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# Identification of positive childhood experiences with the potential to mitigate childhood unhealthy weight status in children within the context of adverse childhood experiences: a prospective cohort study

Brooklyn M. Mellar<sup>1,2</sup>, Maryam Ghasemi<sup>3</sup>, Pauline Gulliver<sup>1</sup>, Barry Milne<sup>4</sup>, Fiona Langridge<sup>1</sup>, Tracey McIntosh<sup>5</sup>, Christa Fouché<sup>3</sup>, Boyd Swinburn<sup>1</sup> and Ladan Hashemi<sup>1,6\*</sup>

## Abstract

**Background** Despite potential protective and mitigating effects of positive childhood experiences (PCEs) on poor health outcomes, limited research has identified relevant PCEs and examined their individual and cumulative associations with weight status, or their mitigating effects on the associations between adverse childhood experiences (ACEs) and obesity in children. This study aims to develop an exploratory PCEs Index with the potential to protect against or mitigate the association between ACEs and unhealthy weight status.

**Methods** Data came from the Growing Up in New Zealand study. The analytic sample was restricted to those who provided obesity data at age 8 and one child per mother, resulting in a sample of 4,895 children. Nine individual ACEs and their cumulative scores, a newly developed PCEs index consisting of six individual PCEs and (their) cumulative scores, and an overweight/obesity variable were included in the analyses.

**Results** By age eight, experience of at least 3 PCEs was reported by 72.1% of the sample. However, the experience of the highest number of PCEs (5–6) was only reported by 23% of the sample. Four out of six assessed PCEs were associated with decreased likelihood of overweight/obesity. A dose-response effect was observed where experience of three or more PCEs was associated with decreased odds for obesity (AORs decreased from 0.77 for 3 PCEs to 0.54 for 5–6 PCEs). No consistent mitigating effects were found for individual PCEs; however interactions were found between reporting at least four of the six PCEs, experience of cumulative ACEs, and reduced odds for overweight/obesity at age 8.

**Conclusions** A critical number of PCEs may be required to mitigate the detrimental impacts of ACEs on weight status among children. These findings reinforce the need to consider a constellation of strength-focused ecological domains to alleviate the burden of childhood obesity, particularly for children exposed to multiple adversities.

\*Correspondence:

Ladan Hashemi  
Ladan.hashemi@city.ac.uk

Full list of author information is available at the end of the article



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**Keywords** Positive childhood experiences, Adverse childhood experiences, Childhood obesity, Mitigation

## Introduction

Overweight and obesity in childhood have long-term impacts on health and wellbeing [1–4], and rates are increasing internationally [5]. In light of unsuccessful child obesity reduction efforts, the contributions of a broader range of social, emotional, and environmental contexts of child development must be examined to gain a more complete understanding of possible risk and protective factors for unhealthy weight in children [6, 7].

International research has shown that individuals impacted by Adverse Childhood Experiences (ACEs) are at greater risk of developing obesity [7–9], in addition to a range of poor physical and mental health outcomes across the lifespan [10–13]. ACEs include indicators of child abuse and family dysfunctions (e.g., mental illness, substance abuse, incarceration, parental separation or death, and intimate partner violence) [10, 12]. Most research linking ACEs and obesity has measured this relationship in adults, but there is limited information about this risk in children [8]. In response to critiques that ACEs research overemphasizes risks in lieu of protective factors [14, 15], research has recently begun to identify positive childhood experiences (PCEs) that may promote childhood resilience, healthy development, and counter the damaging effects of adversity [15–19]. PCEs encompass a range of domains including family and parenting environment, healthcare services and education, peer relationships, cultural and community connectedness, and neighborhood environment [20, 21].

PCEs remain relatively underexplored compared with ACEs research [22]; for example, most existing data has relied on small or non-representative and standardized PCE measurement tools are underdeveloped or designed for retrospective assessment of PCEs during adulthood [20, 21, 23]. Further, prior research has focused on the protective role of PCEs using a limited range of PCEs [20, 24], or independently examined individual PCEs [17]. Scholars have emphasized the need for ecological models of childhood experiences that draw on a constellation of environmental factors [17]. This aligns with theoretical frameworks such as Bronfenbrenner's Ecological Systems Theory [25], which posits that child development is influenced by a range of interconnected systems, within which ACEs and PCEs coexist and shape outcomes [20, 21].

Resilience has been posited as a protective mechanism for obesity prevention in childhood [8]. Understanding what differentiates children who exhibit resilience is critical for improving the effectiveness of health-related prevention and intervention efforts for children exposed to adversity. Research shows that resilience-building

traits, (such as self-esteem, emotional regulation, and prosocial skills), equip children to manage stress, foster positive social interactions, and maintain a sense of self-worth [26–28]. PCEs contribute to the development of resilience-building traits [29], which may potentially disrupt the theorized biological pathways linking ACEs to poor health and well-being [20, 30–34]. However, limited research has examined the association between PCEs and weight status or their mitigating effects in ACEs-obesity association in children and adolescents [24, 35]. Further research is required to understand these connections and to identify crucial intervention points for addressing physical and mental health challenges associated with ACEs [17]. The present study aims to address these gaps by developing an exploratory PCE Index to further understanding of the relationship between PCEs and unhealthy weight status in a prospective cohort of New Zealand (NZ) children, with potential to mitigate the association between ACEs and unhealthy weight status. This study focuses on identifying PCEs that may be modifiable through public health interventions or policy initiatives, which, unlike non-modifiable factors such as genetic predispositions, are actionable targets for child obesity reduction efforts.

## Methods

### Population and data

Participants were members of Growing Up in NZ (GUiNZ), a contemporary NZ-based prospective cohort study, for which methodological details can be found elsewhere [36]. The study antenatally recruited 6853 children born between 2009 and 2010; characteristics of the original cohort aligned with the national birth cohort during 2007–2010 [36]. Data collection waves (DCWs) used face-to-face and phone interviews to gather information on various aspects of the children's development and family environment. Ethics approval was granted by the NZ Ministry of Health Northern Y Regional Ethics Committee, and all enrolled parents provided informed consent.

Follow-up procedures included regular data collection points from pregnancy through various stages of the children's development. Major DCWs occurred antenatally, at birth, at 6 weeks, at 9 months, at 2 years, at 4.5 years, and at 8 years, up to the time of this study.

The current study was restricted to one child per participating mother and to those who provided obesity data during the age 8 DCW (2017–2019), resulting in an analytic sample of 4,895 children. Compared to children recruited at baseline, children lost to attrition by DCW8 were more likely to be in lower socioeconomic groups, of

an ethnicity other than European, have younger mothers, and present BMI in the range of overweight/obesity at age 4.5 years (Supplementary Table 3).

Reporting of this analysis follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [37].

## Key measures

### ACEs

A literature review was conducted to compile a comprehensive list of commonly studied ACEs. All available GUiNZ datasets and instruments (from antenatal data collection up to age 8) were systematically reviewed to identify proxies for commonly investigated ACEs. To capture a wide range of adversities and reduce bias associated with parental reporting, we included both child and parent reports and utilised standardised questionnaires across eight waves of GUiNZ data.

Specifically, we constructed dichotomous indicators of exposure for nine ACEs: child exposure to emotional abuse, physical abuse, parental substance (alcohol/drug) abuse, parental mental illness, parental incarceration, parental separation/divorce, intimate partner violence (IPV) against the mother, maternal experience of ethnic discrimination, and peer bullying. Each ACE was identified through multiple questions, with predetermined criteria applied to synthesise responses; an ACE was considered present if it was reported in one or more questions, regardless of any inconsistencies across responses. Due to the absence of direct data on children's personal experiences of ethnic discrimination, we used the mother's exposure to ethnic discrimination as a proxy for this ACE.

An ACE score (0, 1, 2, 3, or 4+ ACEs) was generated to reflect the cumulative exposure to adversities. ACE measures are detailed in Supplementary Table 1.

### Overweight/obesity

Body mass was measured by interviewers collecting child's weight and height measurements during the DCW at age 8. BMI-for-age z scores were derived using World Health Organization 2006 child growth chart standards and binarized into normal or underweight versus overweight or obesity. Combined overweight/obesity was used to ensure sufficient data density for interactions and enable comparability with prior studies [24]. BMI categories were utilized to enhance the clarity of the findings for non-specialists (such as policymakers, educators, and healthcare providers), supporting the translation of them into interventions and policy recommendations.

### PCEs

Given the plethora of instruments and variables collected on potential PCEs in GUiNZ, a post-hoc approach

was employed for PCEs selection to explore the under-researched field of PCEs and child weight. PCEs were based on the Healthy Outcomes Positive Experiences (HOPE) Framework developed by Sege and Browne, as it provided a well-supported conceptual basis for development of a PCE Index using available GUiNZ data [15, 38]. HOPE comprises four broad categories for PCEs to align with: (1) being in nurturing, supportive relationships, (2) living, developing, playing, and learning in safe, stable, protective, and equitable environments, (3) having opportunities for constructive social engagement and connectedness, (4) learning social and emotional competencies [15].

PCE measures which focused on the presence of assets (rather than absence of adversity) were mapped to three HOPE categories, as the fourth domain (learning social and emotional competencies) may be an indicator of outcomes [22]. PCEs collected prior to DCW8 were prioritized to enable temporal sequencing by comparison with age 8 outcomes.

For refinement, PCEs were selected if they were achievable and modifiable, and met at least one of the following criteria:

- Associated with reduced odds of reporting overweight/obesity at age 8 (after sociodemographic adjustment), to test predictive validity of the PCE index for overweight/obesity;
- Interacted with reduced odds of reporting overweight/obesity at age 8 (after sociodemographic adjustment) for at least one ACEs score;
- Closely bordered decreased odds for overweight/obesity at age 8, if supported by published literature.

Six PCEs were selected: parents in a committed relationship, mother interacted well with child, mother involved in social groups, child engaged in experiences and activities, child lived in a house with routines and rules, and child attended effective early childhood education. PCE measures were transformed into binary variables (Yes/No) set around the 55th percentile of the sample responses, to capture slightly better than average responses. PCE measures are detailed in Table 1.

PCE variables were binarized to improve result interpretability, particularly in identifying the number of PCEs needed to mitigate ACE effects. A cumulative PCE score was calculated and grouped (0–1, 2, 3, 4, and 5–6 PCEs). Given the small sample size for each cell, this enabled us to ensure adequate statistical power to detect meaningful associations and interactions (sliced up by overweight/obesity, ACEs score, and PCEs score). Four different groups of binarized PCEs scores were tested to find the optimal number of PCEs with the potential to mitigate

**Table 1** Measures used to define positive childhood experiences using data from the Growing up in New Zealand Study

| PCE                                         | HOPE Category                                                                                                                                   | Data Collection Wave (DCW) | Questions & Response Options                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Threshold/Scoring                                                                                                              | Notes                                                                                                                                                                                                                                                                                                                                                                     |
|---------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mother in committed relationship            | (2) Living in a safe & stable environment                                                                                                       | 1, M                       | "I want to grow old with my partner"<br>"When I imagine what my life will be like in the future, I always see my partner standing next to me"<br>Likert Scale: (1) Strongly disagree, (2) disagree, (3) not sure, (4) agree, (5) strongly agree                                                                                                                                                                                                                                                                                                                                                                                                               | Median/55th percentile<br>'Strongly agree' to both questions (score: 10), versus low personal commitment or having no partner. | Questions pertaining to moral and structural commitment were excluded as the three measured types of commitment can be differently associated with outcomes, and have low correlation with each other [63].                                                                                                                                                               |
| Mother interacted well with child           | (1) Being in nurturing, supportive relationships                                                                                                | 5, O                       | Children and their mothers undertook a set task (creation of a party invitation), and via observed measures interviewers assessed the quality of how the mother interacted: a) promoted the child's learning (used who/what/where/how/ why questions and engaged in print talk e.g., "How do you draw a b"; b) provided support and sensitive assistance (mother and child completed task together, versus either dominating the task), and c) gave warmth and encouragement (instances of praise e.g., "Nice one!").                                                                                                                                         | Median/55th percentile<br>Derived from continuous score from four measures.                                                    | A measure on child's focus during the task was excluded to center the mother's role in the interaction and to ensure that the measure was not inadvertently biased against children with behavioral issues. The task has been used among a broad range of cultures and socioeconomic backgrounds [64, 65]. Further detail on this measure is provided elsewhere [66].     |
| Mother involved in social groups            | (3) Having opportunities for constructive social engagement & connectedness.                                                                    | 1, M                       | "Do you belong to any of these social networks, groups or organizations":<br>9 options: sports club; church or spiritual group; hobby or interest group; community/voluntary group; education group; parent and baby; ethnic/cultural groups; Marae; family/whanau; online group; people from work/school; other                                                                                                                                                                                                                                                                                                                                              | Median/55th percentile<br>At least 2 groups                                                                                    | As in the HOPE principles, children's PCEs also encompass their parents' positive experiences; mother's social engagement and participation in social and community groups has been posited to provide a link between family and community via parental support and social integration, and influence child perception of and participation in organized activities [67]. |
| Child engaged in experiences and activities | (2) Developing, playing & learning in safe & stable environments<br>(3) Having opportunities for constructive social engagement & connectedness | 2, M                       | "Which of the these activities [child] has done or places [child] has been at any time since [he/she] was born":<br>37 options: library; park; beach; Santa parade; cinema; church, temple, mosque; art gallery; swimming lessons; music groups; playgroup; zoo; aquarium; museum; Diwali; lantern festival; Matariki; White Sunday; flea market; farmers market; Pasifika festival; Polyfest; Marae event; agricultural field days; mustering; nature walks; coffee groups; organised physical activity; picnics; watching sports; community galas/fairs; overseas travel; transport experience; aquatic/outdoor activities; concert, play, live show; other | Median/55th percentile<br>At least 13 activities                                                                               |                                                                                                                                                                                                                                                                                                                                                                           |

**Table 1** (continued)

| PCE                                                       | HOPE Category                                                                                                                                                                                                                  | Data Collection Wave (DCW) | Questions & Response Options                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Threshold/Scoring                                                                                                                                                                                                                        | Notes                                                                                                                                                                                                                                                                                                                                                                                                       |
|-----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Child lived in a home with routines and rules             | (2) Living, developing, playing, & learning in safe & stable environments                                                                                                                                                      | 2 & 4, M                   | <p>a) "Are there rules about: what TV programs your child can watch? How many hours of TV, videos, and DVDs your child can watch? When your child watches TV?"</p> <p>"How often do you make sure your child follows the rules about TV use?" All of the time, most of the time, half of the time, less than half of the time, never.</p> <p>b) "Does [name] go to bed at a similar time each night?" Never, sometimes, usually, always.</p> <p>c) "How many days a week does your family including [name] usually sit together to eat any main meal? Includes occasions when not all family members are present."</p>                          | <p>If all three thresholds were met:</p> <p>a) Has TV rules or no TV, enforced at least most of time (reported by 53.6% of sample)</p> <p>b) Bedtime usually or always consistent (92.5%)</p> <p>c) At least 6 days per week (81.6%)</p> | Home routines constitute part of having a safe and stable home, as well as conferring health benefits for sufficient sleep and non-sedentary playtime. Similar iterations of this PCE have been explored in various studies [17, 21, 62, 68].                                                                                                                                                               |
| Mother was satisfied with early childhood education (ECE) | <p>(1) Being in nurturing, supportive relationships</p> <p>(2) Developing, playing &amp; learning in safe &amp; stable environments</p> <p>(3) Having opportunities for constructive social engagement &amp; connectedness</p> | 5, M                       | <p>"How satisfied are you with the effect that this early childhood education or care arrangement has had on your child's:"</p> <p>10 domains: independence, social skills (playing, joining in, relationships with others); development of language &amp; communication; development of cultural awareness &amp;/or belonging; pre-writing/writing skills; pre-reading/reading skills; skills with numbers; physical or motor skills; interest in music or singing; interest in learning &amp; exploring. Likert scale: (1) very satisfied, (2) satisfied, (3) neither satisfied nor dissatisfied, (4) dissatisfied, (5) very dissatisfied</p> | <p>55th percentile</p> <p>Derived from continuous score from 10 Likert scales. Those who did not attend ECE were marked as not having this PCE.</p>                                                                                      | <p>Mother's report of satisfaction of ECE effect on child can be considered a proxy for the quality of ECE. No involvement in ECE may limit children from opportunities to learn in safe environments, especially for those who have experienced ACEs. It has been previously contended that children's involvement in quality childcare can have a protective effect for the impacts of ACEs [69, 70].</p> |

Note. DCW number corresponds to child's age. M=Mother; O=Observed by interviewer. Median/55th percentile indicates that the median score and score at the 55th percentile were the same

the impact of ACEs on the outcome variable (0–1 vs. 2–6, 0–2 vs. 3–6, 0–3 vs. 4–6, 0–4 vs. 5–6).

Certain PCEs from later GUINZ waves were omitted from our list due to potential social desirability biases or insufficient predictive validity with weight status. While the ACEs list includes adversities up to age 8, the final list of PCEs encompasses positive experiences in the child's life up to age 5, in attempt to capture early exposure to resilience-building factors that may precede experience of ACEs.

### Covariates

Sociodemographic variables were used to explore the prevalence rates of ACEs scores, individual PCEs and PCE scores, and the overweight/obesity indicator among sub-populations and as potential confounders in multivariable analyses. Demographic characteristics of the child were child's sex and ethnicity. Socioeconomic status

measures included food insecurity and area deprivation level [39].

### Analytic methods

Statistical analyses were performed using Stata 15 [40]. Prevalence rates for all variables were computed, and bivariate associations between sociodemographic characteristics and ACEs scores, individual PCEs, PCE scores, and overweight/obesity were evaluated using  $\chi^2$  tests (Tables 2 and 3).

Associations between individual PCEs and PCEs scores and overweight/obesity were assessed using logistic regression analyses, presenting odds ratios unadjusted and adjusted for sociodemographic characteristics (Table 4). Associations between ACEs scores and overweight/obesity were assessed using logistic regression analyses and are reported as unadjusted and adjusted odds ratios in Table 5.

**Table 2** Sociodemographic distribution of the GUINZ sample, ACEs scores, and overweight/obesity, and prevalence of overweight/obesity by ACEs scores

|                                                   | Total <sup>a</sup> | ACEs score              |                    |                       |                   |                         | Overweight/obesity (BMI) |
|---------------------------------------------------|--------------------|-------------------------|--------------------|-----------------------|-------------------|-------------------------|--------------------------|
|                                                   |                    | 0                       | 1                  | 2                     | 3                 | 4+                      |                          |
|                                                   | <b>4,895 (100)</b> | <b>640 (12.9)</b>       | <b>1355 (27.4)</b> | <b>1334 (27.0)</b>    | <b>828 (16.7)</b> | <b>789 (16.0)</b>       | <b>1682 (34.36)</b>      |
| <b>Gender</b>                                     |                    |                         |                    |                       |                   |                         |                          |
| Boy                                               | 2,522 (51.5)       | 303 (11.9)              | 689 (27.1)         | 693 (27.2)            | 432 (16.9)        | 433 (17.0)              | 895 (35.49)              |
| Girl                                              | 2,373 (48.5)       | 337 (14.1)              | 666 (27.8)         | 641 (26.8)            | 396 (16.5)        | 356 (14.9)              | 787 (33.16)              |
| $\chi^2$ (p-value)                                |                    |                         |                    | 8.52 (0.07)           |                   |                         | 2.93 (0.087)             |
| <b>Child's prioritised ethnicity<sup>b</sup></b>  |                    |                         |                    |                       |                   |                         |                          |
| Māori                                             | 1,099 (22.8)       | 85 (7.7)                | 199 (17.9)         | 298 (26.8)            | 216 (19.5)        | 313 (28.2)              | 495 (45.04)              |
| Pacific                                           | 524 (10.9)         | 27 (5.0)                | 82 (15.3)          | 126 (23.5)            | 131 (24.4)        | 171 (31.8)              | 358 (68.32)              |
| Asian                                             | 695 (14.4)         | 75 (10.7)               | 175 (24.9)         | 219 (31.1)            | 130 (18.5)        | 105 (14.9)              | 181 (26.04)              |
| MELAA                                             | 105 (2.2)          | < 10 <sup>f</sup> (8.6) | 35 (33.3)          | 35 (33.3)             | 18 (17.1)         | < 10 <sup>f</sup> (7.6) | 29 (27.62)               |
| European                                          | 2,406 (49.8)       | 431 (17.8)              | 853 (35.3)         | 638 (26.4)            | 318 (13.2)        | 179 (7.4)               | 595 (24.73)              |
| $\chi^2$ (p-value)                                |                    |                         |                    | <b>579.85 (0.001)</b> |                   |                         | <b>446.06 (0.001)</b>    |
| <b>Experienced food insecurity<sup>c</sup></b>    |                    |                         |                    |                       |                   |                         |                          |
| No                                                | 3,689 (80.9)       | 543 (14.62)             | 1134 (30.5)        | 1053 (28.5)           | 566 (15.2)        | 418 (11.3)              | 1,116 (30.25)            |
| Yes                                               | 871 (19.1)         | 62 (7.0)                | 141 (15.9)         | 189 (21.3)            | 193 (21.8)        | 301 (33.9)              | 423 (48.56)              |
| $\chi^2$ (p-value)                                |                    |                         |                    | <b>354.59 (0.001)</b> |                   |                         | <b>105.68 (0.001)</b>    |
| <b>Area deprivation level (NZDep)<sup>d</sup></b> |                    |                         |                    |                       |                   |                         |                          |
| Least                                             | 1,745 (35.8)       | 308 (17.5)              | 610 (34.7)         | 491 (27.9)            | 221 (12.6)        | 128 (7.3)               | 454 (26.02)              |
| Moderate                                          | 1,841 (37.8)       | 242 (13.1)              | 521 (28.1)         | 517 (27.9)            | 320 (17.3)        | 256 (13.8)              | 568 (30.85)              |
| Most                                              | 1,283 (26.4)       | 86 (6.6)                | 218 (16.7)         | 317 (24.3)            | 280 (21.5)        | 403 (30.9)              | 650 (50.66)              |
| $\chi^2$ (p-value)                                |                    |                         |                    | <b>468.64 (0.001)</b> |                   |                         | <b>215.14 (0.001)</b>    |
| <b>Overweight/obesity<sup>e</sup></b>             |                    | 141 (22.2)              | 386 (28.7)         | 437 (33.0)            | 327 (40.0)        | 391 (50.5)              | -                        |
| $\chi^2$ (p-value)                                |                    |                         |                    | <b>162.76 (0.001)</b> |                   |                         |                          |

Note. <sup>a</sup> The total sample used in the present study was restricted to those who had obesity data at DCW8

<sup>b</sup> Ethnicity (DCW4) was externally prioritized based on NZ Ministry of Health protocol to the categories: Māori (NZ indigenous peoples), Pacific peoples, Asian, Middle Eastern/Latin American/African (MELAA), and NZ European/New Zealander/Other ('European'). European and New Zealanders were combined as the majority of those who identify as New Zealanders are European [71]

<sup>c</sup> Food security was identified if the mother confirmed that they could "always" afford to eat properly. Responses of "sometimes" or "never" were recorded as indicating food insecurity (DCW8)

<sup>d</sup> 2013 Index of Deprivation [39], categorized into "Least deprived (NZDep 1–3)", "Moderately deprived (NZDep 4–7)", and "Most deprived (NZDep 8–10)"

<sup>e</sup> For prevalence of overweight/obesity by each ACEs score, column percentages are presented

<sup>f</sup> Cells have fewer than 10 counts. Exact numbers not reported to protect the anonymity of participants

The bold font indicates significant p-value at  $p < .05$

**Table 3** Distribution of individual PCEs and PCEs scores in the GUINZ sample ( $n = 4,895$ ) by sociodemographic characteristics and ACEs scores

|                                | Individual PCEs, n(%)            |                                    |                                  |                              |                                          | PCEs score, n(%)              |            |             |                        |              |              |
|--------------------------------|----------------------------------|------------------------------------|----------------------------------|------------------------------|------------------------------------------|-------------------------------|------------|-------------|------------------------|--------------|--------------|
|                                | Mother in committed relationship | Mother in-teracted well with child | Mother involved in social groups | Child engaged in experiences | Child lived in home with rules & routine | Mother was satisfied with ECE | 0–1 PCEs   | 2 PCEs      | 3 PCEs                 | 4 PCEs       | 5–6 PCEs     |
| Gender                         | 3,335 (69.6)                     | 2,800 (62.0)                       | 3,425 (71.4)                     | 2,599 (53.8)                 | 1,981 (40.6)                             | 2,359 (50.2)                  | 534 (10.9) | 831 (17.0)  | 1,166 (23.8)           | 1,237 (25.3) | 1,125 (23.0) |
| Boy                            | 1,713 (69.5)                     | 1,357 (59.5)                       | 1,801 (73.0)                     | 1,373 (55.2)                 | 1,011 (40.2)                             | 1,157 (49.1)                  | 286 (11.3) | 441 (17.5)  | 590 (23.4)             | 646 (25.6)   | 558 (22.1)   |
| Girl                           | 1,622 (69.7)                     | 1,422 (64.8)                       | 1,624 (69.7)                     | 1,226 (52.4)                 | 970 (41.1)                               | 1,202 (52.9)                  | 248 (10.5) | 390 (16.4)  | 576 (24.3)             | 591 (24.9)   | 567 (23.9)   |
| $\chi^2$ (p-value)             | 0.03 (0.875)                     | 13.6 ( <b>0.001</b> )              | 6.3 ( <b>0.012</b> )             | 3.9 ( <b>0.048</b> )         | 0.4 (0.514)                              | 13.3 ( <b>0.001</b> )         |            |             | 4.0 (0.408)            |              |              |
| Child's prioritised ethnicity  |                                  |                                    |                                  |                              |                                          |                               |            |             |                        |              |              |
| Māori                          | 644 (59.7)                       | 615 (60.1)                         | 751 (69.7)                       | 621 (57.3)                   | 379 (34.6)                               | 547 (51.4)                    | 126 (11.5) | 206 (18.7)  | 279 (25.4)             | 284 (25.8)   | 204 (18.6)   |
| Pacific                        | 304 (60.7)                       | 267 (56.7)                         | 352 (70.3)                       | 220 (43.3)                   | 158 (30.4)                               | 236 (48.1)                    | 89 (16.9)  | 120 (22.9)  | 133 (25.4)             | 104 (19.8)   | 78 (14.9)    |
| Asian                          | 447 (66.1)                       | 292 (49.0)                         | 407 (60.1)                       | 230 (34.0)                   | 229 (33.0)                               | 265 (39.1)                    | 150 (21.6) | 162 (23.3)  | 185 (26.6)             | 123 (17.7)   | 75 (10.8)    |
| MELAA                          | 75 (74.3)                        | 57 (63.3)                          | 74 (73.3)                        | 61 (58.1)                    | 43 (40.9)                                | 47 (39.1)                     | <10 (6.7)  | 23 (21.9)   | 20 (19.0)              | 37 (35.2)    | 18 (17.1)    |
| European                       | 1,837 (77.1)                     | 1,547 (67.5)                       | 1,813 (76.0)                     | 1,449 (60.4)                 | 1,160 (48.2)                             | 1,264 (53.4)                  | 124 (5.1)  | 302 (12.5)  | 545 (22.6)             | 686 (28.5)   | 749 (31.1)   |
| $\chi^2$ (p-value)             | 136.8 ( <b>0.001</b> )           | 79.3 ( <b>0.001</b> )              | 69.7 ( <b>0.001</b> )            | 178.2 ( <b>0.001</b> )       | 113.6 ( <b>0.001</b> )                   | 45.3 ( <b>0.001</b> )         |            |             | 412.8 ( <b>0.001</b> ) |              |              |
| Experienced food insecurity    |                                  |                                    |                                  |                              |                                          |                               |            |             |                        |              |              |
| No                             | 2,679 (73.9)                     | 2,202 (64.4)                       | 2,680 (73.9)                     | 2,101 (57.5)                 | 1,617 (43.9)                             | 1,849 (51.7)                  | 279 (7.6)  | 552 (15.0)  | 892 (24.2)             | 995 (27.0)   | 969 (26.3)   |
| Yes                            | 448 (53.0)                       | 436 (55.2)                         | 544 (64.2)                       | 366 (43.1)                   | 269 (31.1)                               | 379 (46.2)                    | 184 (21.1) | 183 (21.0)  | 205 (23.5)             | 190 (21.8)   | 109 (12.5)   |
| $\chi^2$ (p-value)             | 142.6 ( <b>0.001</b> )           | 23.4 ( <b>0.001</b> )              | 31.7 ( <b>0.001</b> )            | 57.7 ( <b>0.001</b> )        | 47.8 ( <b>0.001</b> )                    | 8.3 ( <b>0.004</b> )          |            |             | 207.3 ( <b>0.001</b> ) |              |              |
| Area deprivation level (NZDep) |                                  |                                    |                                  |                              |                                          |                               |            |             |                        |              |              |
| Least                          | 1,328 (76.9)                     | 1,053 (65.0)                       | 1,289 (74.7)                     | 1,076 (62.2)                 | 801 (46.0)                               | 889 (52.0)                    | 94 (5.4)   | 254 (14.6)  | 386 (22.1)             | 512 (29.3)   | 499 (28.6)   |
| Moderate                       | 1,295 (71.6)                     | 1,091 (63.7)                       | 1,296 (71.7)                     | 988 (54.3)                   | 767 (41.7)                               | 886 (49.9)                    | 184 (10.0) | 286 (15.5)  | 458 (24.9)             | 467 (25.4)   | 444 (24.1)   |
| Most                           | 692 (56.0)                       | 624 (55.5)                         | 827 (66.9)                       | 517 (41.4)                   | 403 (31.6)                               | 574 (48.3)                    | 251 (19.6) | 288 (24.5)  | 318 (24.8)             | 246 (19.2)   | 180 (14.0)   |
| $\chi^2$ (p-value)             | 154.6 ( <b>0.001</b> )           | 28.9 ( <b>0.001</b> )              | 21.7 ( <b>0.001</b> )            | 126.7 ( <b>0.001</b> )       | 64.9 ( <b>0.001</b> )                    | 4.0 (0.134)                   |            |             | 272.9 ( <b>0.001</b> ) |              |              |
| ACEs Score                     |                                  |                                    |                                  |                              |                                          |                               |            |             |                        |              |              |
| 0 ACEs                         | 531 (85.4)                       | 391 (67.3)                         | 468 (75.2)                       | 371 (59.1)                   | 319 (50.5)                               | 323 (52.9)                    | 30 (4.7)   | 85 (13.4)   | 133 (21.0)             | 179 (28.3)   | 206 (32.5)   |
| 1 ACE                          | 1,038 (78.1)                     | 795 (64.6)                         | 1,014 (76.3)                     | 782 (58.8)                   | 629 (46.9)                               | 671 (51.1)                    | 82 (6.1)   | 179 (13.3)  | 326 (24.3)             | 377 (28.1)   | 379 (28.2)   |
| 2 ACEs                         | 956 (74.0)                       | 764 (62.1)                         | 964 (74.5)                       | 725 (55.3)                   | 549 (41.5)                               | 668 (52.7)                    | 124 (9.4)  | 197 (14.9)  | 324 (24.4)             | 353 (26.6)   | 328 (24.7)   |
| 3 ACEs                         | 470 (59.4)                       | 426 (58.4)                         | 518 (65.5)                       | 387 (48.2)                   | 266 (32.7)                               | 370 (47.4)                    | 132 (16.2) | 177 (21.7)  | 199 (24.4)             | 181 (22.2)   | 128 (15.7)   |
| 4+ ACEs                        | 340 (44.7)                       | 403 (57.2)                         | 461 (60.7)                       | 334 (44.3)                   | 218 (28.4)                               | 327 (44.9)                    | 166 (21.5) | 24.9 (19.3) | 184 (23.8)             | 147 (19.0)   | 84 (10.9)    |
| $\chi^2$ (p-value)             | 390.9 ( <b>0.001</b> )           | 21.3 ( <b>0.001</b> )              | 82.7 ( <b>0.001</b> )            | 59.0 ( <b>0.001</b> )        | 116.8 ( <b>0.001</b> )                   | 16.0 ( <b>0.003</b> )         |            |             | 347.6 ( <b>0.001</b> ) |              |              |

**Table 4** Prevalence of overweight/obesity by individual PCEs and PCEs scores, and odds ratios for associations between individual PCEs, PCEs scores and overweight/obesity

|                                                                   | Overweight/Obesity ( <i>n</i> = 1,682) |                         |                         |
|-------------------------------------------------------------------|----------------------------------------|-------------------------|-------------------------|
|                                                                   | n(%)                                   | OR [95% CI]             | AOR [95% CI]            |
| <b>Individual PCE</b>                                             |                                        |                         |                         |
| Mother in a committed relationship ( <i>n</i> = 3,335)            | 1054 (31.6)                            | <b>0.70 [0.61–0.79]</b> | <b>0.83 [0.72–0.96]</b> |
| Mother interacted well with child ( <i>n</i> = 2,800)             | 880 (31.7)                             | <b>0.77 [0.67–0.87]</b> | <b>0.82 [0.72–0.95]</b> |
| Mother involved in social groups ( <i>n</i> = 3,425)              | 1133 (33.1)                            | <b>0.86 [0.75–0.98]</b> | 0.87 [0.75–1.01]        |
| Child engaged in experiences ( <i>n</i> = 2,599)                  | 823 (31.7)                             | <b>0.79 [0.70–0.89]</b> | <b>0.86 [0.75–0.98]</b> |
| Child lived in a home with routines and rules ( <i>n</i> = 1,981) | 572 (28.9)                             | <b>0.66 [0.58–0.75]</b> | <b>0.75 [0.66–0.86]</b> |
| Mother was satisfied with ECE ( <i>n</i> = 2,359)                 | 814 (34.5)                             | 1.04 [0.92–1.17]        | 1.04 [0.91–1.19]        |
| <b>PCE Scores</b>                                                 |                                        |                         |                         |
| 0–1 PCEs ( <i>n</i> = 534)                                        | 242 (45.3)                             | Ref.                    | Ref.                    |
| 2 PCEs ( <i>n</i> = 831)                                          | 313 (37.7)                             | <b>0.73 [0.58–0.91]</b> | <b>0.75 [0.58–0.97]</b> |
| 3 PCEs ( <i>n</i> = 1,166)                                        | 420 (36.0)                             | <b>0.68 [0.55–0.84]</b> | <b>0.77 [0.60–0.98]</b> |
| 4 PCEs ( <i>n</i> = 1,237)                                        | 410 (33.1)                             | <b>0.60 [0.49–0.74]</b> | <b>0.69 [0.54–0.88]</b> |
| 5–6 PCEs ( <i>n</i> = 1,125)                                      | 297 (26.4)                             | <b>0.43 [0.35–0.54]</b> | <b>0.54 [0.42–0.69]</b> |

AOR: Odds ratios adjusted for child's gender, food insecurity, child's ethnicity

The bold font indicates significant OR/AOR at  $p < .05$ **Table 5** Multivariable models for odds of overweight/obesity by PCEs, ACEs scores, and PCEs/ACEs interaction terms

|                                                   | <i>Model 1<sup>b</sup></i> | Overweight/obesity<br>AOR <sup>a</sup> [95%CI]        |                                           |                                           |                                           |
|---------------------------------------------------|----------------------------|-------------------------------------------------------|-------------------------------------------|-------------------------------------------|-------------------------------------------|
|                                                   |                            | <i>Model 2<sup>c</sup></i><br>0–1 (ref.) vs. 2–6 PCEs | <i>Model 3</i><br>0–2 (ref.) vs. 3–6 PCEs | <i>Model 4</i><br>0–3 (ref.) vs. 4–6 PCEs | <i>Model 5</i><br>0–4 (ref.) vs. 5–6 PCEs |
| Adjusted for SES covariates & unadjusted for ACEs | -                          | <b>0.60 [0.50–0.71]</b>                               | <b>0.69 [0.60–0.78]</b>                   | <b>0.68 [0.61–0.77]</b>                   | <b>0.62 [0.53–0.72]</b>                   |
| Adjusted for SES covariates & ACEs score          | -                          | <b>0.75 [0.60–0.94]</b>                               | 0.87 [0.75–1.01]                          | <b>0.82 [0.72–0.94]</b>                   | <b>0.75 [0.64–0.89]</b>                   |
| <b>ACE Index (Ref = 0)</b>                        |                            |                                                       |                                           |                                           |                                           |
| 1 ACE                                             | <b>1.45 [1.14–1.84]</b>    | <b>1.44 [1.14–1.83]</b>                               | <b>1.45 [1.14–1.83]</b>                   | <b>1.43 [1.13–1.82]</b>                   | <b>1.43 [1.12–1.81]</b>                   |
| 2 ACEs                                            | <b>1.51 [1.19–1.92]</b>    | <b>1.50 [1.18–1.90]</b>                               | <b>1.50 [1.18–1.90]</b>                   | <b>1.49 [1.17–1.89]</b>                   | <b>1.48 [1.17–1.88]</b>                   |
| 3 ACEs                                            | <b>1.84 [1.43–2.38]</b>    | <b>1.80 [1.39–2.33]</b>                               | <b>1.80 [1.39–2.34]</b>                   | <b>1.77 [1.37–2.30]</b>                   | <b>1.77 [1.37–2.29]</b>                   |
| 4+ ACEs                                           | <b>2.30 [1.77–3.00]</b>    | <b>2.23 [1.71–2.90]</b>                               | <b>2.23 [1.71–2.91]</b>                   | <b>2.20 [1.68–2.87]</b>                   | <b>2.20 [1.68–2.86]</b>                   |
| <b>Interaction: PCEs x ACEs</b>                   |                            |                                                       |                                           |                                           |                                           |
| PCEs x 1 ACE                                      |                            | 1.12 [0.37–3.35]                                      | 0.97 [0.52–1.82]                          | <b>0.60 [0.36–0.99]</b>                   | <b>0.60 [0.36–0.99]</b>                   |
| PCEs x 2 ACEs                                     |                            | 1.66 [0.57–4.82]                                      | 1.04 [0.56–1.92]                          | <b>0.57 [0.35–0.95]</b>                   | <b>0.59 [0.35–0.98]</b>                   |
| PCEs x 3 ACEs                                     |                            | 1.47 [0.51–4.25]                                      | 1.13 [0.60–2.12]                          | 0.62 [0.36–1.05]                          | 0.71 [0.39–1.30]                          |
| PCEs x 4+ ACEs                                    |                            | 1.13 [0.40–3.22]                                      | 0.89 [0.48–1.67]                          | <b>0.50 [0.29–0.86]</b>                   | <b>0.36 [0.18–0.70]</b>                   |

Note. <sup>a</sup> SES covariates were child's prioritized ethnicity (DCW4), child's gender (DCW0), food insecurity (DCW8)<sup>b</sup> Model 1 is unadjusted for PCEs<sup>c</sup> Models 2–5 are adjusted for SES covariates, ACEs, and PCE thresholdsThe bold font indicates significant OR/AOR at  $p < .05$ 

For assessing the combined effect of cumulative PCEs and ACEs, we used a series of binary PCE scores to ensure adequate statistical power to detect meaningful interactions given the small cell sizes (sliced by overweight/obesity, ACEs score, and PCEs score). We tested four different binary PCEs scores to find the optimal number of PCEs for mitigating the impact of ACEs on overweight/obesity (0–1 vs. 2–6, 0–2 vs. 3–6, 0–3 vs. 4–6, 0–4 vs. 5–6). Separate multivariable logistic regression analyses were conducted to evaluate associations between cumulative PCEs scores and overweight/obesity

while adjusting for sociodemographic characteristics, and also unadjusted and adjusted for ACEs scores (Table 5). Multivariable logistic regressions were used with interaction terms to identify changes between overweight/obesity for different PCEs and ACEs scores (Table 5).

All multivariable models were adjusted for child's sex, child's ethnicity, and food insecurity. We did not adjust for area-level deprivation to avoid multicollinearity between sociodemographic variables. Odds ratios are presented with 95% confidence intervals throughout, and statistical significance was set at  $p < .05$ .

## Results

Just over half of the study population were boys (51.5%), and half were European (49.8%). Māori children comprised 22.8% of the sample, followed by Asian (14.4%), and Pacific children (10.9%), 19.1% of the sample were identified as food insecure at DCW8 (Table 3).

ACEs exposure was prevalent in the sample: around 54% reported 1 or 2 ACEs and 32% reported at least 3 ACEs. Higher ACEs were more prevalent among Māori or Pacific children, and those living in the most deprived areas and in food insecure households (Table 3).

Overall, 34.4% of the sample's BMI z-score placed them in the overweight/obesity category at age 8. Overweight/obesity was more prevalent among Pacific and Māori children, and those living in food insecure households or higher deprivation areas (Table 3). A trend was observed between ACEs scores and overweight/obesity, with higher ACEs scores associated with increased odds of overweight/obesity. For example, those who experienced 1 ACE were 1.45 [1.14–1.84] times more likely to present overweight/obesity at age 8, compared with those who reported no ACEs (Model 1, Table 5), the odds ratio increased to 2.30 [1.77–3.00] times for those who experienced 4+ ACEs.

Mother involved in social groups was the most prevalent PCE reported by 71.4% of the sample, followed by mother in a committed relationship (69.6%). Living in a household with routines and rules was the least prevalent PCE reported by (40.6%) of the sample. Some sociodemographic differences were observed across individual PCEs. For example, boys were more likely to have a mother involved in social groups and they were more likely to be engaged in experiences and activities than girls, whereas girls were more likely to have mothers who were satisfied with their ECE and who interacted well with them. PCEs were less prevalent among Asian children, those living in the most deprived areas, and those living in food insecure households (Table 3).

Regarding cumulative scores, experience of at least 3 PCEs was reported by 72.1% of the sample. However, around one in ten (10.9%) experienced zero or only one PCE, and the 5–6 PCEs was only reported by 23% of the sample. The prevalence of multiple PCEs varied across sociodemographic subgroups and showed similar patterns to individual PCEs. In the context of ACEs, the proportion of those reporting each individual PCE decreased as the number of ACEs increased. A similar pattern was observed for cumulative PCEs where, higher ACEs scores were accompanied by lower PCEs scores, and lower ACEs scores were accompanied by higher PCEs scores (Table 3).

Table 4 demonstrates the predictive validity of protective effects for each individual PCE on overweight/obesity at age 8; four individual PCE were associated with

decreased odds of overweight/obesity. In terms of cumulative impact, a dose-response association was observed for crude associations, with additional PCEs conferring lower odds of overweight/obesity. After sociodemographic adjustment, a stepwise association was not clear for less than 3 PCEs but was maintained from 3 PCEs (AOR 0.77 [0.60–0.98]), 4 PCEs (AOR 0.69 [0.54–0.88]), to 5–6 PCEs (AOR 0.54 [0.42–0.69]).

We did not find consistent mitigating effects for individual PCEs (Supplementary Table 2). After controlling for ACEs scores and sociodemographic characteristics, associations between cumulative PCEs with overweight/obesity slightly attenuated (Table 5). Interactions were found between reporting at least four of the six PCEs, experience of 1 ACE, 2 ACE or 4+ACEs and reduced likelihood for overweight/obesity at age 8. That is, children who experienced 4+PCEs had lower odds of overweight/obesity at all levels of ACEs (except for 3 ACEs) than children who experienced less than 4 PCEs (Table 5).

The mitigating effect was stronger for 5–6 PCEs compared to 4–6 PCEs. Notably, among children with 4+ACEs, those with 5–6 PCEs had 64% lower odds of overweight/obesity (AOR 0.36 [0.18–0.70]), while those with 4–6 PCEs had 50% lower odds of overweight/obesity (AOR 0.50 [0.29–0.86]). Interestingly, within the group of children with 4–6 PCEs, those with 4+ACEs experienced lower odds of overweight/obesity than those with 1 or 2 ACEs (Table 5).

## Discussion

The PCEs Index developed in this study supported the hypothesis that PCEs may mitigate the association between ACEs and child weight at age 8 years. Our findings can inform future development of PCEs Indices for childhood obesity and other health outcomes, including further validation of tools for appropriate PCEs measurement.

Using data from a large cohort of NZ children, this study found that high counts of ACEs and PCEs were prevalent among the GUINZ cohort with almost one in three experiencing 3+ACEs and one in four experiencing 5–6 PCEs. However, there were observable inequities; children living in financially disadvantaged households experienced a higher number of ACEs and the lowest prevalence of experiencing all individual PCEs and lower PCEs scores. The prevalence of ACEs found in this study is substantially higher than those reported in retrospective cross-sectional studies utilizing standardized ACEs questionnaires [12, 41], but is in the range of those reported in international prospective ACEs studies [42]. Comparison of PCE prevalence rates found in other studies is difficult due to methodological inconsistencies, such as varying PCE definitions (including cumulative

versus individual PCEs) [29] and sample heterogeneity (notably retrospective PCEs assessment in adults) [14].

In line with previous studies [7], we found a dose-response association between exposure to higher ACEs scores and higher odds of childhood overweight/obesity. An inverse pattern was found for PCEs; a higher number of PCEs was associated with reduced likelihood of overweight/obesity at age 8, which held true regardless of ACEs score and socioeconomic status. The observed indications for a protective effect of PCEs against childhood overweight/obesity supports findings of limited existing research [24].

In addition to protective effects, our findings also indicate that cumulative PCEs may mitigate the impact of ACEs on the development of overweight/obesity. However, at least 4 PCEs were needed for mitigating effects to manifest, and the effect of ACEs on weight status could not be alleviated when children experienced 3 or less PCEs. This is consistent with limited existing evidence suggesting that individual PCEs or a low number of PCEs is not enough to prevent or mitigate negative health outcomes [14, 20, 43].

The association between ACEs and unhealthy weight status identified in our study underscores the importance of targeting children at risk of adversity and implementing primary ACE prevention strategies. Our findings on the protective and mitigating effects of PCEs against overweight/obesity highlight the need to identify and support existing PCEs and resiliency factors within families and communities. Additionally, considering the interaction between PCEs and ACEs in relation to obesity may improve intervention efforts by leveraging existing strengths within communities and families [44].

Informed by the HOPE Framework and contrasting with highly individualized (and often victim-blaming) approaches commonly found in childhood obesity interventions, our findings on the protective and mitigating cumulative impact of PCEs underscore the importance of considering multiple ecological domains of children's lives when conceptualizing PCEs [45].

Our findings serve as a policy, social and economic imperative for creating healthy and PCEs-promoting environments for children and their families to alleviate the burden of diseases such as obesity [23]. Through consideration of the insofar underexplored role of family environments and relationships in the prevention and treatment of childhood obesity in New Zealand, factors included in our PCE and ACE indexes can assist with the development of family-based interventions and prevention strategies. For example, our study shows that provision of appropriate and effective support for parents and families, especially those at-risk of experiencing adversity, is essential to both preventing ACEs and for mitigating their effects. Therefore, government-funded mental

health and educational programs and related support services for parents should be well-funded and targeted to meet the needs of different communities. Furthermore, the importance of healthily enforced rules and routines should be emphasised for parents, healthcare workers, and educators. This is of particular importance to child obesity outcomes as explored in this study, as promotion of healthy weight behaviours may be particularly challenging if home environments are not supportive of household routines. Consistent household routines require planning, time and clear communication, and are essential to the establishment of stability and predictability for young children [46], all of which can be less frequent and more complex in families that face adversity [47].

While research has shown that early family environments and effective parenting (including responsiveness, warmth, and discipline) can influence developmental outcomes related to flourishing [44], resilience [17], and obesity [48, 49], PCEs explored in our study also highlight the need for broader evidence-based tools and intervention strategies based outside families to outweigh ACEs [44]. Directing attention towards neighbourhood and community-level contributors to obesity (such as lack of access to green/recreational spaces, social/community activities, and healthy foods) naturally aligns with ecological approaches to PCEs and ACEs research [50, 51]. Trauma-informed approaches also parallel many evidence-based strategies for supporting healthy weight behaviours in children (e.g., consistent home routines, extracurricular activities) [46, 52], which can be more complex in families who face adversity [47]. Similarly, while primary prevention of ACEs remains the best course of action [53], strategies for preventing ACEs often align with identified PCEs, such as promoting and investing in public settings like education, healthcare services, and community and recreational activities (e.g., after-school programs, libraries, pools, and social groups) [12], which may play convergent roles in supporting healthy development for children and families at the population-level. Population-level efforts must also target socioeconomic and ethnic inequities for ACEs and PCEs to ensure a more inclusive and supportive environment. Higher prevalence rates of ACEs among ethnic minority groups, particularly Māori and Pacific peoples who also face the compounded effects of racism and colonization [54, 55], may contribute to and further entrench inequities in obesity rates and related health outcomes. Prevention of ACEs, particularly for Māori communities, also requires addressing and healing the intergenerational and historical impacts of trauma. Trauma-informed and culturally-appropriate approaches, and adequate resourcing of such services, are especially important for communities that experience structural inequities and discrimination in access to

healthcare, including obesity treatment [56, 57]. This may be of particular relevance where differences in associations between ACEs and obesity may exist, and for those with lower likelihood of experiencing PCEs.

This study supports the need for large-scale surveys and standard data collection to integrate PCEs assessment to advance knowledge of child development and wellbeing by capturing the heterogeneity of experiences across the lifecourse [20, 23], and help to identify and target areas for strengths-focused interventions and resourcing to disrupt pathways towards risks of adverse health outcomes [20, 58].

By measuring ACEs and PCEs at various time-points during childhood, our findings are less prone to recollection bias than many retrospective studies collecting data in adulthood [43, 59]. Further, obesity data was gathered using standardized objective measures, unlike previous ACEs studies that relied on parental report of child's measurements to derive BMI [24].

### Limitations

Study attrition likely impacted our findings (Supplementary Table 3), as those who were at increased likelihood of reporting ACEs and having obesity were found to be more likely to not partake in DCW8 in which obesity data was measured. Thus, our results likely underestimated the true impact of ACEs on unhealthy weight outcomes. While the study sample remained socioeconomically and ethnically diverse, our findings should not be considered representative of the NZ children population at-large. By selecting PCEs based on sample-level indicators, our index likely had a Eurocentric bias; further research which focuses on ethnic-specific PCEs is warranted.

This study mainly relied on mother-reported data, as there were demographic differences between subjects with partner data in GUINZ and those without. Mother-reported indicators may also have presented social desirability biases, particularly for questions related to parenting behaviours as they may invoke feelings of guilt or shame [22]. However, it was inappropriate or impractical to collect some data from children in the earlier waves. Childhood sexual abuse (which has been linked to the development of obesity) [7] had not been measured in GUINZ at DCW 8; child-reported ACEs and PCEs should be explored as these data become available.

Our PCEs index is not a definitive concept; we focused on achievable and modifiable measures to ensure the practical application to overweight/obesity outcomes specifically, and different PCEs may have strong mitigation power to outweigh impacts of ACEs on health outcomes other than obesity, as is characteristic of research in this area [60]. Some PCE indicators collected in GUINZ were excluded from the current study due to possible social desirability biases or lack of predictive

validity for use with weight status. The breadth of PCEs considered and their testing with ACEs in individual and cumulative models will help to support further research. However, our post-hoc approach to PCEs selection may have increased the risk of type I error. While this approach offers valuable exploratory insights, it may limit the precision and replicability of the findings, particularly for outcomes other than child overweight/obesity. This study supports the need for future research to develop a standardized PCE measure tailored specifically for outcomes like child weight, to enhance consistency and generalizability.

Dichotomization of ACEs and PCEs increased interpretability but may have obscured more nuanced findings. For example, “parents separated/divorced” or “mother in a committed relationship” are not infallible constructs; many children with separated parents grow up happy and healthy. These conceptual limitations are buffered by the cumulative nature of the PCEs score, echoing previous research that found that the accumulation of a sufficient number of PCEs is more important than the individual PCEs themselves [20, 61, 62]. While this study treats dichotomous PCEs cumulatively, the timing, magnitude, and consistency of PCEs could also significantly affect their impact on the development of health outcomes. Future research might explore these dimensions to identify which PCEs, when, and at what levels of intensity, offer the most effective intervention points for reducing obesity risk among children exposed to adversity. Future research should also explore clustering of individual PCEs and ACEs in cumulative models, as this may help to explain potentially spurious or inconsistent associations, such as the findings that among those with the highest number of PCEs, the highest number of ACEs (4+) was associated with lower odds of overweight/obesity than those with 1 or 2 ACEs. Sample size limitations, particularly at the ends of ranges (i.e., those with high ACEs and high PCEs or no ACEs and low PCEs) [60] may have resulted in false-negative findings in some cases.

### Conclusion

Our exploratory PCEs index contributes to a nascent field of research, particularly through the use of prospective data from a large population-based sample of children. Overall, findings suggest that presence of a sufficient number of PCEs may mitigate the detrimental impacts of ACEs on weight status among children. Our findings prompt further investigation into potential mitigating effects of PCEs on the impact of ACEs on a range of health outcomes during childhood to identify points of intervention along developmental pathways.

Significant attention must be granted to the creation, promotion, and nurturing of positive experiences that

both reflect and generate resilience within children, families, and communities [20]. Provision of appropriate and effective support for parents and families, especially those at-risk for experiencing adversity, is essential to both preventing ACEs and for mitigating their effects across the life course, but also for enhancing children's wellbeing at the population-level.

## Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12889-024-20727-y>.

Supplementary Material 1

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## Author contributions

B.M.: methodology, statistical analysis, funding acquisition, writing the original draft. M.G.: statistical analysis, review and editing. P.G., B.M., F.L., C.F., B.S.: conceptualization, methodology, review, editing, funding acquisition. T.M.: review, editing, cultural advice, funding acquisition. L.H.: conceptualization, methodology, writing the original draft, review, editing, funding acquisition, and supervision. All authors contributed to the article and approved the submitted version.

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## Data availability

The data utilised in the submitted manuscript was collected by the Growing Up in New Zealand study team. Researchers seeking access to this data may apply by submitting a data access application to the Data Access Committee at ([dataaccess@growingup.co.nz](mailto:dataaccess@growingup.co.nz)).

## Declarations

### Ethics approval and consent to participate

Ethics approval for Growing Up in New Zealand Study was granted by the NZ Ministry of Health Northern Y Regional Ethics Committee, and all enrolled parents provided informed consent.

### Consent for publication

Not applicable.

### Competing interests

The authors declare no competing interests.

### Author details

<sup>1</sup>Faculty of Medical and Health Sciences, University of Auckland, Auckland, New Zealand

<sup>2</sup>Intergenerational Health Research Group, Murdoch Children's Research Institute, Melbourne, VIC, Australia

<sup>3</sup>Faculty of Education and Social Work, University of Auckland, Auckland, New Zealand

<sup>4</sup>Centre of Methods and Policy Application in Social Sciences, University of Auckland, Auckland, New Zealand

<sup>5</sup>Wānanga o Waipapa School of Māori Studies and Pacific Studies, University of Auckland, Auckland, New Zealand

<sup>6</sup>Violence and Society Centre, City St George's, University of London, London, UK

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