things that really matter?
2. Other Adult Relationship<sup>b</sup>: Other than you or other adults in your home, is there at least one other adult ... who knows this child well and who they can rely on for advice or guidance?
3. Self-Regulation<sup>c</sup>: How often does the child stay calm and in control when faced with a challenge?
4. Mastery<sup>b</sup>: During the past 12 months, did this child participate in:
  - a. Any clubs or organizations after school or on weekends?
  - b. A sports team or did they take sports lessons after school or on weekends?
  - c. Any other organized activities or lessons, such as music, dance, language, or other arts?
  - d. Any type of community service or volunteer work at school, place of worship, or in the community?
5. Hopeful/Affirming Cultural Tradition<sup>d</sup>: When your family faces problems, how often are you likely to stay hopeful even in difficult times?

<sup>a</sup>Responses of “very well,” “somewhat well,” “not very well,” “not at all”; <sup>b</sup>responses of “yes” or “no”; <sup>c</sup>responses of “always,” “usually,” “sometimes,” “never”; <sup>d</sup>responses of “all of the time,” “most of the time,” “some of the time,” “none of the time”

**Table 2** HOPE framework items on the 2018–2020 National Survey of Children’s Health**Category 1: Supportive and nurturing relationships**

1. Mentor Relationship<sup>a</sup>: Other than you or other adults in your home, is there at least one other adult ... who knows this child well and who they can rely on for advice or guidance?
2. Family Resilience<sup>b</sup>: When your family faces problems, how often are you likely to do each of the following?
  - a. Work together to solve problems
  - b. Talk together about what to do
  - c. Know we have strengths to draw on
  - d. Stay hopeful even in difficult times

**Category 2: Being in stable, safe, equitable, and protective environments**

3. Supportive Neighborhood<sup>c</sup>:
  - a. We watch out for each other’s children in this neighborhood
  - b. People in this neighborhood help each other out
  - c. When we encounter difficulties, we know where to go for help in our community
4. Safe Neighborhood<sup>c</sup>: This child is safe in our neighborhood

**Category 3: Opportunities for social engagement and developing connections**

5. After-School Activities<sup>a</sup>: During the past 12 months, did this child participate in:
  - a. Any clubs or organizations after school or on weekends?
  - b. A sports team or did they take sports lessons after school or on weekends?
  - c. Any other organized activities or lessons, such as music, dance, language, or other arts?
6. Volunteerism<sup>a</sup>: During the past 12 months, did this child participate in any type of community service or volunteer work at school, place of worship, or in the community?

**Category 4: Learning emotional and social competencies**

7. Sharing Ideas<sup>d</sup>: How well can you and this child share ideas or talk about things that really matter?

<sup>a</sup>Responses of “yes” or “no”; <sup>b</sup>responses of “all of the time,” “most of the time,” “some of the time,” “none of the time”; <sup>c</sup>responses of “definitely agree,” “somewhat agree,” “somewhat disagree,” “definitely disagree”; <sup>d</sup>responses of “very well,” “somewhat well,” “not very well,” “not at all”

NSCDC PCE score by summing the NSCDC protective factors coded as “yes.” The scores were separated into low (0 to 2 PCEs), moderate (3 to 4 PCEs), and high (5 PCEs) groups.

**Covariates**

Several covariates were included from the NSCH. The highest level of educational attainment by the caregiver was based upon their response on the survey (“less than high school,” “high school,” “some college or associate degree,” or “college degree or higher”). Other child characteristics included the child’s sex (“male” or “female”) and the child’s race (“Black or African American alone,” “White alone,” or “Other”) as coded by the NSCH. Age was recoded as 13 to 17 years old compared to 10 to 12 years old to differentiate between adolescents and pre-adolescents. Another covariate was family income, which was based on the average of estimated values of the family poverty level (FPL) provided by the NSCH (United States Census Bureau, 2021c) that were recategorized into three groups (0 to 199%, 200–399%, and 400% or higher) for comparison purposes. Finally, due to 2020 NSCH data collection occurring during the COVID-19 pandemic, a variable (COVID-19) was added to control for possible differences due to the timing of the surveys during (“yes”) or before the pandemic (“no”).

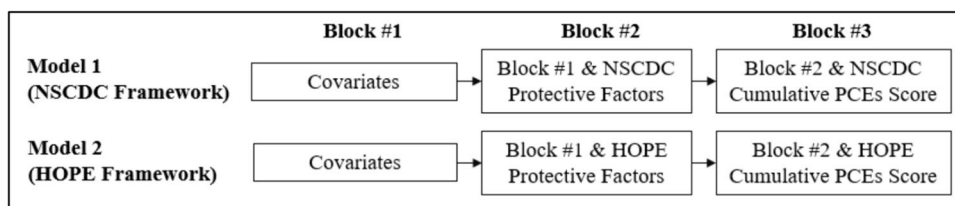
**Statistical Analysis**

IBM SPSS Statistics for Windows, Version 27.0 was used for all statistical analyses. The prevalence of covariates, protective factors, childhood obesity, ACE groupings, and cumulative PCE groupings were first identified. Then, bivariate analyses were conducted using  $X^2$  tests to compare differences in childhood weight status by covariates, protective factors, ACE groupings, and PCE groupings. To explore the study’s aims, model comparisons using hierarchical logistic regression were conducted using the entire sample excluding ACEs, and then again while controlling for ACE groupings. While not reported in this paper, model comparisons using hierarchical logistic regression were also completed with the four different ACE groupings (0 ACEs, 1 ACE, 2–3 ACEs, and 4 or more ACEs) to ensure consistency across ACEs levels. The sample met the assumptions of logistic regression. All observations were independent. The assumption of no multicollinearity was met due to the VIF values being between 1 and 10 (Marquardt, 1970). The sample and subsamples had a large enough sample size (Bujang et al., 2018); the outcome variable was dichotomous.

Figure 1 depicts the analyses conducted using the entire sample excluding ACEs. For all analyses, the NSCDC framework (model 1) and HOPE framework (model 2) were compared to determine which had the strongest association with childhood obesity. The effectiveness of



**Fig. 1** Hierarchical logistic regression for analyses excluding ACEs



the NSCDC and HOPE frameworks was based on whether the  $\Delta R^2$  from block 1 to 2 was significant. To determine which framework had a stronger association with childhood weight status, Nagelkerke's  $R^2$  values from block 2 using the NSCDC and HOPE frameworks were compared. The adjusted odds ratios in block 2 were compared within each framework to determine which protective factors had the strongest association with childhood obesity. Finally, if the  $\Delta R^2$  from blocks 2 to 3 was significant, that framework's cumulative PCE score improved the model.

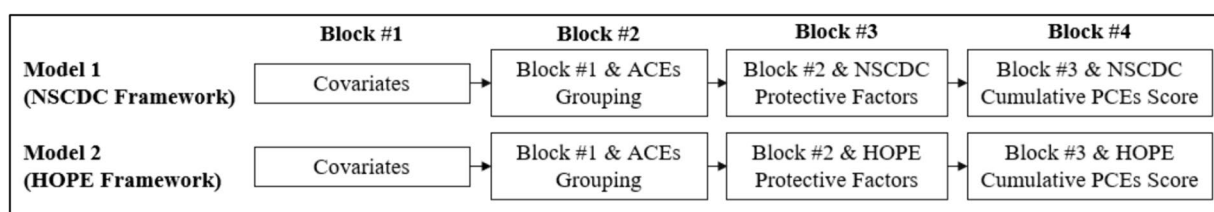
Figure 2 depicts the analysis conducted for the logistic regression models that included the entire sample and controlled for ACEs. The study controlled for ACEs given the previously established link between ACEs and childhood obesity to determine the unique contribution of each framework/protective factors among children who have experienced ACEs. The analyses were identical, except an additional block (block 2) was added with ACEs groupings. The effectiveness of each framework was determined based on whether the  $\Delta R^2$  from blocks 2 to 3 was significant. To determine which framework had a stronger association with childhood obesity, Nagelkerke's  $R^2$  values were compared in block 3. The strength of protective factors after controlling for ACEs was compared in block 3. If the  $\Delta R^2$  from blocks 3 to 4 was significant, that framework's cumulative PCEs score significantly contributed to the model after controlling for ACEs. A p-value of 0.05 was used to determine significance, but results were also interpreted with effect sizes due to the large sample size.

## Results

### Descriptive Statistics and Bivariate Analyses

Table 3 summarizes the demographic characteristics of the entire sample and  $X^2$  tests comparing characteristics by childhood weight status. The full sample included 46,672 children between 10 and 17 years old ( $M_{age} = 13.8$ ; 48% female; 78.8% Caucasian, 14.5% other race, 6.7% Black/African American). Approximately 13.6% of children were obese; 46.4% of children experienced at least 1 ACE, with 6.9% experiencing 4 or more ACEs. All the covariates had a significant association with childhood obesity. Based on a Cramer's V value of more than 0.15 (Akoglu, 2018), parental education had a strong association with childhood obesity, with obesity being less common among children when a parent completed college. Household income and the number of ACEs experienced had a moderate to strong association with childhood obesity.

The prevalence of childhood obesity is summarized and compared by NSCDC and HOPE framework protective factors and cumulative PCE scores utilizing  $X^2$  tests in Table 4. While all the protective factors were significant, parent relationship/sharing ideas, family resilience, other adult relationship/mentor relationship, and a hopeful/affirming cultural tradition had a very weak to weak effect size based on Cramer's V (Akoglu, 2018). While only having a weak to moderate association (Akoglu, 2018), after-school activities, both cumulative PCE scores, and mastery in some areas were most strongly associated with childhood obesity.



**Fig. 2** Hierarchical logistic regression for analyses including ACEs

**Table 3** Study sample demographic and other characteristics by childhood weight status

Sample characteristics	Overall, n (%) (n = 46,672)	BMI $\geq$ 95th percentile <sup>a</sup> , n (%) (n = 6348, 13.6%)	BMI < 95th percentile <sup>a</sup> , n (%) (n = 40,324, 86.4%)	p-value <sup>b</sup> / Cramer's V
Race/ethnicity				
Caucasian	36,797 (78.8%)	4725 (12.8%)	32,072 (87.2%)	< 0.001
Black/African American	3111 (6.7%)	699 (22.5%)	2412 (77.5%)	0.070
Other	6764 (14.5%)	924 (13.7%)	5840 (86.3%)	
Sex				
Male	24,254 (52.0%)	3909 (16.1%)	20,345 (83.9%)	< 0.001
Female	22,418 (48.0%)	2439 (10.9%)	19,979 (89.1%)	0.076
Age				
10–12 years old	15,022 (32.2%)	2326 (15.5%)	12,696 (84.5%)	< 0.001
13–17 years old	31,650 (67.8%)	4022 (12.7%)	27,628 (87.3%)	0.038
Household income <sup>c</sup>				
< 200% FPL	11,759 (25.2%)	2437 (20.7%)	9322 (79.3%)	< 0.001
200–399% FPL	16,867 (36.1%)	2315 (13.7%)	14,552 (86.3%)	0.135
$\geq$ 400% FPL	18,046 (38.7%)	1596 (8.8%)	16,450 (91.2%)	
Parents highest education				
Less than high school	1216 (2.6%)	264 (21.7%)	952 (78.3%)	< 0.001
High school	6136 (13.1%)	1413 (23.0%)	4723 (77.0%)	0.158
Some college/assoc degree	11,075 (23.7%)	2023 (18.3%)	9052 (81.7%)	
$\geq$ College degree	28,245 (60.5%)	2648 (9.4%)	25,597 (90.6%)	
COVID <sup>d</sup>				
Prior to COVID-19	27,169 (58.2%)	3605 (13.3%)	23,564 (86.7%)	0.013
During COVID-19	19,503 (41.8%)	2743 (14.1%)	16,760 (85.9%)	0.011
ACEs <sup>e</sup>				
0 ACEs	25,031 (53.6%)	2621 (10.5%)	22,410 (89.5%)	< 0.001
1 ACE	10,942 (23.4%)	1641 (15.0%)	9301 (85.0%)	0.109
2–3 ACEs	7491 (16.1%)	1398 (18.7%)	6093 (81.3%)	
4 or more ACEs	3208 (6.9%)	688 (21.4%)	2520 (78.6%)	

<sup>a</sup>Children with a BMI  $\geq$  95th percentile were classified as having childhood obesity; <sup>b</sup>p-value based on chi-squared test of independence; <sup>c</sup>family income as percentage of the federal poverty level; <sup>d</sup>COVID based on whether the survey was administered prior to or during the COVID-19 pandemic; <sup>e</sup>adverse childhood experiences

## Comparison of Resilience Frameworks and Models

Table 5 summarizes the amount of variance in childhood obesity explained by each analysis, model, and block based on Nagelkerke's  $R^2$ . The  $\Delta R^2$  describes the additional amount of variance explained by the factors added in that block; the significance determines whether the new factors significantly improved the model. In the full sample excluding ACEs, block 1 only including covariates was significant ( $X^2(10) = 17,822.77$ ,  $p < 0.001$ ) and explained 6.8% of the variance in childhood obesity. In block 3, the NSCDC ( $X^2(15) = 1926.81$ ,  $p < 0.001$ ) and HOPE framework ( $X^2(17) = 1939.01$ ,  $p < 0.001$ ) models were significant with the  $\Delta R^2$  also being significant for both models. Despite significantly improving both models, both frameworks explained the same amount of variance in childhood obesity (7.4%), a modest increase of 0.6% compared to block 1. In block 4,

the overall NSCDC and HOPE framework models were both significant, but the  $\Delta R^2$  from block 3 to 4 was not significant, demonstrating that the addition of a cumulative PCE score did not significantly improve either model.

For the analysis that included ACEs, the model in block 2 including ACEs and covariates was significant ( $X^2(13) = 1952.71$ ,  $p < 0.001$ ), and the addition of ACEs significantly improved the model ( $\Delta R^2 = 0.007$ ,  $p < 0.001$ ). After adding protective factors in block 3, the NSCDC ( $X^2(18) = 2050.13$ ,  $p < 0.001$ ) and HOPE ( $X^2(20) = 2060.45$ ,  $p < 0.001$ ) frameworks' models were significant, with the  $\Delta R^2$  being significant after controlling for ACEs. In block 3, the HOPE framework explained slightly more variance in childhood obesity (7.9%) than the NSCDC framework (7.8%). In block 4, the  $\Delta R^2$  was not significant after the addition of a cumulative PCE score for either model. While the primary focus of this study was not on ACEs

**Table 4** NSCDC and HOPE framework protective factors by childhood weight status

Sample characteristics	Overall, n (%) (n = 46,672)	BMI $\geq$ 95th percentile <sup>a</sup> , n (%) (n = 6348, 13.6%)	BMI < 95th percentile <sup>a</sup> , n (%) (n = 40,324, 86.4%)	<i>p</i> -value <sup>b</sup> /Cramer's <i>V</i>
<b>NSCDC<sup>c</sup> protective factors</b>				
Parent/caregiver relationship				
Yes	44,203 (94.7%)	5912 (13.4%)	38,291 (86.6%)	< 0.001
No	2469 (5.3%)	436 (17.7%)	2033 (82.3%)	0.028
Other adult relationship				
Yes	43,002 (92.1%)	5745 (13.4%)	37,257 (86.6%)	< 0.001
No	3670 (7.9%)	603 (16.4%)	3067 (83.6%)	0.024
Strong self-regulation				
Yes	36,198 (77.6%)	4429 (12.2%)	31,769 (87.8%)	< 0.001
No	10,474 (22.4%)	1919 (18.3%)	8555 (81.7%)	0.074
Mastery in some area				
Yes	42,688 (91.5%)	5423 (12.7%)	37,265 (87.3%)	< 0.001
No	3984 (8.5%)	925 (23.2%)	3059 (76.8%)	0.086
Hopeful/affirming cultural tradition				
Yes	43,862 (94.0%)	5877 (13.4%)	37,985 (86.6%)	< 0.001
No	2810 (6.0%)	471 (16.8%)	2339 (83.2%)	0.023
Cumulative NSCDC <sup>c</sup> PCE <sup>d</sup> score				
0 to 2 PCEs	1464 (3.1%)	311 (21.2%)	1153 (78.8%)	< 0.001
3 to 4 PCEs	14,894 (31.9%)	2587 (17.4%)	12,307 (82.6%)	0.090
5 PCEs	30,314 (65.0%)	3450 (11.4%)	26,864 (88.6%)	
<b>HOPE<sup>e</sup> framework protective factors</b>				
Mentor relationship				
Yes	43,002 (92.1%)	5745 (13.4%)	37,257 (86.6%)	< 0.001
No	3670 (7.9%)	603 (16.4%)	3067 (83.6%)	0.024
Family resilience				
Yes	38,578 (82.7%)	5085 (13.2%)	33,493 (86.8%)	< 0.001
No	8094 (17.3%)	1263 (15.6%)	6831 (84.4%)	0.027
Supportive neighborhood				
Yes	29,075 (62.3%)	3438 (11.8%)	25,637 (88.2%)	< 0.001
No	17,597 (37.7%)	2910 (16.5%)	14,687 (83.5%)	0.067
Safe neighborhood				
Yes	33,503 (71.8%)	4155 (12.4%)	29,348 (87.6%)	< 0.001
No	13,169 (28.2%)	2193 (16.7%)	10,976 (83.3%)	0.056
After-school activities				
Yes	39,857 (85.4%)	4878 (12.2%)	34,979 (87.8%)	< 0.001
No	6815 (14.6%)	1470 (21.6%)	5345 (78.4%)	0.096
Volunteerism				
Yes	24,639 (52.8%)	2823 (11.5%)	21,816 (88.5%)	< 0.001
No	22,033 (47.2%)	3525 (16.0%)	18,508 (84.0%)	0.066
Sharing ideas				
Yes	44,203 (94.7%)	5912 (13.4%)	38,291 (86.6%)	< 0.001
No	2469 (5.3%)	436 (17.7%)	2033 (82.3%)	0.028
Cumulative HOPE <sup>e</sup> PCE <sup>d</sup> score				
0 to 2 PCEs	1623 (3.5%)	376 (23.2%)	1247 (76.8%)	< 0.001
3 to 5 PCEs	19,737 (42.3%)	3225 (16.3%)	16,512 (83.7%)	0.094
6 to 7 PCEs	25,312 (54.2%)	2747 (10.9%)	22,565 (89.1%)	

<sup>a</sup>Children with a BMI  $\geq$  95th percentile were classified as having childhood obesity; <sup>b</sup>*p*-value based on chi-squared test of independence; <sup>c</sup>National Scientific Council on the Developing Child; <sup>d</sup>positive childhood experiences; <sup>e</sup>Health Outcomes from Positive Experiences

**Table 5** Comparison of the NSCDC<sup>a</sup> and HOPE<sup>b</sup> frameworks relationship with childhood weight status<sup>c</sup> based on Nagelkerke's  $R^2$ 

Analysis type/framework	Overall sample size	Block #1 (covariates only)	Block #2 (block #1 and ACE <sup>d</sup> count) (if applies)		Block #3 (block #2 and protective factors)		Block #4 (block #3 and cumulative PCE <sup>e</sup> count)	
		<i>R</i> <sup>2</sup>	<i>R</i> <sup>2</sup>	Δ <i>R</i> <sup>2</sup>	<i>R</i> <sup>2</sup>	Δ <i>R</i> <sup>2</sup>	<i>R</i> <sup>2</sup>	Δ <i>R</i> <sup>2</sup>
Analysis excluding ACEs <sup>d</sup>								
NSCDC <sup>a</sup> framework	46,672	0.068***			0.074***	0.006***	0.074***	0.000
HOPE <sup>b</sup> framework	46,672	0.068***			0.074***	0.006***	0.074***	0.000
Analysis including ACEs <sup>d</sup>								
NSCDC <sup>a</sup> framework	46,672	0.068***	0.075***	0.007***	0.078***	0.003***	0.078***	0.000
HOPE <sup>b</sup> framework	46,672	0.068***	0.075***	0.007***	0.079***	0.004***	0.079***	0.000

<sup>a</sup>National Scientific Center for the Developing Child; <sup>b</sup>Health Outcomes from Positive experiences; <sup>c</sup>based on whether or not the child had a BMI  $\geq$  95th percentile, meeting the criteria for childhood obesity; <sup>d</sup>adverse childhood experiences; <sup>e</sup>positive childhood experiences; <sup>f</sup>adverse childhood experiences; \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$

subgroups, it is worth mentioning that analyses conducted with each ACEs subgroup resulted in the same findings, except for children experiencing 4 or more ACEs. In this subgroup, the  $\Delta R^2$  was not significant, which may partially be attributed to the smaller sample size ( $n = 3208$ ).

### Comparison of Protective Factors Within Frameworks

Table 6 presents the adjusted odds ratios from block 3 after controlling for covariates and ACEs (if applicable) from the NSCDC framework analyses. All covariates except for COVID-19 and other race compared to Caucasians were associated with childhood obesity across analyses. Parents' highest education, female compared to male, Black/African American compared to Caucasian, and household income were the covariates with the strongest association with childhood obesity. The only NSCDC protective factors significantly associated with childhood obesity were strong self-regulation and mastery.

The adjusted odds ratios after controlling for covariates and ACEs (if applicable) in the HOPE framework analyses are presented in Table 7. The same covariates identified in the NSCDC analyses were also significant in the HOPE framework. Lower levels of parental education, males, Black/African Americans compared to Caucasians, children from lower-income households, and children between 10 and 12 years older were more likely to be obese. In the full sample including ACEs, children experiencing 4 or more ACEs were 1.51 times more likely to be obese. Participating in after-school activities was the strongest protective factor, followed by living in a supportive neighborhood. Sharing ideas with a parent or caregiver and living in a safe neighborhood were only significant in the analyses excluding ACEs. No other HOPE framework protective factors were significant.

### Discussion

This study aimed to compare the association between three resilience frameworks and childhood obesity among children who experienced ACEs. The study also identified which protective factors in each framework had the strongest association with childhood obesity and determined if these results were consistent after controlling for ACEs. The addition of protective factors from both the NSCDC and HOPE frameworks significantly improved the regression models when including and excluding ACEs, demonstrating the effectiveness of both frameworks. While the HOPE framework explained slightly more variance in childhood obesity after controlling for ACEs, the difference was modest (0.001). Thus, the two frameworks had similar effectiveness. The addition of a cumulative PCE score did not significantly strengthen either logistic regression model. Across analyses, mastery and self-regulation were the strongest NSCDC protective factors, and after-school activities and a supportive neighborhood were the strongest HOPE framework protective factors.

### Comparison of Resilience Frameworks

When considering the first and fourth aims, the researchers hypothesized that the NSCDC framework would have a stronger association with childhood obesity than the HOPE framework. While the NSCDC framework was associated with childhood obesity, this hypothesis was not supported since the HOPE framework explained similar variance in childhood obesity across analyses. Nevertheless, the NSCDC framework was associated with childhood obesity. In support of this finding, a previous study found the NSCDC framework was associated with childhood mental health issues (Keane & Evans, 2022). The effectiveness of the NSCDC framework may be attributed to the emphasis placed on resilience-building adult relationships and self-regulation



**Table 6** Adjusted odds ratios of child weight status<sup>a</sup> using NSCDC<sup>b</sup> framework across analyses<sup>c</sup>

Covariates/protective factors	Analysis framework with PCEs only <sup>d</sup>		Analysis framework with PCEs <sup>d</sup> and ACEs <sup>e</sup>	
	aOR	95% CI <sup>f</sup>	aOR	95% CI <sup>f</sup>
<b>Covariates</b>				
Race/ethnicity				
Caucasian (referent)				
Black/African American	1.59***	(1.45–1.74)	1.55***	(1.41–1.70)
Other	1.03	(0.96–1.12)	1.02	(0.95–1.11)
Female (male as referent)	0.64***	(0.61–0.68)	0.64***	(0.61–0.68)
13 to 17 years old (10 to 12 as referent)	0.81***	(0.77–0.86)	0.80***	(0.76–0.85)
Household income				
≥ 400% FPL (referent)				
200–399% FPL	1.31***	(1.22–1.41)	1.26***	(1.18–1.36)
< 200% FPL	1.61***	(1.49–1.75)	1.49***	(1.37–1.61)
Parents' highest education				
College degree or higher (referent)				
Some college or associate degree	1.77***	(1.66–1.90)	1.70***	(1.59–1.82)
High school degree or other	2.20***	(2.04–2.39)	2.12***	(1.96–2.30)
Less than high school	1.84***	(1.58–2.14)	1.85***	(1.59–2.15)
During COVID-19 (prior to as referent)	1.04	(0.99–1.10)	1.05	(0.99–1.11)
Number of ACEs <sup>e</sup> experienced				
0 ACEs (referent)				
1 ACE			1.25***	(1.17–1.34)
2 to 3 ACEs			1.45***	(1.34–1.56)
4 or more aces			1.51***	(1.36–1.66)
<b>NSCDC<sup>b</sup> framework protective factors</b>				
Parent/caregiver relationship	0.96	(0.85–1.07)	0.98	(0.87–1.10)
Other adult relationship	1.02	(0.92–1.12)	1.02	(0.93–1.12)
Strong self/regulation	0.75***	(0.70–0.80)	0.79***	(0.74–0.84)
Mastery	0.78***	(0.71–0.85)	0.79***	(0.72–0.86)
Hopeful/affirming tradition	0.94	(0.84–1.04)	0.99	(0.89–1.10)

<sup>a</sup>Based on whether or not the child had a BMI ≥ 95th percentile, meeting the criteria for childhood obesity;<sup>b</sup>National Scientific Center for the Developing Child; <sup>c</sup>all analyses based on block 3; <sup>d</sup>positive childhood experiences; <sup>e</sup>adverse childhood experiences; <sup>f</sup>95% confidence interval; \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$ 

(NSCDC, 2015). Both factors have an extensive evidence base (Bellis et al., 2017; Masten, 2018; Polizzi & Lynn, 2021; Yamaoka & Bard, 2019) and have been associated with childhood obesity (Anderson & Keim, 2016). The previous NSCDC framework study also identified these as the strongest two protective factors (Keane & Evans, 2022).

The HOPE framework had a stronger association with childhood obesity than hypothesized by the researchers. One explanation is that childhood obesity is a complex health issue influenced by a myriad of factors across ecological levels (Boonpleng et al., 2013; Sahoo et al., 2015; Williams et al., 2018). The HOPE framework identified protective factors from multiple ecological levels, including the family and community levels that were not as prevalent in the NSCDC framework and have been associated with childhood obesity (Boonpleng et al., 2013). Thus, while self-regulation was a

key protective factor excluded from the HOPE framework, the inclusion of community-level factors such as a supportive neighborhood and safe neighborhood may explain the effectiveness of the HOPE framework in this study. These findings highlight the importance of identifying protective factors at multiple ecological levels and suggest that frameworks may be developed by integrating key protective factors from the NSCDC with additional HOPE protective factors from various ecological levels.

Even though the NSCDC and HOPE frameworks significantly improved the regression models, the amount of variance in childhood obesity explained by the models including covariates was modest (7.4 to 7.9%). Thus, other factors not included in the model accounted for most of the variance in childhood obesity. Previous research has identified that genetics, poor nutritional patterns, sleep, family

**Table 7** Adjusted odds ratios of child weight status<sup>a</sup> using the HOPE<sup>b</sup> framework across analyses<sup>c</sup>

Covariates/protective factors	Analysis framework with PCEs only <sup>d</sup>		Analysis framework with PCEs <sup>d</sup> and ACEs <sup>e</sup>	
	aOR	95% CI <sup>f</sup>	aOR	95% CI <sup>f</sup>
<b>Covariates</b>				
Race/ethnicity				
Caucasian (referent)				
Black/African American	1.54***	(1.40–1.69)	1.52***	(1.38–1.66)
Other	1.01	(0.93–1.09)	1.00	(0.93–1.08)
Female (male as referent)	0.64***	(0.61–0.68)	0.64***	(0.60–0.67)
13 to 17 years old (10 to 12 as referent)	0.79***	(0.74–0.84)	0.78***	(0.73–0.82)
Household income				
≥ 400% FPL (referent)				
200–399% FPL	1.29***	(1.20–1.38)	1.25***	(1.16–1.34)
< 200% FPL	1.58***	(1.45–1.71)	1.46***	(1.35–1.58)
Parents' highest education				
College degree or higher (referent)				
Some college or associate degree	1.74***	(1.63–1.86)	1.68***	(1.57–1.80)
High school degree or other	2.14***	(1.97–2.32)	2.07***	(1.91–2.25)
Less than high school	1.76***	(1.51–2.05)	1.78***	(1.53–2.08)
During COVID-19 (prior to as referent)	1.05	(1.00–1.11)	1.06	(1.00–1.12)
Number of ACEs <sup>e</sup> experienced				
0 ACEs (referent)				
1 ACE			1.25***	(1.16–1.33)
2 to 3 ACEs			1.44***	(1.34–1.55)
4 or more ACEs			1.51***	(1.37–1.67)
<b>HOPE<sup>b</sup> framework protective factors</b>				
Mentor relationship	1.07	(0.97–1.18)	1.06	(0.96–1.17)
Family resilience	0.95	(0.89–1.02)	0.99	(0.92–1.07)
Supportive neighborhood	0.84***	(0.79–0.89)	0.86***	(0.81–0.92)
Safe neighborhood	0.93*	(0.87–1.00)	0.96	(0.89–1.02)
After-school activities	0.75***	(0.69–0.80)	0.76***	(0.70–0.81)
Volunteerism	0.96	(0.91–1.02)	0.99	(0.93–1.05)
Sharing ideas	0.89*	(0.79–1.00)	0.92	(0.82–1.03)

<sup>a</sup>Based on whether or not the child had a BMI ≥ 95th percentile, meeting the criteria for childhood obesity;<sup>b</sup>Health Outcomes from Positive Experiences; <sup>c</sup>all analyses based on block 3; <sup>d</sup>positive childhood experiences; <sup>e</sup>adverse childhood experiences; <sup>f</sup>95% confidence interval; \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$ 

meal habits, parents' behaviors, activity levels, screen time, household rules, mental health, emotional regulation, government policies, and other factors are associated with childhood obesity (Boonpleng et al., 2013; Sahoo et al., 2015; Williams et al., 2018). Given the numerous factors influencing childhood obesity, the link between ACEs, protective factors, and obesity may be more complex than other outcomes. Thus, protective factors may have a more indirect influence on childhood obesity by influencing other factors linked to childhood obesity not included in this study, like exercise or nutrition. In support of this explanation, the protective factors identified in this study that had the strongest association with childhood obesity were those associated with physical activity and

food consumption, like mastery, after-school activities, and self-regulation. Future studies should include other factors associated with obesity and explore whether they mediate the association between protective factors and childhood obesity. Also, the items on the NSCH did not fully capture the protective factors as described by the original theorists. The HOPE framework measures used were also adopted by future researchers and not identified by the original developers of the framework (Sege & Harper Browne, 2017). The HOPE framework could potentially be strengthened by the addition of other protective factors within the four protective categories. Thus, studies using instruments that fully capture the protective factors as described by the original developers of the

NSCDC and HOPE frameworks are needed to further validate these models and could account for more variance in childhood obesity.

The second aim explored whether the addition of a cumulative PCE score from each framework strengthened the association between each framework and childhood obesity. Consistent with the researchers' hypothesis, the cumulative PCE score did not strengthen the association between either framework and childhood obesity. These findings contrast with previous studies that found higher cumulative PCE scores were associated with more positive outcomes among those experiencing ACEs (Baglivio & Wolff, 2020; Bethell et al., 2019; Crandall et al., 2019; Novak & Fagan, 2022; Robles et al., 2019). However, unlike those studies, this study explored whether the addition of a cumulative PCE score added any protective value above the individual factors. Previous ACEs researchers have found that not all ACEs are equal, with certain ACEs having greater impacts than others on negative outcomes (Lacey & Minnis, 2020; Negriff, 2020; Sayyah et al., 2022). Thus, this study suggests that the most salient protective factors may have a stronger association with childhood obesity. Future studies should explore if a similar association exists with other outcomes. Another explanation is that the PCEs in this study differed from previous studies. Cumulative PCE scores with different protective factors may have a stronger link with childhood obesity. Research is needed to identify the most relevant PCEs to better understand the framework's effectiveness.

Each of the three resilience frameworks uses a unique approach to identifying and integrating protective factors. The NSCDC framework identifies four specific protective factors. The HOPE framework identifies four broad categories of protective factors across ecological levels without specifying the individual protective factors. The cumulative PCEs framework seeks to maximize protective factors without identifying the specific protective factors. This study's findings highlight some of the distinct advantages and disadvantages of each approach. While two NSCDC protective factors were associated with childhood obesity, the others were not. By not using a socio-ecological approach, the NSCDC framework failed to integrate factors from various ecological levels that were associated with childhood obesity. While identifying the strongest protective factors is more pragmatic and parsimonious for interventions, they may not be identical across outcomes and must be fully identified to be effective. Due to its ecological approach, the HOPE framework identified a community-level protective factor not identified by the NSCDC framework. However, since the HOPE framework does not identify specific protective factors, previous HOPE framework studies omitted one of the strongest protective factors in this study, self-regulation. Consequently, one of the weaknesses of using broad categories of protective factors is that the individual

protective factors may be interpreted and implemented inconsistently. The study's findings also suggest that frameworks targeting the strongest protective factors are more effective than maximizing the number of protective factors using the cumulative PCEs framework. However, this finding should be taken with caution as different combinations of protective factors may be more effective. Building on these findings, researchers should consider how these approaches may be integrated by identifying the most salient protective factors across ecological levels for key outcomes along with considering what factors matter most for cumulative protection against ACEs.

## Protective Factors

For the third aim, the researchers hypothesized that a supportive parent/caregiver relationship, self-regulation, and a supportive neighborhood would have the strongest association with childhood obesity. This hypothesis was partially supported. Consistent with a previous NSCDC study (Keane & Evans, 2022), self-regulation was one of the strongest protective factors. In the full sample after controlling for ACEs, children with strong self-regulation were 1.27 (1/0.79) times less likely to be obese. Unlike the previous NSCDC study and in contrast to the NSCDC framework (Keane & Evans, 2022; NSCDC, 2015), a strong parent/caregiver relationship was not associated with a lower likelihood of childhood obesity. While not hypothesized, mastery was one of the strongest protective factors across analyses. In the full sample after controlling for ACEs, children who exhibited mastery were 1.27 (1/0.79) times less likely to be obese. One explanation for the strength of self-regulation and mastery may be their more direct link with obesity. Previous research has established that a lack of balance between energy use and consumption is one of the strongest factors associated with childhood obesity (Wyszyńska et al., 2020). In this study, mastery included participation in extracurricular activities, which has a direct link with energy use and is one of the most important modifiable factors in reducing childhood obesity (Wyszyńska et al., 2020). Self-regulation has also been associated with higher levels of physical activity and energy consumption (Dohle et al., 2018; Wills et al., 2007). Thus, protective factors more closely associated with the causes of obesity may be more effective. In contrast, while previous research has linked parent relationships and attachment to childhood obesity, researchers have theorized that self-regulation may mediate the association between parent/child relationships and childhood obesity (Anderson & Keim, 2016). Also, the parent/caregiver relationship measure on the NSCH does not fully capture all characteristics of resilience-building relationships (CDC, 2013) or early parent-child attachment that may protect against childhood obesity (Santos et al., 2021). Thus, studies should consider

whether parent/caregiver relationships and other protective factors may indirectly impact childhood obesity through self-regulation and other factors more closely related to childhood obesity using measures more consistent with the NSCDC framework.

As hypothesized when using the HOPE framework, living in a supportive neighborhood was one of the strongest protective factors across analyses, consistent with a previous HOPE framework study of childhood obesity (Crouch et al., 2022). When including ACEs, children in a supportive neighborhood were 1.16 (1/0.86) times less likely to be obese. Previous research has linked supportive neighborhoods with increased levels of physical activity and lower levels of obesity (Franzini et al., 2009). Consequently, children who live in neighborhoods where they feel supported and connected likely have higher levels of social engagement and activity outside the home. Across analyses, after-school activities were the strongest protective factor. In the full sample that included ACEs, children who participated in after-school activities were 1.32 (1/0.76) times less likely to be obese. Due to the direct association between participating in extracurricular activities and physical activity, this further demonstrates that the most salient protective factors were the ones mostly directly related to factors contributing to childhood obesity (Wyszyńska et al., 2020). These findings also suggest that the strongest protective factors may differ by outcome.

As discussed previously, some NSCDC and HOPE framework protective factors utilized the same or similar NSCH items even though they were conceptualized differently. Across frameworks, the similar mastery items from the NSCDC framework and extracurricular activity items from the HOPE framework had one of the strongest associations with childhood obesity. While the NSCDC framework framed this protective factor as mastery or the opportunity to build self-efficacy, the HOPE framework framed this factor as an opportunity for social engagement and developing connections (NSCDC, 2015; Sege & Harper Browne, 2017). Based on the NSCH item, the impact of participation in these extracurricular activities is unclear. Nevertheless, there is an association between these variables. Thus, research is needed to determine which aspects of participation in these activities build resilience against ACEs. This could have important implications for generalizability to other types of strategies that may promote these protective factors. Further, while the HOPE framework category of learning emotional and social competencies seems to align with self-regulation, prior HOPE framework researchers using the NSCH focused on the ability of children to express challenges and feelings rather than the self-regulation item used by the NSCDC framework of staying calm when experiencing challenges (Crouch et al., 2022; Keane & Evans, 2022). Thus, future studies should consider whether self-regulation fits within

this HOPE category to strengthen the overall framework. While the items were also the same for mentoring relationships and other adult relationships, neither was associated with childhood obesity. Collectively, these findings highlight the need for future research to refine the specific protective factors within each framework, develop instruments to specifically measure each framework's protective, and consider whether these protective factors can be combined in an integrated framework.

While NSCDC and HOPE protective factors were associated with childhood obesity, some covariates had a stronger association with childhood obesity than the previously identified protective factors. In the analysis including ACEs, parental education, sex, race/ethnicity, and socioeconomic status had a stronger association with childhood obesity than the identified protective factors. Parents' highest education had the strongest association across analyses. Children in households where the parent's highest level of education was high school were 2.07 to 2.12 times more likely to be obese after controlling for ACEs than those with a college degree. These findings demonstrate the complexity of factors contributing to childhood obesity among children, including those who have experienced ACEs. Ecological approaches like the HOPE framework could be strengthened by considering other protective from various ecological levels while recognizing the influence of other social determinants of health. Future research should consider how to integrate upstream protective factors that may be addressed at a policy, organizational, or community level to gain a fuller picture of factors that build resilience against the impact of ACEs on childhood obesity (CDC, 2019; Nobles et al., 2021).

### Strengths, Limitations, and Implications

This study made several contributions to the literature. This was the first known study to compare the effectiveness of three resilience frameworks among children who experienced ACEs. Moreover, the study also took the unique approach of determining whether the addition of a cumulative PCE score strengthened the association between each framework and childhood obesity. The findings demonstrated that the most salient protective factors have a stronger link with childhood obesity than a cumulative score, with some preliminary evidence that ecological frameworks may be more effective. This study expanded the evidence base for the NSCDC and HOPE frameworks. While a previous study explored the association between the NSCDC framework and childhood mental health (Keane & Evans, 2022), the current study was the first study to explore the association between the NSCDC framework and childhood obesity. Additionally, while a prior HOPE framework study explored the association between individual protective



factors and childhood obesity (Crouch et al., 2022), this study was the first examination of the framework's overall effectiveness with childhood obesity. Importantly, this study also took a step further by investigating these associations after controlling for ACEs to examine the association between these frameworks and childhood obesity among children who experienced ACEs. Further, due to the differing approaches of each framework, this study was able to identify the strengths and weaknesses of frameworks that identify specific protective factors, identify broad categories of protective factors, and seek to maximize the number of protective factors.

Nevertheless, this study had several limitations. Even though previous NSCDC and HOPE studies utilized the NSCH, the survey items did not fully capture the protective factors as described by the original developers (NSCDC, 2015; Sege & Harper Browne, 2017). Also, due to the way the protective factors were conceptualized in previous NSCH NSCDC and HOPE framework studies, there were overlap and discrepancies between how certain items on the NSCH were categorized. Further, the HOPE framework could possibly be strengthened with the inclusion of other NSCH items not included in previous HOPE framework studies. Also, since no consensus exists on the protective factors to be included in PCEs scores, the cumulative PCEs score utilized each framework's protective factors as opposed to those used in previous studies. Future studies are needed using instruments designed to capture each framework's protective factors as described by the original developers. Studies are also needed to define the specific protective factors more clearly within the HOPE and cumulative PCEs frameworks. Since the primary focus of this study was comparing resilience frameworks, the study did not consider how protective factors or cumulative PCEs scores interact with ACEs to build resilience against childhood obesity. Future studies should consider how protective factors or PCE scores may interact to mitigate the impact of ACEs on childhood obesity.

Causal or temporal associations also could not be determined in this study due to the cross-sectional nature of the study. Further, conclusions cannot be drawn on the bi-directional association between childhood obesity and some of the protective factors (i.e., mastery/extracurricular activities). Also, the NSCH had lower response rates among some higher risk demographic groups while certain demographic groups and children with more ACEs were more likely to be excluded from the sample due to missing data. Thus, some populations may be underrepresented in the study sample. The NSCH also utilized parent or caregiver-reported data, which may not fully represent the experiences and perspectives of the children in this study. This study also utilized BMI to determine childhood obesity. While recognized as an appropriate measure of childhood obesity, BMI has

limitations as it is a measure of body mass that may not account for those with more or less body mass due to athletic training, differing developmental stages, and other factors; additional measures should be used to confirm findings in a clinical setting (U.S. Department of Health & Human Services & Centers for Disease Control and Prevention, 2011). Further, self-reported height and weight used to calculate BMI, particularly from a parent or caregiver, have lower reliability than BMI calculated from actual measurements (Karchynskaya et al., 2020). Thus, future studies should seek to replicate these findings using measured BMI with subsequent confirmatory measures. The ACEs on the NSCH also did not align with the ACEs in the original ACEs study (Felitti et al., 1998). While the NSCDC and HOPE frameworks significantly improved each model, the amount of variance in childhood obesity explained by each model was relatively low. Thus, other factors not included in the study contributed to much of the variance. Finally, while protective factors from the NSCDC and HOPE frameworks were associated with childhood obesity, some covariates had a stronger association with childhood obesity.

Despite these limitations, this study had several important implications. First, the study established that the NSCDC and HOPE frameworks were associated with childhood obesity after controlling for ACEs. Also, the addition of a cumulative PCE score did not strengthen the association between either framework and childhood obesity. This suggests that interventions focusing on the strongest protective factors may be most effective. Strong self-regulation, mastery/after-school activities, and supportive neighborhoods were also associated with a lower likelihood of childhood obesity. However, the strongest protective factors associated with childhood obesity differed somewhat from those associated with mental health based on a previous study (Keane & Evans, 2022) and another manuscript in preparation by the authors. Thus, future research should examine how protective factors may differ across outcomes among children who experienced ACEs. Future research is also needed to identify other potential protective factors consistent with these frameworks, explore moderating factors, establish instruments that better measure each framework, explore these frameworks with other outcomes, and determine if a combination of these frameworks may be more effective. Nevertheless, the findings still have implications for future interventions.

This study also identified several covariates such as parental education, race/ethnicity, age, sex, and exposure to ACEs that were associated with childhood obesity. Interventions should target social determinants of health related to these variables, along with interventions that prevent ACEs, to reduce the risk of childhood obesity. The study identified that strong self-regulation, mastery/after-school activities, supportive neighborhoods, and household income were

associated with childhood obesity. To reduce the likelihood of childhood obesity, interventions are needed to empower communities, schools, and families to utilize strategies to improve child self-regulation while encouraging and increasing child participation in after-school activities. Ecological approaches that strengthen community cohesion while reducing economic disparities may also be promising.

## Conclusions

When comparing the NSCDC, HOPE, and cumulative PCEs frameworks, this study found that the NSCDC and HOPE frameworks were associated with a lower likelihood of childhood obesity among children experiencing ACEs. Three protective factors were associated with a lower likelihood of childhood obesity among children experiencing ACEs. This study demonstrated the promise of both frameworks, but future research is needed to further validate these frameworks with these and other outcomes. These findings are important in guiding future ACEs interventions to build resilience against the negative impact of ACEs on childhood obesity.

**Author Contribution** All authors contributed to the study's conceptualization and design. Material preparation, statistical analysis, and the first draft of the manuscript were written by Kevin Keane. Retta Evans provided supervision; Larrell Wilkinson assisted with the statistical analysis. All authors commented/provided edits on previous versions of the manuscript and also read/approved the final manuscript.

**Data Availability** The data used in this study was from the 2018, 2019, and 2020 National Survey for Children's Health, which is a publicly available data source. The data can be accessed from the United States Census Bureau at the following link: <https://www.census.gov/progr/ams-surveys/nsch/data/datasets.html>.

## Declarations

**Ethical Approval** Data used in this study was de-identified, secondary data from the 2018–2020 National Survey of Children's Health that was determined to be not human subjects research based upon review by the University of Alabama at Birmingham Institutional Review Board.

**Conflict of Interest** The authors declare no competing interests.

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