Adverse childhood experiences and childhood obesity

Can positive childhood experiences mitigate the association?

MINISTRY OF SOCIAL DEVELOPMENT
TE MANATŪ WHAKAHIATO ORA

THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

This report has been produced for the Ministry of Social Development with funding from the Children and Families Research Fund

www.msd.govt.nz

Authors

Dr Ladan Hashemi[1,2], Brooklyn Mellar[1], Maryam Ghasemi[3], Dr Pauline Gulliver[1], Professor Boyd Swinburn[1], Associate Professor Barry Milne[4], Dr Fiona Langridge[1], Professor Tracey McIntosh[5], Professor Christa Fouche[3]

[1] Faculty of Medical and Health Sciences, University of Auckland
[2] Violence and Society Centre, City, University of London
[3] Faculty of Education and Social Work, University of Auckland
[4] Centre of Methods and Policy Application in Social Sciences, University of Auckland, Auckland, New Zealand
[5] Wānanga o Waipapa School of Māori Studies and Pacific Studies, University of Auckland, Auckland, New Zealand

Suggested citation: Hashemi L, Mellar B, Ghasemi M, Gulliver P, Swinburn B, Milne B, Langridge F, McIntosh T, Fouche C (2025). Adverse Childhood experiences and childhood obesity: Can positive childhood experiences mitigate the association? Wellington: New Zealand Ministry of Social Development

Acknowledgements

We acknowledge first and foremost the children and the families who are part of the Growing Up in New Zealand (GUiNZ) study. We acknowledge the Ministry of Social Development for funding the research in this report, and the numerous government agencies that fund and support the GUiNZ study.

This report is made possible using *Growing Up in New Zealand* (GUiNZ) data. We acknowledge the work of the Growing Up in New Zealand interviewers and research team at the University of Auckland who designed the study and collected and processed the data, making it available for us to use. The data has been accessed and used in accordance with the GUiNZ Data Access Protocol. We also thank Beth Ferguson and the Policy team at Oranga Tamariki Evidence Centre for sharing their expertise and knowledge in discussions about this research.

Disclaimer

The views and interpretations in this report are those of the researchers, and are not the official position of the Ministry of Social Development.

The final decisions for data analyses and presentation rest with the authors, who fully take responsibility for any errors or omissions. The views and interpretations in this report are those of the researchers and not the official position of the Ministry of Social Development or the policy team at Oranga Tamariki–Ministry for Children.

Published

January 2025
Ministry of Social Development
PO Box 1556
Wellington 6140
New Zealand
Web: www.msd.govt.nz

ISBN

978-1-99-11065-3

Contents

Executive summary

Adverse childhood experiences (ACEs) and childhood obesity are prevalent issues with far-reaching health implications; however, their interconnection has been critically overlooked. Additionally, the potential positive effects of Positive childhood experiences (PCEs), which encompass nurturing, supportive, and enriching events or relationships during childhood, enhancing a child's well-being and development, remain inadequately studied in their role of protecting against health issues and mitigating the effects of early adversity. This study used data from 4,895 participants in the demographically diverse *Growing Up in New Zealand* (GUiNZ) longitudinal study to explore five research questions:

1. How prevalent are adverse childhood experiences (ACEs) (individually and cumulatively) at age 8 and how are they distributed across socioeconomic and ethnic groups?
2. How does exposure to ACEs (individually and cumulatively) influence the development of childhood obesity and how does the relationship vary by ethnicity, socioeconomic status, and gender?
3. Does exposure to ACEs increase the risk of obesogenic behaviours (unhealthy diet, inadequate sleep duration, excessive screen time, physical inactivity)?
4. How prevalent are positive childhood experiences (PCEs) (individually and cumulatively) and how are they distributed across socioeconomic and ethnic groups?
5. Which PCEs have the potential to protect against obesity and mitigate against effects of ACEs?

We found that after adjustment for child's prioritised ethnicity, child's gender, and food insecurity children who experienced at least one ACE were twice as likely as children who had not experienced any ACEs to be obese at age 8. The risk increased as the number of ACEs increased. Children who experienced 4+ ACEs were almost three times more likely to be obese. Children who experienced ACEs were also more likely to adopt unhealthy weight-related behaviours. Furthermore, there was a relationship between ethnicity, poverty and increased risk for reporting both ACEs and obesity. Children who experienced PCEs were less likely to be obese and experience of 4+ PCEs decreased the likelihood of developing obesity, even among those who experienced high numbers of ACEs.

Our findings highlight the policy and clinical need to recognise the links between ACEs and obesity and implement well-supported initiatives to address contributing factors. This will require a holistic approach to child wellbeing by providing early support to prevent ACEs and responding to those who have experienced ACEs using trauma-informed and strengths-based approaches to provide healing opportunities. Importantly, our findings highlight the need to identify and promote positive factors in all New Zealand children's lives to improve long-term health and wellbeing.

Introduction

Background

Childhood obesity is a global health emergency, as prevalence rates have dramatically increased over recent decades (Abarca-Gómez et al., 2017). This serious public health issue is associated with short- and long-term physical and mental health complications and comorbidity, and has become an increasingly dominant reason for consultation in primary healthcare settings (Di Cesare et al., 2019; Simmonds et al., 2015). Childhood overweight and obesity is highly predictive of adult obesity and the development of a range of non-communicable diseases in adulthood, including type II diabetes and coronary heart disease (Craigie et al., 2009; Daniels, 2006; Ward et al., 2017).

Identifying factors that contribute to the development of obesity during childhood are imperative in developing effective preventive measures and interventions that have the potential to promote optimal health outcomes among both children and adult populations. Traditionally, research in childhood obesity has been focused on proximal factors (e.g., consumption of calorie-dense junk food and lack of physical activity). However, traditional interventions targeting energy balance and individual health behaviour change (e.g., caloric restriction, increased physical activity) have not substantially decreased the prevalence of obesity and effective solutions for the obesity epidemic are still lacking (K. Schroeder, Schuler, Kobulsky, & Sarwer, 2021).

In fact, obesity has proved resistant to conventional treatment, through biological adaptations such as reduced metabolic rate and increased appetite-increasing hormones (Greenway, 2015). Early prevention efforts are therefore a critical priority at the population-level (Pandita et al., 2016), as is increased understanding about early childhood risk factors and how these risk factors interact (Hemmingsson, 2018; Zhou, Yuan, Wang, Niu, & Zhang, 2020). Recently, there have been calls to examine the contributions of a broader range of social, emotional, and environmental contexts in which a child develops, to gain a more complete understanding of possible risk factors for overweight or obesity in children (Baranowski, Motil, & Moreno, 2019; Davison & Birch, 2001; K. Schroeder et al., 2021). This information is needed to inform the growing focus on addressing early life and social determinants of healthy development and lifelong health, at the national and international levels (Davison & Birch, 2001).

Childhood stressors, trauma, or severely stressful life events have gained traction as important factors for increased likelihood of experiencing a range of poorer physical and mental health outcomes, including obesity, among children and adults. During the 1990s, the seminal Adverse Childhood Experiences (ACE) Study was conducted in the US, which identified key relationships between childhood adversity and health in adulthood (Felitti et al., 1998). As a specific definition of stressors during childhood, ACEs have subsequently emerged as a key focus in

research on child development and on the national policy agendas in many countries (including the UK and US). ACEs are traumatic experiences that occur during childhood and traditionally include indicators of child abuse and maltreatment (e.g., child physical, psychological, and sexual abuse), as well as multiple family dysfunctions (e.g., household mental illness, substance abuse, incarceration, parental separation/divorce or death, and intimate partner violence against female caregiver) (CDC, 2016; Felitti et al., 1998).

International research has shown that individuals impacted by childhood adversities are at greater risk of developing obesity, however, the vast majority of these studies have been focused on adults and on long-term weight gain and the development of obesity (Hemmingsson, Johansson, & Reynisdottir, 2014; McLeod, Fergusson, Horwood, Boden, & Carter, 2018). From this remote vantage point it is difficult to ascertain whether it is these particular childhood experiences or unmeasured covariates that are the most important predictors (Finkelhor, Shattuck, Turner, & Hamby, 2013). Few studies have specifically addressed childhood obesity and most have relied on adults retrospectively reporting adversity and weight status in childhood (Danese & Tan, 2014; Lynch et al., 2016; K. Schroeder et al., 2021). By relying on retrospective data collected several decades after childhood, there may be an over- or under-estimation of exposure to ACEs. Moreover, this approach cannot identify when negative impacts on weight gain may begin (e.g., during early or middle childhood or adolescence)(Pretty, O'Leary, Cairney, & Wade, 2013). Non-objective measures of obesity used in these studies are also questionable. Measuring childhood adversities during childhood, rather than in adulthood, allows the possibility of obtaining a more accurate assessment of childhood events than one would be able to obtain after many years. It would also allow a more sensitive untangling of the relationship among various adversities, demographics, and behaviours in ways that can better explain causal sequences.

While some research has found relationships between adverse experiences and obesity among children, most of them were limited in scope, considering only maltreatment and exposure to a limited number or subset of ACEs (e.g., adverse family experiences or stressful family life events) (Schroeder, Schuler, Kobulsky, & Sarwer, 2021) (Lynch et al., 2016). While providing valuable insight indicating that experiencing even a few ACEs results in significantly higher obesity rates, a more comprehensive assessments of ACEs is required. Research has demonstrated that it is not so much specific events or the constellation of a limited number of ACEs which are detrimental to health, but rather an accumulation of events (regardless of which specific events they are and spanning over home, family, school, and society context, across the childhood life course) that confers risk for negative health effects.

In addition, the original ACE Study list of preventable childhood adversities omits a number of key domains that have been judged by many developmental researchers as important predictors in immediate health and well-being outcomes

(Finkelhor et al., 2013). Among the predictors missing from the ACEs scale created by the original ACEs Study are exposure to violence outside the family (including peer victimisation and community violence), and death of parents. Furthermore, there may be contextual or cultural specificities relevant to childhood experiences. For example, wholesale adoption of international ACE scales may overlook experiences related to colonisation and racism in New Zealand (Joy & Beddoe, 2019).

New Zealand (NZ) has a high prevalence of ACEs and childhood obesity. The New Zealand Health Survey 2020/21 found that around 1 in 8 children (aged 2–14 years) were classified as obese (12.7%), up from 9.5% in 2019/20 (Ministry of Health, 2021). Regarding ACEs prevalence rates, recent data from the 2019 NZ Family Violence Study (NZFVS), a retrospective cross-sectional study of representative sample of NZ's adult population, revealed that half of the adult population in the study (55%) reported at least one ACE and 20% reported at least three. Māori and Pacific children and those living in more deprived areas were disproportionately adversely affected (Fanslow, Hashemi, Gulliver, & McIntosh, 2021). One prospective study using Growing Up in New Zealand (GUiNZ) data found that approximately half of children had experienced one ACE by 4.5 years old, and 2.6% had experienced four or more ACEs (M. Walsh, Joyce, Maloney, & Vaithianathan, 2019). This estimate is likely relatively underreported as ACEs studies are usually designed to cover longer childhood periods (i.e., from birth to 18 years) to capture their cumulative nature.

High prevalence of ACEs and obesity (and potential association between them), together with the severity of their negative health consequences, make ACEs an urgent public health concern. Nonetheless, the connection between ACEs and childhood obesity has yet to be verified within the Aotearoa/NZ context. This research aims to build on the existing work on ACEs prevalence in NZ by investigating a wider range of ACEs, their co-occurrence, and the association between each individual as well as cumulative ACEs and childhood obesity.

Mechanisms underlying ACEs-obesity association

Histories of adversity might influence the development of poor weight outcomes through different potential mechanisms. The suggested mechanisms for adult population encompass, but are not limited to, mental and emotional perturbations (e.g., depression), social disruption, maladaptive coping responses (e.g., binge eating), chronic stress responses, inflammation and metabolic disturbances (Wiss & Brewerton, 2020; Zeller et al., 2015). Research on adult populations has also shown that these pathways may also contribute to the adoption of high-risk health behaviours by those who experience ACEs. The list of 'health behaviours' is extremely broad, including excessive screen time, high consumption of low-nutrient-density food, physical inactivity, sleep difficulties, etc., all of which have major implications on human health. Furthermore, co-occurring environmental stressors in the household and neighbourhood, such as financial insecurity, are

also associated with increased risks of ACEs and may further hinder a family's ability to support healthy behaviours (K. Schroeder et al., 2021). Few empirical studies have explored and tested potential pathways by which the ACEs-obesity relationship manifests in populations of children. More specifically, there is a dearth of population-based epidemiologic studies focused on the wide range of ACEs and their associations with a broad range of age-specific weight related health behaviours for children. While there are a wide range of complex environmental determinants of both childhood obesity and experiences of childhood adversity; broadening our understanding of factors that may compound or intersect with these social and environmental determinants can strengthen efforts to improve both.

This study aimed to examine a potential pathway for ACEs-obesity relationship in NZ children by exploring the association between ACEs and a constellation of key childhood unhealthy weight-related behaviours that have well known contributions to childhood obesity (so-called obesogenic behaviours). We hypothesise ACEs will be positively associated with obesogenic behaviours in a dose-response manner. An understanding of this relationship can help address the precursors of obesity and poor weight outcomes in children exposed to adverse experiences. Identifying novel pathways may be useful to inform future intervention strategies at the individual (trauma-informed care/treatment) and public health (trauma-informed social policies) levels. In addition to exploring potential mechanisms underlying ACEs-obesity connection, investigating factors with potential to mitigate the negative impacts of ACEs on children's weight outcomes is also imperative as it provides another window to help children who suffer the consequences of ACEs.

Mitigating the effects of ACEs on children's weight outcomes through positive childhood experiences (PCEs)

The focus on ACEs has been criticised for overemphasizing risks and inadequately addressing resilience/protective factors (Crandall et al., 2020; Sege & Harper Browne, 2017). In fact, despite the presence of risk, not all those who experience childhood adversity present worsened health outcomes. Recently, a shift from a trauma focus to a healing perspective has been at the heart of a growing number of studies. Researchers are especially curious to clarify the effects of protective and resilience factors in moderating the impact of childhood trauma on children's outcomes (Bachler et al., 2018; Yule, Houston, & Grych, 2019).

It has been theorised that childhood resilience serves as a protective mechanism for obesity prevention in childhood (Hemmingsson, 2014). One way to develop childhood resilience is through exposure to positive childhood experiences (PCEs) (Sege & Harper Browne, 2017). PCEs are a series of cumulative positive experiences in childhood which encompass a range of domains, including family and parenting environment, equity/access/quality of healthcare services and early childhood education, peer relationships, school environment, cultural connectedness, and community belonging & neighbourhood environment (Bethell,

Jones, Gombojav, Linkenbach, & Sege, 2019; Narayan, Rivera, Bernstein, Harris, & Lieberman, 2018).

It has been suggested that PCEs promote healthy development, improve overall wellness, and help to moderate the detrimental impact of ACEs, through potential pathways such as reducing the hormonal responses to ACEs (Sege & Harper Browne, 2017). Despite the role of PCEs in mitigating the potential consequences of ACEs exposure and increasing overall childhood resilience, few subsequent studies on ACEs have simultaneously evaluated PCEs, and only limited research has examined the association between PCEs and overweight or obesity status, or their mitigating effects in ACEs-obesity association in children (e.g., Crouch et al., 2022). There is also a lack of exploration in the specific effects of ACEs and PCEs after adjusting for each other. Lack of standardised measures to assess PCEs might have contributed to this scarcity. For the same reason, the prevalence of PCEs at the population-level for children are still unknown.

We hypothesise that, in the presence of ACEs, children experiencing PCEs will have a decreased likelihood of having overweight or obesity and that experiencing an optimal number of PCEs has the potential to mitigate the detrimental effects of ACEs on body weight status among children, particularly for those exposed to greater numbers of PCEs. Findings from this study will be informative for health and wellbeing programme developers and policy makers, as they have the potential to highlight the 'value add' of interventions designed to reduce ACEs and promote PCEs, by impacting on immediate and long term, chronic health conditions.

Part One: Prevalence and impacts of obesity and association with adverse childhood experiences (ACEs)

Current study

In summary, this study aims to describe the prevalence of exposure to ACEs and PCEs among a longitudinal cohort of NZ school-aged children across ethnic and socioeconomic groups, assess their effects on the development of childhood obesity and obesogenic behaviours, and explore PCEs' potential to promote healthy weight and offset effects of early adversity.

By identifying and analysing the impact of modifiable PCEs on childhood obesity outcomes, our research can support the evidence-informed development of effective approaches for promoting the wellbeing of NZ children. This can shift the discourse about adversity forward in a novel and strengths-focused direction appropriate for the New Zealand context. Importantly, this lens shifts the focus from what is not working to what is going well.

Method

Methods used for this research are presented in two parts. Methods pertaining to objectives 1 to 3 (creation of ACEs index, calculation of ACEs prevalence rates, and assessment of ACEs-obesogenic behaviours-obesity associations) are presented in the following section and Methods pertaining to objectives 4 and 5 (PCEs creation, prevalence rates, mitigating effects) are presented in Part 2.

Participants

Growing Up in New Zealand (GUiNZ) is a contemporary child cohort study, which enrolled 6822 pregnant women with an expected due date between 25-April-2009 and 25-March-2010 and 4401 of their partners, and then the 6853 children born to these women who survived to age 6 weeks (Morton et al., 2015) Further detail about the GUiNZ cohort up to age 8 is available elsewhere (Morton et al., 2020). In the current study, we restricted our sample to one child per mother to avoid dependent observations (i.e., where mothers gave birth to twins or triplets), and those who responded to the eight-year data collection wave (DCW8) and had obesity data, which reduced the sample to 4,895 children.

Missingness

Of the 6,853 children originally recruited into the GUiNZ study, prior to the eight-year DCW (undertaken from July 2017 to January 2019), 282 children had either been formally opted out of the study by their parents or had died in early life (14 children died during the first six years of the study). Of 6,571 children who were

invited to participate in the eight-year DCW, 1,015 children did not participate (15% of eligible), 5,556 (85%) participants completed at least one component of the DCW8, however 546 had mother-only data and of the 4,996 that had child observation data, 101 did not have obesity data which resulted in the sample size of 4,895. Each individual ACEs variable had less than 4% missing data, leading to a slightly smaller sample size for the regression analyses. To estimate the impact of attrition bias on our findings, we explored the possibility of using imputation and sensitivity analyses. Multiple imputation was not feasible across all DCWs given the number of variables included in the analysis (the initial list exceeded 1000 variables including all potential indicators of ACEs and PCEs). Sensitivity analyses were conducted to understand the patterns of missingness and the impact of missingness due to attrition on our findings. Data on outcome variable (child's obesity), socio-demographic characteristics, and some selected ACEs were used in these analyses. More specifically, the characteristics of children and mothers who participated in the eight-year DCW and provided data on child obesity were compared with those who did not participate at the eight-year DCW or did not have obesity data (the findings are detailed in **Supplementary Table 1)**. Children who did not participate at DCW8 had higher odds of overweight/obesity at age 4.5 than those who participated at DCW8. Mothers of children who did not participate in the eight-year DCW were more likely to be younger (≤29 years old, $P < 0.001$), have no tertiary qualifications ($P < 0.001$) and identify with an ethnicity other than European ($P < 0.001$), compared to mothers of children who did participate at DCW8. They were also less likely to be in a relationship at pregnancy (DCW0) and more likely to live in areas of moderate and high deprivation (both $P < 0.001$). Children with missing obesity data at DCW8 were more likely to be exposed to IPV and parental incarceration in earlier DCWs.

Further, no gender differences were found between children participated at DCW8 with those who did not participate.

Lastly, we sought the possibility of using weights (survey weights and attrition weights) but GUiNZ weights were not available.

Overall, these findings in line with previous ACEs research, show that data are unlikely to be missing at random (Doidge, Edwards, Higgins, & Segal, 2017). Therefore, the findings need to be considered with these differential retentions rates in mind.

Measures

Construction of main exposure of interest: Adverse childhood experiences (ACEs)

A rapid literature review was conducted to identify a comprehensive list of commonly studied ACEs in the literature. Due to time restrictions, conducting a comprehensive systematic literature review did not seem feasible. Our purpose was to explore whether the adversities enumerated by the ACE Study (Felitti et al., 1998) could be improved upon by considering a more comprehensive range of

possible adversities, including some of the domains not considered in the ACE Study. We were particularly focused on potential ACEs appropriate for the NZ context which could reflect unique cultural and historical features of NZ, applicable across socioeconomic positions. This literature review revealed that 8 ACEs are commonly measured in the research comprising two major categories: child maltreatment (exposure to emotional, physical, and sexual abuse) and household dysfunction (exposure to household mental illness, household alcohol and substance abuse, household incarceration, violence against mother, parental divorce/separation). Common additional content includes assessing exposure to bullying or peer victimisation and ethnic discrimination (see **Table 1** for a list of the potential ACEs).

Mapping ACEs list with GUINZ data dictionaries

GUiNZ study has included 19 variables in the latest available DCW8 that could be matched to ACEs (see **Table 1**). Mothers were asked to report child's experience of each ACE. This list only includes 4 out of 8 original ACEs (i.e., parent in prison, mental illness in the immediate family, drug-taking/alcoholism in the immediate family, divorce/separation of parents). ACEs studies are designed to focus on accumulation of ACEs over time. To maximise the possibility of capturing a wide range of ACEs and to avoid bias that might be associated with parental reporting of child experience of ACEs, in addition to the list of ACEs included in DCW8, we used all available GUiNZ datasets and instruments (antenatal to age 8) to identify appropriate proxies to commonly investigated ACEs.

Table 1. Potential ACEs items considered for inclusion in the ACEs index and our decision

Potential ACE	Decision and data collection wave
1-Emotional abuse	Included (DCW2Y, DCW54M, DCW8Y)
2-Physical abuse	Included (DCW54M)
3-Parental substance abuse (including alcohol abuse)	Included (DCW9M, DCW54M, DCW8)
4-Parental mental illness	Included (DCW0,DCW9M, DCW54M, DCW8)
5-Parental incarceration	Included (DCW9M, DCW54M, DCW8)
6-Parental separation/ divorce	Included (DCW9M, DCW2Y,DCW54M, DCW8)
7-IPV against mother	Included (DCW9M, DCW54M, DCW8)
8-Ethnic discrimination	Included (DCW0, DCW2Y)
9. Peer bullying	Included (DCW8)
9-Experience of death including death of a parent or **10-death of a close family member or** **11- death of a close friend or** **12-death of a pet (or injury or loss of a pet)**	Initially tested and then decided to exclude (no significant association with child's outcome variables) (DCW8)
13-Moving house	Not included (not well supported by the literature) (DCW8)
14- Moving country	Not included (not well supported by the literature) (DCW8)
15-Stay in foster home/ residential care	Not included (low frequency, n=15) (DCW8)
16-Serious physical illness / injury **17-Serious physical illness / injury of a family member**	Not included. Does not align with our conceptual framework which focuses on modifiable factors (ACEs) related to family dynamic (DCW8)
18-Christchurch Earthquake, **19-Natural disaster (other than Christchurch Earthquake)**	Low frequency (n=37 and n= 49, 1%) (DCW8)
Additional victimisation and adversity items not included in original ACE study	
Poverty	Not included (controlled for as covariate)
Physical neglect	Not included (overlap with poverty and inequity measures)
Emotional neglect	Not measured in GUINZ study and substantial overlap with assault (risk of double counting)

Unsafe neighbourhood	Not included: neighbourhood safety is included in the NZ deprivation index (one of our covariates) as stated in the definition of NZ deprivation scale "NZDep2018 decile 9 and 10 are more susceptible to environmental risks such as noise, overcrowding, and less security".

Briefly, dichotomous constructs indicating exposure to adversities were created for nine ACEs including exposure to emotional abuse, physical abuse, parental substance (alcohol/drug) abuse, parental mental illness, parental incarceration, parental separation/divorce, intimate partner violence (IPV) against mother, parental experience of ethnic discrimination, and peer bullying. Multiple questions feed into each ACE using predetermined criteria; an ACE is assumed to have been experienced if it is reported in one or more of the questions, even if there are inconsistencies between the questions. Priority was given to modifiable ACEs which could be potentially prevented or their effects could be mitigated through appropriate trauma-informed care initiatives/services. Item contents and item response options for the final version of our ACEs index are presented in **Table 2.** Two included items (ethnic discrimination and bullying) are new to the NZ context.

No data on children's direct experience of ethnic discrimination was collected as part of the GUiNZ study up to and including the 8-year data collection wave. Therefore, mother's exposure to ethnic discrimination was used as a proxy for child's exposure to this ACE and was deemed to be appropriate for the NZ context. Peer bullying was included in the final draft of ACEs index due to its repeated nature and prolonged and detrimental impact on children's development, physical and mental health (Rigby, 2003). The Center for Disease Control (CDC) and World Health Organization also listed bullying as an ACE, placing the impact of bullying behaviour on par with all other ACEs (CDC, 2022; World Health Organization, 2018).

Which ACEs were not included and why?

Table 1 contains a full list of potential ACEs and reasons for exclusion. Nine items (out of the listed 19) were reported by a very low frequency (≤1%) of the sample and were not included in our index (e.g., Christchurch earthquake (n=37, 1%), natural disasters (other than Christchurch earthquake) (n=49, 1%), stay in foster home/residential care (n=15, 0%), experience of family conflict, experience of other conflict, or other disturbing events. Inclusion of two items (moving country and moving house) were not supported by literature.

Information on exposure to sexual abuse during childhood has not been specifically collected as part of the GUiNZ study to date. Four ACEs items included in DCW8 were related to the child's exposure to death or loss (death of a parent, death of a close family member, death of a close friend, death of a pet). We created a binary variable for experience of at least one of these items, but our aggregated variable did not show any significant association with children's outcomes and regression models were not improved when this item was included in earlier drafts of the ACEs index. Another version of this variable which only included death of a parent or death of a close family member yielded similar findings. Therefore death was not used in the final ACEs index.

Table 2. Definition of ACE types used in our ACEs index

Individual ACE	Description
Emotional abuse	A child was classified as being emotionally abused if mothers and/or partner reported the following in DCW2Y, DCW54M, or DCW8Y: - Always or almost always have lost their temper with child, raised their voice, yelled or shouted at child (mother reported, DCW8Y), - Very often or always yelled or shouted when child misbehaved or exploded with anger (mother reported, DCW54M), - - Very often shouted when child was naughty or very often, extremely often, or all the time got angry at the child, criticise their child's ideas, shouted at the child because they were upset with their child (mother and/or partner reported, DCW2Y).
Physical abuse	Children were coded as having this ACE if: - Mothers responded **'often', 'always or almost always'** to using physical punishment such as smacking as a way of interacting with their child (DCW8Y), - Mothers used physical punishment as a way of disciplining their child '**half the time', 'very often', or 'always'** (DCW54M), - Mother reported smacking the child **'often' 'very often'** when he/she was naughty (DCW2Y).
Parental substance abuse (including alcohol abuse)	A child was coded as exposed to this ACE if the mother or partner reported any of the followings: - Mother reported that the child has experienced this ACE (drug taking / alcoholism in the immediate family, DCW8Y), - Mother reported heavy episode drinking (drinking five or more standard drinks on a typical day when drinking, DCW54M, DCW8Y, or drinking six or more standard drinks on one occasion at least monthly, DCW54M and DCW8Y) (West, Najjar, & Leasure, 2019), - Mother reported drinking 10 or more drinks per week (DCW54M) (Health, Australian Government Department of, 2019), - Mother ever sought help in relation to alcohol use (DCW54M), - Mother or partner reported using amphetamines, cocaine, ecstasy, opiates, hallucinogens or party pills since the birth of the child (DCW9M).
Parental mental illness	A child was assigned to this ACE if any of the following was the case: - Mother reported that the child has been exposed to mental illness in the immediate family (DCW8Y), - If the mother or partner was classified as moderately or severely depressed (a score of 15 or higher on the Patient Health Questionnaire Depression Screener (Kroenke & Spitzer, 2002)) or as probably depressed (a

	score of 12 or higher on Edinburgh Postnatal Depression Scale (Choi et al., 2012)) (DCW8Y, DCW54M, DCW9M, or DCW0).
Parental incarceration	A child was assigned to this ACE if any of the following was the case: - Mother reported that the child has experienced this ACE (parent in prison, DCW8Y), - Mother reported that she has ever been convicted of a crime which resulted in a jail sentence (DCW54M), - Partner reported that he has ever been convicted of a crime which resulted in a jail sentence (DCW9M).
Parental separation/ divorce	Child was coded as having this ACE if the mother reported any of the following: - Child has experienced divorce/ separation of parents (DCW8Y), - Mother was not in a relationship with this same partner when her child was two years old, - Mother did not have a current partner during 54months, 2 years, or 9 months interviews.
IPV against mother	A child was coded as having this ACE if mother reported: - Child was present when she had a physical conflict with her partner, - Or, mother reported any of the following during past 4 weeks prior to the data collection in any frequency other than never, o Their partner slapped them or threw things at them that could have hurt them; pushed or shoved them or pulled their hair; hit them with a fist or something else that could have hurt them (DCW54M, DCW8Y), or o Mother and partner pushed and shoved each other while arguing (DCW9M).
Mother experience of ethnic discrimination	A child was coded as having this ACE if mother reported that: - She has ever been treated unfairly in New Zealand because of her ethnicity (DCW2Y), - Or mother has ever felt any of the following within the past 12 months or more than 12 months ago (DCW0): o Being a victim of an ethnically motivated attack - that is verbal, or physical abuse to the person or property in New Zealand o Being treated unfairly (e.g., treated differently, kept waiting) by a health professional, e.g., a doctor, nurse, dentist because of your ethnicity in New Zealand o Being treated unfairly at work or been refused a job because of your ethnicity in New Zealand o Being treated unfairly when renting or buying housing because of your ethnicity in New Zealand o Being treated unfairly by the police, the justice system (courts), or the corrections department (prison, community service, periodic detention, parole, probation) because of your ethnicity in New Zealand o Being treated unfairly when asking for loans, a mortgage, hire purchase or credit cards because of your ethnicity in New Zealand

	○ Being treated unfairly when attending a place of learning because of your ethnicity in New Zealand.
Recurrent peer-bullying/peer victimisation	A child was coded as having this ACE if he/she reported frequent experience of one of the following (at least one or two times a month): - Do other children put you down, call you names, or tease you in a mean way? - Do other children leave you out in a mean way? - Do other students hit, push, or hurt you in a mean way? - Do other children tell lies about you in a mean way? - Do other children threaten you in a mean way, or force you to do things? - Do other children take or break your stuff in a mean way (e.g., money or pens)? - Do other children say mean things about your culture or family? - Are other children mean to you because you learn in a different way to them? - Do other children use cell phones (like texting) or the Internet (like Facebook) to be mean to? - At school, are you bullied by other students?

Note: Data taken from DCW8Y includes items drawn from ACEs list as well as items taken from other parts of this DCW.

ACEs scores

To measure cumulative effects of childhood adversities, an ACEs score (count variable) was calculated, which is an integer between 0 and 9. The cumulative ACEs score is a severity index emphasising the accumulation of the types of experiences, which indicates how many types of adversities a child has experienced. We grouped cumulative scores into the categories: 0, 1, 2, 3, or 4 or more ACEs experienced. This ensured adequate sample sizes in each group while maintaining differentiation between individuals who experienced a high or low number of ACEs. The ACE score approach is widely used and has advantages, including the recognition that ACEs tend to co-occur and that the worst outcomes tend to be for people exposed to multiple ACEs. We used four as our threshold as the original ACEs study and other studies found that risk of experiencing health problems dramatically increased with exposure to four or more ACEs (Felitti et al., 1998). This categorisation also enables comparability with previous studies (Felitti et al., 1998; Houtepen et al., 2020). A binary variable was also created for experience of zero ACEs versus one or more (any ACEs).

Covariates: Sociodemographic characteristics

Sociodemographic variables were used to explore the prevalence rates of each ACE and each indicator of obesity variables among sub-populations and as potential confounders in multivariable analyses. Variables included: child's gender (DCW1), child's age (DCW8), and child's ethnicity (DCW54M) – externally prioritised from total response ethnicity collected according to MOH protocol: Māori, Pacific, Asian, MELAA [Middle East, Latin American, African], European/New Zealander/Other. European and New Zealanders were combined as prior research has found that the majority of those who identify as New Zealanders are European (Cormack & Robson, 2010). Due to small sample size, 'Other' (n=2) was also combined with European/New Zealander. For simplicity, we refer to this group as European in this report. Food insecurity was derived from mother's responses at DCW8 to "We can afford to eat properly. How often has this been true for your household over the past year?", binarised to "Always" versus "Sometimes"/ "Never". Area deprivation level at DCW8 was derived according to NZDep2013 Index of Deprivation (Atkinson, Salmond, & Crampton, 2014). We did not adjust multivariable logistic regressions for area level deprivation to avoid multicollinearity between this variable and other measures of sociodemographic characteristics (ethnicity and food insecurity).

Main outcome of interest – Obesity

Weight and height were objectively measured by trained interviewers during computer assisted face-to-face interviews when the cohort children were 8 years old using a standard protocol that included the removal of shoes or hats, jackets or jumpers, and the taking of duplicate measurements. The protocol for measuring weight and height was prescribed by the World Health Organization (WHO, 1995)

and adapted for use in NZ by the Ministry of Health (MOH, 2008). Third measurements of weight and height were collected if differences in weight were > 0.1 kg and in height if >0.5 cm. The average values between the two measurements or the two closest measurements were calculated and considered the final weight and height measurement.

Waist circumference (centimeters) was also collected in addition to height and weight at 8 years DCW according to the Ministry of Health protocol (MOH, 2008). Duplicate measurements were taken and if differences between the two measurements were greater than 1 cm, a third measurement was performed. The average values between the two measurements or the two closest measurements were calculated and considered the final waist circumference.

Values of height, weight, and body mass index (BMI) were standardised by age and gender, according to the WHO Growth Reference for school-aged children and adolescents (de Onis et al., 2007) using the software WHO Anthro Plus for children 60 months or older (WHO, 2009) which defines overweight as a BMI-for-age between 1 and 2 standard deviations above the WHO Growth Reference median (a BMI between the 85th and 94th percentiles); and obesity as greater than 2 standard deviations above the WHO Growth Reference median (BMI ≥95th percentile).

Derived variables

A binary obesity variable (presence of obesity defined as BMI ≥95th percentile vs absence of obesity) was used as the primary outcome variable in the ACEs-obesity component of this report. Although it is still the most-widely used measure for obesity status, BMI as a definition of obesity is not without its criticisms, particularly for use at the individual level (Gutin, 2018). In a 2021 systematic review on associations between ACEs and childhood obesity, the majority of studies investigated (21 out of 24) found an association between ACEs and childhood obesity, however inconsistent results were reported using certain measures of obesity. The review subsequently suggested use of multiple obesity measurements to verify associations when conducting research on ACEs and obesity (K. Schroeder et al., 2021).

To this end, two other measures of obesity were included. A combined overweight/obesity variable (BMI ≥85th percentile) was created to increase sample size particularly for analyses using ACEs score. Combined overweight/obesity was used as the primary outcome in the PCE component (Part 2) of this project as the low numbers for obesity alone compromised data density and statistical significance of analysis when models assessed interactions across both ACEs and PCEs subgroups. Combined overweight/obesity has been used by similar studies (Crouch, Radcliff, Kelly, Merrell, & Bennett, 2022), and overweight children are also at increased risk for non-communicable diseases and obesity in adulthood (Singh, Mulder, Twisk, van Mechelen, & Chinapaw, 2008).

Thirdly, a measure of central/abdominal adiposity (waist circumference/height ratio or WHtR) was used which is created by dividing the waist circumference values (cm) by the height values (cm). The WHtR is a measure of the relative distribution of body fat. Higher values of WHtR are linked to adverse metabolic profiles and greater systemic inflammation, both potent risk factors for the development of cardiovascular disease and later obesity (Maffeis, Banzato, & Talamini, 2008). A universal WHtR cutoff point of ≥0.5 is considered as high and widely accepted as a screening tool for metabolic syndrome risks independent of sex and ethnicity in adults, and even in children and adolescents (Browning, Hsieh, & Ashwell, 2010; Chung, Park, Park, & Yoo, 2016; Kim, 2019). The WHtR has several advantages; it is easy to calculate and interpret and does not require sex- and age-specific centiles. Several systematic reviews and meta-analyses of data in children and adolescents (Ashwell, Gunn, & Gibson, 2012; Chen, Ji, Chen, & Meng, 2022; Yoo, 2016) have supported the superiority of WHtR ratio over the use of BMI in predicting early health risk. Although not being superior in discriminatory power, WHtR is more commonly used as an effective tool for measuring obesity and overweight in children than BMI (Lo, Wong, Khalechelvam, & Tam, 2016).

In addition to the commonly used binary BMI z-score obesity variable, analyses for logistic regressions in the ACEs-obesity component of the report were repeated using the combined overweight/obesity variable and WHtR. While the obesity measures BMI z-score and WHtR are strongly correlated with each other (BMI z-score obesity and WHtR correlation: 0.73), combined overweight/obesity is less correlated (0.57 with each obesity and WHtR). Still, using them collectively gives us a better understanding of ACEs-obesity association which could not be captured with only one measure of obesity.

Obesogenic behaviours

Eight mother-reported obesogenic behaviours were explored measuring four key obesogenic behaviours at age 8 (DCW8) (Daniels & Hassink, 2015). Four indicators for unhealthy dietary behaviours including age-specific inadequate fruit and vegetable consumption (<5 servings per day), frequent soft drink consumption, frequent fast food consumption, no regular/daily breakfast consumption were measured. Other key obesogenic behaviours including age-specific inadequate sleep duration (<9 hours), age-specific excessive screen time (>2 hours per day), and leisure-time physical inactivity, leisure time sedentary behaviour were also measured. New Zealand Ministry of Health and WHO guidelines were followed in creating derived variables (Ministry of Health, 2012, 2020; WHO, 2020). Exact wordings and variable definitions for studied obesogenic behaviours are provided in **Table 9.**

Analytical procedure

Statistical analyses were performed using Stata 15 (StataCorp, 2017). First, prevalence of individual and cumulative ACEs, and obesity variables were described in the sample, overall and by sociodemographic characteristics (**Tables 3 & 4**). Chi-square tests were used to examine differences between ACEs (individual and scores) and obesity outcomes (**Tables 3 & 4**).

Descriptive statistics (percentages) were used to describe the prevalence of each individual ACE and ACEs scores by each obesity outcome (**Table 6**). Next, the association of each individual ACE and ACEs scores with each obesity outcome was assessed using logistic regression analyses with unadjusted odds ratio and adjusted odds ratios adjusted for sociodemographic characteristics reported (**Table 7**). The individual ACEs are analysed separately in order to provide detail on whether certain ACEs are driving any associations of the ACE score or whether the patterns of associations differ across types of ACEs. We did not adjust for other ACEs as covariates when analysing each individual ACE as this would likely have resulted in overadjustment, based on the rationale that the causal structure linking multiple ACEs is complex and largely unknown (Houtepen et al., 2020).

To determine whether there were any sociodemographic differences in the association between ACEs scores and childhood obesity, multivariable logistic regression models were conducted with ACEs scores, sociodemographic characteristics (gender, ethnicity, food insecurity) and interaction terms (between ACEs scores and sociodemographic characteristics) included. These regression models were also adjusted for other sociodemographic variables. This is particularly important when considering the effects by ethnicity as these sociodemographic variables (e.g., food insecurity) are heavily confounded with ethnicity.

The association of ACEs scores with obesogenic behaviours were assessed using logistic regression analyses and odds ratios adjusting for sociodemographic characteristics (**Table 10**). Associations between these obesogenic behaviours and obesity (BMI) were also tested. In order to align with ethical considerations and privacy guidelines, cell sizes less than 10 in tables were suppressed and denoted as <10, while percentages were not reported and replaced with 'NR'.

Results: Part One

The sociodemographic characteristics of the sample are provided in **Table 3.** Slightly over half of the children in DCW8 (51.5%) were boys, and children identified as European comprised 49.8% of the sample, 22.8% identified as Māori and 10.8% as Pacific. Over a quarter (26.3%) lived in the most deprived areas, and 19.1% were classified as food insecure.

Table 3 demonstrates the prevalence of obesity outcomes for the whole sample and stratified by sociodemographic characteristics. Of the sample, one out of three (34.4%) were identified as overweight or obese, 14.5% were identified as obese, and 15.6% with high waist circumference/height ratio. Boys, children identified as Pacific and Māori, those living in a food insecure household, and those living in most deprived areas had significantly higher overweight/obesity rates.

Prevalence of each individual ACE

Table 4 demonstrates the prevalence of each ACE for the whole sample and as stratified by sociodemographic characteristics. Of individual ACE types, experience of bullying was the most prevalent ACE reported by more than half of the sample (58.5%), followed by parental experience of ethnic discrimination (33.0%). At least one out of five children experienced parental substance abuse (26.6%), parental mental illness (21.3%), and emotional abuse (20.6%). The least prevalent exposure category was having an incarcerated parent (2.1%).

ACEs were widespread across different sociodemographic groups, however, some sub-populations were more likely to experience specific ACEs. For example, while most ACEs had similar prevalence across genders, boys were more likely to experience physical abuse and bullying than girls. Across ethnic sub-groups, children who were identified as Māori or Pacific experienced the greatest prevalence of almost all ACEs. Children who were identified as European experienced the lowest prevalence of almost all ACEs. ACEs were also more prevalent among children who were living in the most deprived areas and those living in food insecure households (**Table 4**).

Table 3. Sociodemographic characteristics of the GUiNZ respondents (at wave 8) and prevalence of obesity outcomes

	n (row%)			
Sociodemographic	**Overweight/ obesity (BMI)**	**Obesity (BMI 95%)**	**WHtR**	**Total (n col%)**
Whole sample	1682 (34.4)	709 (14.5)	752 (15.6)	4,895 (100)
Gender (n=4,895)				
Boy	895 (35.5)	410 (16.3)	376 (15.2)	2,522 (51.5)
Girl	787(33.2)	299 (12.6)	376 (16.0)	2,373 (48.5)
χ2 (p-value)	2.9 (0.087)	13.2 (**0.001**)	0.7 (0.397)	
Child's prioritised ethnicity (n=4,829)				
Māori	495 (45.0)	235 (21.4)	224 (20.6)	1,099 (22.8)
Pacific	358 (68.3)	224 (42.7)	201 (38.8)	524 (10.8)
Asian	181 (26.0)	70 (10.1)	90 (13.1)	695 (14.4)
MELAA[a]	29 (27.6)	10 (8.6)	15 (14.4)	105 (2.2)
NZ European/NZer	595 (24.7)	160 (6.6)	209 (8.8)	2,406 (49.8)
χ2 (p-value)	446.1 (**0.001**)	514.2 (**0.001**)	319.5 (**0.001**)	
Area deprivation level (NZ DEP 2013, n=4,869)				
Least (1-3)	454 (26.0)	147 (8.4)	160 (9.3)	1,745 (35.8)
Moderately (4-7)	568 (30.8)	202 (11.0)	235 (12.9)	1,841 (37.8)
Most (8-10)	650 (50.7)	354 (27.6)	353 (28.0)	1,283 (26.3)
χ2 (p-value)	215.1 (**0.001**)	248.7 (**0.001**)	209.6 (**0.001**)	
Experienced food insecurity (n=4,560)				
No	1,116 (30.2)	403 (10.9)	444 (12.2)	3,689 (80.9)
Yes	423 (48.6)	232 (26.6)	235 (27.5)	871 (19.1)
χ2 (p-value)	105.7 (**0.001**)	145.1 (**0.001**)	127.1 (**0.001**)	

a Middle Eastern, Latin American, African.
Sample size differs for each variable due to differences in missingness.
The bold font indicates significant χ2 at $p < .05$

Table 4. Prevalence of individual ACEs for the whole sample and by sociodemographic characteristics (for wave 8 participants)

	Emotional abuse	Physical abuse	Parental substance abuse	Parental mental illness	Parental incarcer-ation	Parental separation /divorce	IPV against mother	Ethnic discrimination	Bullying
					n (%)				
Total sample	1019(20.6)	870 (17.6)	1314(26.6)	1054(21.3)	104 (2.1)	763 (15.4)	548 (11.5)	1625(33.0)	2849(58.5)
Missingness	1 (0.0)	4 (0.1)	1 (0.0)	0 (0.0)	20 (0.4)	0 (0.0)	184 (3.7)	20 (0.4)	72 (1.5)
Child's gender									
Boy	543 (21.3)	507 (19.9)	648 (25.4)	552 (21.6)	52 (2.1)	394 (15.5)	287 (11.7)	848 (33.4)	1527(61.1)
Girl	476 (19.9)	363 (15.2)	666 (27.8)	502 (20.9)	52 (2.2)	369 (15.4)	261 (11.3)	777 (32.5)	1322(55.7)
χ^2 (p-value)	1.5 **(0.3)**	20.0**(0.001)**	3.6 (0.06)	0.4 (0.55)	0.1 (0.75)	0.002(0.96)	0.2 (0.68)	0.4 (0.53)	14.6(**0.001**)
Child's prioritised ethnicity									
Māori	269 (24.2)	234 (21.1)	497 (44.7)	288 (25.9)	60 (5.4)	291 (26.2)	146 (14.2)	491 (44.4)	666 (61.0)
Pacific	189 (35.2)	214 (39.9)	143 (26.6)	165 (30.7)	11 (2.1)	127 (23.7)	124 (25.0)	205 (38.4)	350 (66.4)
Asian	174 (24.7)	145 (20.6)	42 (6.0)	172 (24.4)	<10 (NP)	64 (9.1)	162 (23.4)	309 (44.2)	387 (56.1)
MELAA	18 (17.1)	15 (14.3)	14 (13.3)	17 (16.2)	<10 (NP)	14 (13.3)	<10 (NP)	39 (37.50)	67 (63.8)
European/NZer	360 (14.9)	258 (10.7)	608 (25.1)	386 (16.0)	24 (0.99)	243 (10.1)	101 (4.2)	557 (23.1)	1339(56.0)
χ^2 (p-value)	134.6 (**0.001**)	275.6 (**0.001**)	351.5 (**0.001**)	90.1 (**0.001**)	84.0 (**0.001**)	204.9 (**0.001**)	315.2 (**0.001**)	220.0 (**0.001**)	25.6 (**0.001**)
Area level deprivation (NZ DEP 2013)									
Least (1-3)	253 (14.4)	175 (10.0)	377 (21.4)	289 (16.4)	14 (0.8)	161 (9.2)	115 (6.7)	492 (28.0)	940 (54.3)
Moderate (4-7	373 (20.1)	290 (15.6)	480 (25.9)	371 (20.0)	30 (1.6)	253 (13.6)	185 (10.3)	609 (32.9)	1072(58.3)
Most (8-10)	388 (29.8)	399 (30.7)	451 (34.6)	389 (29.8)	60 (4.6)	345 (26.5)	244 (20.2)	514 (39.8)	824 (64.5)
χ^2 (p-value)	108.3(**0.001**)	229.1 (**0.001**)	67.3 (**0.001**)	83.2 (**0.001**)	56.4 (**0.001**)	179.1 (**0.001**)	132.7 (**0.001**)	46.5 (**0.001**)	31.3 (**0.001**)
Experienced food insecurity									
Yes	262 (29.6)	249 (28.2)	329 (37.1)	307 (34.7)	48 (5.5)	262 (29.6)	182 (22.6)	371 (42.1)	551 (63.6)
No	664 (17.9)	532 (14.3)	930 (25.0)	657 (17.7)	49 (1.3)	440 (11.8)	319 (8.8)	1119(30.2)	2093(57.0)
χ^2 (p-value)	61.1 (**0.001**)	97.3 (**0.001**)	52.6 (**0.001**)	124.2 (**0.001**)	58.7 (**0.001**)	173.8 **(0.001)**	126.7 (**0.001**)	45.7 (**0.001**)	12.3 (**0.001**)

Prevalence of exposure to cumulative ACEs

In the sample, the mean count for the ACEs Index was 2.05. low quartile (25%) was 1, median (50%) was 2, and upper quartile was 3. Regarding cumulative ACEs scores, our findings indicate that exposure to multiple ACEs by age 8 were widespread; 87.1% of the study sample reported at least one ACE (any ACEs), 27.0% experienced two ACEs, 16.7% experienced three ACEs, and 16% experienced four or more ACEs (**Table 5**).

The percentage of those who experienced any or multiple ACEs varied across sociodemographic subgroups and showed similar patterns to individual ACEs. Overall, higher exposure to ACEs were significantly more prevalent among those who were identified as Māori or Pacific (92.4% of Māori and 95% of Pacific children experienced at least one ACE), lived in the most deprived areas, and those living in food insecure households ($p<0.001$) (**Table 5**). The inequality in experiencing ACEs appears higher as the number of ACEs increased. For example, Māori and Pacific children were twice as likely to experience 3 ACEs compared with European children and were over four times more likely to experience 4+ ACEs compared with European children. The proportion of children with 3 ACEs among those living in the most deprived areas was almost double those living in the least deprived areas (21.5% and 12.6%, respectively). This inequality was exacerbated as the number of ACEs increased, as those living in most deprived areas were over four times more likely to experience 4+ ACEs compared with those living in the least deprived areas (30.9 % and 7.3% respectively). The same pattern was observed for children living in a food insecure household where, compared with those living in food secure households, the proportion of children with 3 ACEs was 1.5 times higher and the proportion of those with 4+ ACEs was three times higher (**Table 5**).

Table 5. Number of ACEs experienced by sociodemographic characteristics (for wave 8 participants)

	0 ACEs	1 ACE	2 ACEs	3 ACEs	4+ ACEs	Any ACEs (at least 1)
			n (%)			
Whole sample (n=4946)	640 (12.9)	1355 (27.4)	1334 (27.0)	828 (16.7)	789 (16.0)	4306 (87.1)
Child's gender						
Boy	303 (11.9)	689 (27.1)	693 (27.2)	432 (16.9)	433 (17.0)	2247 (88.1)
Girl	337 (14.1)	666 (27.8)	641 (26.8)	396 (16.5)	356 (14.9)	2059 (85.9)
χ^2 (p-value)	8.5 (0.07)					5.2 (**0.02**)
Child's prioritised ethnicity						
Māori	85 (7.7)	199 (17.9)	298 (26.8)	216 (19.5)	313 (28.2)	1026 (92.4)
Pacific	27 (5.0)	82 (15.3)	126 (23.5)	131 (24.4)	171 (31.8)	510 (95.0)
Asian	75 (10.7)	175 (24.9)	219 (31.1)	130 (18.5)	105 (14.9)	629 (89.4)
MELAA	<10 (NP)	35 (33.3)	35 (33.3)	18 (17.1)	<10 (NP)	96 (91.4)
European/NZer	431 (17.8)	853 (35.3)	638 (26.4)	318 (13.2)	179 (7.4)	1988 (82.2)
χ^2 (p-value)	579.8 (**0.001**)					114.1 (**0.001**)
Area level deprivation						
Least (1-3)	308 (17.5)	610 (34.7)	491 (27.9)	221 (12.6)	128 (7.3)	1450 (82.5)
Moderate (4-7)	242 (13.1)	521 (28.1)	517 (27.9)	320 (17.3)	256 (13.8)	1614 (87.0)
Most (8-10)	86 (6.6)	218 (16.7)	317 (24.3)	280 (21.5)	403 (30.9)	1218 (93.4)
χ^2 (p-value)	468.6 (**0.001**)					79.4 (**0.001**)
Experienced food insecurity						
Yes	62 (7.0)	141 (15.9)	189 (21.3)	193 (21.8)	301 (33.9)	824 (93.0)
No	543 (14.6)	1134 (30.5)	1053 (28.5)	566 (15.2)	418 (11.3)	3171 (85.4)
χ^2 (p-value)	354.6 (**0.001**)					36.4 (**0.001**)

NP: Percentages are not provided due to cell sizes being less than 1

Prevalence of obesity outcomes by individual and cumulative ACEs

Children who experienced physical abuse had the highest rate of obesity (24.8%), followed by those whose mothers experienced IPV (22.9%) and those who experienced parental separation (22.5%). The prevalence of obesity among those who reported no experience of ACEs was almost half of that reported for the whole sample and that reported for those with at least one ACE (6.5% for those with no ACEs, 14.5% for the whole sample, and 15.7% for those with at least one ACE). A dose response effect was observed, as those with higher ACEs scores had higher rates of obesity (6.5%, 10.2%, 13.6%, 17.5%, 26.9% for those who respectively experienced zero, one, two, three, or at least four ACEs) (**Table 6**).

Exposure to individual and cumulative ACEs and the risk of obesity

Table 7 indicates that after adjusting for potential confounders, six out of nine assessed ACEs (emotional and physical abuse, parental mental illness, parental separation/divorce, exposure to ethnic discrimination, and peer-bullying) showed significant associations with childhood obesity. That is, children who experienced these ACEs were at increased risk of developing obesity at age 8 (AOR ranging from 1.22 to 1.44). Certain ACEs related more strongly to obesity than others. For example, after adjusting for confounders, physical abuse showed stronger associations with obesity than other ACEs. A significant dose-response effect was observed where experience of a higher number of ACEs was associated with greater risk for obesity. The exposure to even one ACE was associated with increased risk for obesity. The point estimate (AORs) increased as the number of ACEs increased (from 1.78 for one ACE to 2.84 for 4+ ACEs). A similar pattern was observed using other measures of obesity (i.e., combined overweight/obesity and WHtR).

Subgroup analyses: Association between ACEs and obesity by sociodemographic characteristics

To assess whether childhood adversity is associated with child obesity in the same way across ethnicity, gender, and socioeconomic sub-populations, interaction terms were added to logistic regression models. Food insecurity was used as an indicator of severe poverty. Analyses were repeated for the outcome variables obesity, overweight/obesity, and WHtR (data not reported). Only two significant interactions were found, one for ethnicity when WHtR was used as outcome variable: Māori children with 1 ACE were more likely to have high WHtR than European children with 1 ACE. Using overweight/obesity as the outcome variable, a second significant interaction was found where girls with 2 ACEs were more likely to be obese/overweight than boys with 2 ACEs. Given the large number of tests we ran, these two significant results could well be due to chance. As most of the interaction terms were not significant, no stratified analyses are reported for each ethnic group, child's gender, or food insecurity factors.

Table 6. Distribution of each obesity outcome by individual ACEs and ACEs scores

Individual ACEs	Overweight/obesity n(%)	Obesity n(%)	WHtR n(%)
Emotional abuse (n=1,019)	426 (42.3)	203 (20.1)	206 (21.0)
Physical abuse (n=870)	393 (46.1)	212 (24.8)	209 (24.7)
Parental substance abuse (n=1,314)	536 (41.3)	229 (17.7)	241 (18.9)
Parental mental illness (n=1,054)	414 (39.9)	210 (20.2)	209 (20.5)
Parental incarceration (n=104)	46 (45.1)	19 (18.6)	21 (20.8)
Parental separation/Divorce (n=763)	334 (44.7)	168 (22.5)	186 (25.3)
IPV against mother (n=548)	244 (25.4)	123 (22.9)	117 (22.2)
Parental experience of ethnic discrimination (n=1,625)	627 (39.1)	289 (18.1)	283 (18.0)
Bullying (n=2,849)	1059 (37.4)	459 (16.2)	492 (17.6)
ACE scores			
Ref. 0 ACEs (n=640)	141 (22.2)	41 (6.5)	46 (7.3)
1 ACE (n=1,355)	386 (28.7)	137 (10.2)	157 (11.9)
2 ACEs (n=1,334)	437 (33.0)	180 (13.6)	193 (14.7)
3 ACEs (n=828)	327 (40.0)	143 (17.5)	151 (18.7)
4+ ACEs (n=789)	391 (50.5)	208 (26.9)	205 (27.0)
Any ACEs (one or more) (n=4,306)	1541 (36.2)	668 (15.7)	706 (16.8)

Table 7. Exposure to individual and cumulative ACEs and risk of obesity by age 8 in GUiNZ

	Overweight/obesity		Obesity		WHtR	
Individual ACEs	**OR (95%CI)**	**AOR (95%CI)**	**OR (95%CI)**	**AOR (95%CI)**	**OR (95%CI)**	**AOR (95%CI)**
Emotional abuse	**1.53 (1.33-1.77)**	**1.25(1.06-1.46)**	**1.68(1.41-2.02)**	**1.22(1.01-1.50)**	**1.58(1.32-1.89)**	**1.21(1.01-1.48)**
Physical abuse	**1.82 (1.57-2.11)**	**1.32(1.11-1.57)**	**2.36(1.97-2.83)**	**1.44(1.16-1.78)**	**2.08(1.74-2.49)**	**1.42(1.16-1.75)**
Parental substance abuse	**1.51 (1.32-1.72)**	**1.33(1.14-1.54)**	**1.39(1.17-1.65)**	1.16(0.95-1.41)	**1.39(1.17-1.64)**	**1.23(1.02-1.49)**
Parental mental illness	**1.35(1.17-1.56)**	1.11(0.95-1.30)	**1.70(1.46-2.04)**	**1.26(1.02-1.55)**	**1.56(1.30-1.86)**	**1.18(0.97-1.47)**
Parental incarceration	**1.59(1.07-2.36)**	1.11(0.72-1.72)	1.36(0.82-2.26)	0.83(0.47-1.45)	1.43(0.88-2.33)	0.88(0.51-1.52)
Parental separation/divorce	**1.68(1.43-1.96)**	**1.22(1.02-1.46)**	**1.93(1.59-2.34)**	**1.27(1.01-1.59)**	**2.10(1.74-2.54)**	**1.59(1.28-1.96)**
IPV against mother	**1.76 (1.47-2.11)**	**1.31(1.96-1.62)**	**2.03(1.63-2.54)**	1.18(0.91-1.54)	**1.73(1.38-2.16)**	1.14(0.86-1.48)
Parental exposure to ethnic discrimination	**1.37(1.21-1.55)**	**1.20(1.04-1.38)**	**1.52(1.29-1.79)**	**1.32(1.09-1.59)**	**1.31(1.11-1.54)**	1.12(0.94-1.34)
Bullying	**1.42(1.28-1.61)**	**1.34(1.17-1.53)**	**1.49(1.26-1.76)**	**1.35(1.12-1.63)**	**1.50(1.27-1.77)**	**1.41(1.18-1.69)**
ACE scores (0=Referent)						
1	**1.41 (1.13-1.76)**	**1.45(1.14-1.84)**	**1.65(1.15-2.36)**	**1.78(1.19-2.67)**	**1.70(1.21-2.40)**	**1.82(1.25-2.64)**
2	**1.72(1.38-2.14)**	**1.51(1.19-1.92)**	**2.28(1.60-3.24)**	**1.93(1.29-2.88)**	**2.18(1.56-3.06)**	**1.84(1.27-2.67)**
3	**2.34 (1.85-2.95)**	**1.84(1.43-2.38)**	**3.07(2.13-4.42)**	**2.08(1.37-3.16)**	**2.91(2.05-4.12)**	**2.17(1.48-3.20)**
4+	**3.58(2.83-4.52)**	**2.30(1.77-3.00)**	**5.32(3.74-7.59)**	**2.84(1.88-4.28)**	**4.67(3.32-6.56)**	**2.87(1.95-4.21)**
Any ACEs (1 or more)	**1.99(1.63-2.42)**	**1.64(1.33-2.04)**	**2.69(1.94-3.74)**	**2.06(1.42-2.98)**	**2.55(1.87-3.48)**	**2.05(1.46-2.90)**

OR: Unadjusted odds ratios; AOR: Odd ratios adjusted for child's gender, food insecurity, child's prioritised ethnicity.
The bold font indicates significant OR/AOR at $p < .05$

To further explore any variation in ACEs-obesity association by ethnicity that might not have been detected by using interaction terms, we ran analyses separately for each ethnic group. **Table 8** presents an example of stratified analyses for each ethnic group. Stratified results illustrated that despite non-significant interaction terms, ACEs had stronger associations with obesity (using WHtR as outcome variable) among Pacific children compared with other ethnicities. Non-significant associations were found for Asians (across all ACEs scores) and for Māori (for 2 and 3 ACEs), indicating that the association between ACEs and obesity seems to operate differently within these population sub-groups. Non-significant findings for MELAA ethnicity are likely attributable to low sample size (which means a larger sample size would be required to detect significant associations if they existed).

Exposure to ACEs and adoption of obesogenic behaviours

Eight obesogenic behaviours were explored for which definitions are provided in **Table 9.** Experience of even two ACEs were significantly associated with higher odds of adopting obesogenic/unhealthy dietary behaviours such as higher odds of consuming inadequate servings of fruits and vegetables, higher odds of consuming fast foods and soft drinks, and lower odds of regularly consuming breakfast after adjustment for socio-demographic factors (AORs ranging between 1.33 and 1.85) (**Table 10**). The risk increased as the numbers of ACEs increased, as those with 4+ ACEs had 2 to 3-fold increased risk of reporting obesogenic dietary behaviours. A similar pattern was observed for other obesogenic behaviours but associations reached significance with a score of three or more ACEs where children experiencing at least three ACEs were at increased risk of reporting inadequate sleep, excessive screen time, and physical inactivity and sedentary behaviours. Similarly, a significant dose-response effect was observed for these obesogenic behaviours where those with 4+ ACEs had higher odds of reporting these obesogenic behaviours compared with those with 3 ACEs (**Table 10**).

Table 8. Association between ACEs and obesity by child ethnic groups (WHtR as outcome)

	European		Māori		Pacific		Asian		MELAA	
ACE score Ref = 0	OR (95%CI)	AOR (95%CI)	OR (95%CI)	AOR (95%CI)	OR (95%CI)	AOR (95%CI)	OR (95%CI)	AOR (95%CI)	OR (95%CI)	AOR (95%CI)
1	1.57 (0.96-2.59)	1.56 (0.94-2.57)	**2.21 (1.01-4.76)**	**2.43 (1.08-5.50)**	3.39 (0.93-12.26)	4.09 (0.87-19.23)	0.90 (0.40-2.02)	1.31 (0.53-3.25)	1.17 (0.12-11.63)	1.06 (0.09-11.23)
2	**1.93 (1.17-3.21)**	**1.84 (1.11-3.08)**	1.65 (0.78-3.53)	1.78 (0.80-3.93)	**5.75 (1.64-20.12)**	**7.50 (1.65-34.09)**	0.78 (0.35-1.71)	0.77 (0.30-1.96)	1.17 (0.12-11.63)	0.71 (0.06-8.33)
3	**2.16 (1.23-3.77)**	**2.01 (1.14-3.55)**	2.09 (0.97-4.50)	2.11 (0.93-4.75)	**5.89 (1.68-20.59)**	**6.90 (1.52-31.28)**	0.98 (0.42-2.26)	1.20 (0.46-3.17)	2.00 (0.19-21.43)	2.81 (0.23-34.38)
4+	**3.52 (1.95-6.35)**	**3.12 (1.70-5.70)**	**3.31 (1.59-6.90)**	**3.09 (1.41-6.75)**	**6.02 (1.74-20.80)**	**7.45 (1.66-33.37)**	1.23 (0.53-2.86)	1.53 (0.58-4.05)	-	-
Any ACEs (one or more)	**1.94 (1.23-3.06)**	**1.85 (1.17-2.93)**	**2.31 (1.14-4.69)**	**2.32 (1.10-4.92)**	**5.41 (1.61-18.20)**	**6.58 (1.51-28.71)**	0.92 (0.45-1.87)	1.13 (0.49-2.58)	-	-

OR: Unadjusted odds ratios; AOR: Odd ratios adjusted for child's gender and food insecurity
MELAA results were not returned due to small cell sizes
The bold font indicates significant OR/AOR at $p < .05$

Table 9. Definition of obesogenic behaviours

Derived variable	Question
Inadequate fruit (<2) and vegetable (<3) consumption	On average, how many servings of fruit does eat per day? On average, how many servings of vegetables does eat per day? Responses were categorised as eating less than 5 servings of vegetables or fruits per day versus more than 5 servings.
Frequent soft drink consumption	In the past 7 days, how many times did have a fizzy or soft drink, such as cola or lemonade? Responses were categorised as two or more fizzy drink versus none.
Frequent fast food consumption	In the past 7 days, how many times did eat any food from a fast food place or takeaway shop, such as fish and chips, burgers, fried chicken or pizza? Includes snacks & mealtimes. Responses were categorised as two or more times versus none.
No regular/daily breakfast consumption	Over a usual week, how many days does eat breakfast? Responses were coded as 7 days a week versus <7.
Inadequate sleep duration	On average, how much time does spend asleep at night in total? Following Ministry of Health guideline responses were coded as less than nine hours (inadequate sleep duration) versus nine or more hours.
Excessive screen time	On a normal weekday, spending time watching television programming including free to-air, online, and pay TV or DVDs either on TV or other screen-based devices? On a normal weekend day, spending time watching television programming including free to-air, online, and pay TV or DVDs either on TV or other screen-based devices? Following NZ Ministry of Health and WHO guidelines for screen viewing limitations at age 5 to17 years, total screen time per day was broken into a dichotomous variable representing children who limited screen-viewing time to less than two hours per day (met the guideline) vs. those who viewed one hour or more per day (exceeded the guideline).
Leisure-time physical inactivity	What does usually do when {HE/SHE} has a choice about how to spend free time? A binary variable was created for "usually doing inactive things: yes/no".
Leisure time sedentary behaviour	Some kids would rather play outdoors in their spare time BUT other kids would rather watch TV (Would prefer TV sort of/really true for me versus would prefer playing outdoors sort of/really true)

Table 10. Adjusted association between obesogenic behaviours, obesity (BMI), and ACEs score

	ACEs			Obesity (BMI)	Obesity (WHtR)
Obesogenic behavior	**ACEs Score**	**No. (%)**		**AOR (95% CI)[a]**	
Inadequate fruit and vegetable consumption (<2 fruits, <3veg)	1	245 (34.8)	1.31 (0.98.1.75)	**1.51 (1.16-1.97)**	**1.86 (1.44-2.40)**
	2	283 (40.8)	**1.39 (1.03-1.86)**		
	3	200 (49.0)	**1.62 (1.17-2.23)**		
	4+	211 (58.0)	**2.00 (1.42-2.81)**		
Frequent soft drink consumption (2+ fizzy/soft drink)	1	285 (23.7)	1.19 (0.93-1.52)	**1.99 (1.62-2.43)**	**1.73 (1.43-2.10)**
	2	332 (28.9)	**1.43 (1.12-1.82)**		
	3	257 (39.0)	**1.97 (1.51-2.56)**		
	4+	280 (48.0)	**2.23 (1.70-2.93)**		
Frequent fast food consumption (2+ times)	1	306 (25.0)	1.07 (0.85-1.35)	**1.51 (1.24-1.84)**	**1.64 (1.36-1.98)**
	2	383 (32.3)	**1.33 (1.05-1.67)**		
	3	305 (43.5)	**1.90 (1.48-2.44)**		
	4+	330 (52.5)	**2.26 (1.74-2.93)**		
No regular/daily breakfast consumption	1	84 (6.7)	1.37 (0.89-2.10)	**1.86 (1.47-2.35)**	**1.82 (1.45-2.30)**
	2	129 (10.5)	**1.85 (1.22-2.80)**		
	3	121 (16.3)	**2.55 (1.67-3.89)**		
	4+	179 (25.6)	**3.16 (2.08-4.81)**		
Inadequate sleep duration (<9 hours)	1	118 (9.8)	1.36 (0.94-1.98)	**1.59 (1.24-2.04)**	**1.69 (1.33-2.14)**
	2	119 (10.3)	1.25 (0.87-1.82)		
	3	117 (17.1)	**1.80 (1.23-2.63)**		
	4+	147 (24.9)	**2.43 (1.66-3.56)**		
Excessive screen time (=>2hours)	1	456 (44.0)	1.05 (0.85-1.30)	**1.65 (1.31-2.08)**	**1.65 (1.32-2.05)**
	2	465 (47.3)	1.15 (0.93-1.42)		
	3	280 (56.0)	**1.51 (1.17-1.94)**		
	4+	245 (61.4)	**1.78 (1.35-2.36)**		
	1	493 (40.4)	1.20 (0.98-1.47)	**1.85 (1.53-2.24)**	**1.73 (1.45-2.08)**

Leisure time physical inactivity (reported by mother)	2	507 (43.1)	**1.29 (1.05-1.58)**		
	3	301 (42.8)	1.24 (0.99-1.56)		
	4+	352 (54.1)	**1.87 (1.47-2.37)**		
Leisure time sedentary behaviour (reported by child)	1	443 (33.1)	1.07 (0.86-1.32)	**1.41 (1.17-1.70)**	**1.53 (1.28-1.82)**
	2	481 (36.6)	1.23 (0.99-1.53)		
	3	348 (42.4)	**1.56 (1.23-1.97)**		
	4+	338 (43.4)	**1.59 (1.25-2.03)**		

AOR= Odd ratios adjusted for child's gender, food insecurity, child's prioritised ethnicity; CI= 95% confidence interval.
The bold font indicates significant OR/AOR at $p < .05$

Part Two: Identifying positive childhood experiences (PCEs) with the potential to protect against and offset effects of ACEs manifesting as unhealthy weight

Methods

Construction of PCEs index as mitigating factor

Background

A rapid literature review was conducted to identify a comprehensive list of commonly studied PCEs in the literature. Due to time restrictions, conducting a comprehensive systematic literature review did not seem feasible. The review found that PCEs research is still very much in exploratory phases compared with ACEs scholarship, with less than a decade of research on PCEs both nationally and internationally. Our review also explored resiliency factors, which are conceptually similar to PCEs and have been studied for a longer period. It is worth noting that there are key differences between PCEs and resiliency factors: PCEs exclusively focus on childhood (whereas resiliency can be explored during any life-stage), PCEs and their cumulative impact are designed in relation to ACEs (whereas resiliency can be studied in relation to broad conceptions of adversity), and PCEs can contribute to and effect resiliency.

Existing research is generally limited by its examination of individual or a small selection of protective factors or PCEs rather than their cumulative impact (Crandall et al., 2020), and many studies which have assessed both PCEs and ACEs have used non-representative samples (e.g.,(Kosterman et al., 2011; Narayan et al., 2018)). It has been put forward that an ecological focus is needed, which draws on a constellation of multiple environmental factors in children's lives (i.e. families, schooling, neighbourhood, community) (Liu, Kia-Keating, Nylund-Gibson, & Barnett, 2020). From the rapid literature review, our list identified dozens of potential PCE measures clustered by broad and varied categories (e.g., family and parenting environment, equity of access/quality of healthcare services, early childhood education, peer relationships, school environment, cultural connectedness, community and neighbourhood environment/belonging). For example, the Protective and Compensatory Experiences (PACEs) scale comprises 10 items, including *relationship factors*: (a) unconditional love from a parent (or other primary caregiver), (b) having a best friend, (c) volunteering in the community, (d) being part of a social group, and (e) having the support of an adult outside of the family (e.g., a mentor), and *resource factors*: (f) living in a clean and safe home with enough food, (g) having resources and opportunities to learn (e.g., good school), (h) having an engaging hobby, (i) playing organised

sports or having regular physical activity, and (j) having routines and fair, consistent rules at home (Hays-Grudo & Morris, 2020).

Measurement of PCEs is a challenging new space that is currently lacking comprehensive and validated tools (Guo et al., 2022). Adaptation of PCE measures used in the literature to creation of a PCE Index using the GUiNZ dataset was difficult due to several comparability or methodological factors. Existing literature featured differences such as: PCEs (including psychometrically validated measures such as the Benevolent Childhood Experiences scale) are designed to be retrospectively measured in adulthood (Bethell et al., 2019; Narayan et al., 2018), specific PCEs were deliberately created and included in data collection for particular studies (Hashemi, Fanslow, Gulliver, & McIntosh, 2021; Narayan et al., 2018), studies did not report replicable methods for PCE selection or threshold setting (Crandall et al., 2020; Wang, Jiang, Yang, & Choi, 2021), or used cross-sectional data for PCEs and outcomes (Bethell et al., 2019; Qu et al., 2022) Furthermore, there is variability across existing measures and the cutoff points used to determine whether children are regarded as possessing this experience or considered as resilient (Afifi & Macmillan, 2011). The GUiNZ dataset enables us to assess a number of PCEs during childhood using a prospective study design, however the pre-designed nature of the dataset meant that tailoring measures for the current study purpose was not possible, and changing methods for measuring the same concept over different DCWs (data collection waves) sometimes created problems in use of accurate and reliable measures for PCEs. For example, a PCE commonly used in the literature, "Presence of a loving and supportive adult" is often measured retrospectively during adulthood, and is difficult to measure by-proxy and susceptible to biases in parental reports, and was not included in child self-reports at DCW8 (the only DCW up to age 8 in which children's voices were heard). Further, we deliberately did not include commonly used internal resources such as positive personal traits, skills and capabilities of children (i.e. self-regulation, self-perception, self-efficacy) that are often tied to resiliency as they are likely already shaped by externally-situated experiences of PCEs and may not be readily modifiable without identification of what these PCEs are (i.e., they are seen as outcomes of PCEs) (Luthar, Cicchetti, & Becker, 2000). Instead, our focus was on exploring modifiable PCEs which are focused on relationships and environmental factors.

We adopted the Health Outcomes from Positive Experiences (HOPE) conceptual framework to inform our selection of PCEs. HOPE emphasises the promotion of PCEs to strengthen the foundation for positive health outcomes, and encompasses a holistic and developmental approach to child wellbeing(Guo et al., 2022). The HOPE framework has been specifically proposed for preventing or mitigating the effects of ACEs (Sege & Harper Browne, 2017). HOPE comprises four broad categories for PCEs to align with:

- being in nurturing, supportive relationships,

- living, developing, playing, and learning in safe, stable, protective, and equitable environments,
- having opportunities for constructive social engagement and connectedness,
- learning social and emotional competencies.

Importantly, the guiding principles for the HOPE framework note that, "Child and parent health and well-being are inextricably linked. Thus, positive experiences must promote child health, parent health, and a healthy parent–child relationship" (Sege & Harper Browne, 2017). HOPE was selected as a framework to guide the present analysis as it provides a strong and well-supported conceptual basis for development of a PCE index, while enabling flexible selection of PCEs from existing data available in the GUiNZ dataset and for the New Zealand context, which includes its alignment with the Government's Child and Youth Wellbeing Strategy (the Strategy)(Department of the Prime Minister and Cabinet, 2019). Specifically, the HOPE framework aligns with the following objectives of the Strategy:

- Children and young people are loved, safe, and nurtured. This means they feel loved and supported, they have family, whānau and homes that are loving, safe and nurturing, they are safe from unintentional and intentional harm, and they are able to spend quality time with their parents, family and whānau.
- Children and young people are learning and developing. This means they are positively engaged with, and progressing and achieving in education, and they develop the social, emotional and communication skills they need as they progress through life.
- Children and young people are happy and healthy. This means they build self-esteem and resilience, they have good mental wellbeing and recover from trauma, and they have spaces and opportunities to play and express themselves creatively.
- Children and young people are accepted, respected, and connected. This means they feel accepted, respected and valued at home, school, in the community and online, they feel manaakitanga (kindness, respect and care for others), they live free from racism and ethnic discrimination, and they have stable and healthy relationships.

Selection of PCEs

The variable mapping process was conducted with all available GUiNZ datasets at the time of this research (DCWs 0-8) to identify the most relevant indicators and proxies for potential PCEs. In total, 59 potential items comprising approximately 496 variables were identified for the PCEs index. Given the breadth of this preliminary list, full mapping of identified variables to obesity outcomes, ACEs, and the HOPE framework are not presented here.

We primarily selected PCE measures that aligned with at least one of three domains of the HOPE framework, as the fourth domain (learning social and emotional competencies) may be considered an indicator of outcomes related to

experiences from the other three domains (Guo et al., 2022). PCE measures, including those measured by multiple questions, were turned into binary variables (Yes/No). Binary variable thresholds were set at the 55th-66th percentile of the sample responses to capture slightly better than average responses and to ensure that PCEs were achievable. PCEs were selected for index refinement if they met *at least* one of the following criteria:

- PCE was significantly associated with reduced odds of reporting overweight/obesity at age 8, after adjustment for sociodemographic factors. This was done to examine whether our PCEs had predictive validity for overweight/obesity. Associations between individual PCEs and overweight/obesity were also stratified by ethnicity to ensure that any selected PCEs did not inadvertently increase overweight/obesity risk for particular ethnic groups.
- PCE significantly interacted with reduced odds of reporting overweight/obesity at age 8 for at least one ACEs score, after adjustment for sociodemographic factors.
- Given the cumulative value of the PCEs index, PCEs that have been commonly used in the literature and closely bordered significance with decreased likelihood for overweight/obesity at age 8 were also considered.

As implemented in other research using the HOPE framework (Guo et al., 2022), we focused on PCEs that were defined by the presence of assets, rather than the absence of risk or adversity. Further, if the same data was collected at various time-points, data collected prior to age 8 was prioritised to enable temporal sequencing by comparison with age 8 outcomes. PCE modifiability (including policy implications) was also considered.

PCEs included in PCE Index

Six PCEs were selected from various DCWs, these were: mother 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, child attended effective early childhood education.

'Mother in a committed relationship' was included for the following HOPE broad category (2) Living in a safe and stable environment. This PCE was measured by mother's responses to questions measuring personal commitment in DCW1: "I want to grow old with my partner" and "When I imagine what my life will be like in the future, I always see my partner standing next to me", with possible responses including strongly disagree, disagree, not sure, agree, and strongly agree. Respondents were scored as reporting high personal commitment in their relationship with their partner if they responded 'Strongly agree' to both questions (scoring '10' on the Likert scales), versus low personal commitment or having no partner. This was considered an appropriate threshold as 10 was the median score reported by mothers. Questions pertaining to moral and structural commitment were excluded as the three types of commitment can be differently associated

with outcomes, and have low correlation with each other (Johnson, Caughlin, & Huston, 1999).

'Mother interacted well with child' was measured via an observed interaction task between mother and child at DCW5, and was included to align with the following HOPE categories (1) Nurturing, supportive relationships. The interaction task was measured via interviewer's observation of GUiNZ children and their mothers undertaking a set task (creation of a birthday party invitation), and interviewer's assessment of the quality of the interaction. The task has been used among a broad range of cultures and socioeconomic backgrounds (Aram & Levin, 2001, 2004), and enables observation of a range of dimensions, including whether the mother interacted in a way that a) promoted the child's learning (used questions beginning with who/what/where/which/how/why?, and engaged in 'print talk' such as "How do you draw a b" or "It starts with M", b) provided support and sensitive assistance (mother and child completed the task together, versus either dominating the task), and c) gave warmth and encouragement (instances of mother providing praise e.g., "Nice one!" (Growing Up in New Zealand, 2020). 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 behavioural issues. Children were defined as having this PCE if their interaction scored within the 55th percentile (same as median) of the continuous score derived from the four measures.

'Mother involved in social groups' (DCW1) was included for the following HOPE broad category (3) Having opportunities for constructive social engagement and to develop a sense of connectedness. As in the HOPE guiding principles, children's PCEs also encompass the positive experiences of their parents; mother's social engagement and connectedness is posited to impact on child's perception of and exposure to these constructs. Mothers were asked of their involvement in a range of groups, for example: sports club, church group, marae, or parent and baby group. The number of groups mothers could take part in ranged between 0 and 9. If the mother took part in at least two social groups or organisations (the median/55th percentile response), participants were deemed as having this PCE. Parental participation in social and community groups has been posited to provide a link between family and community, via parental support and social integration, and influences on child participation in organised activities (Mahoney & Magnusson, 2001).

'Children engaged in experiences and activities' measured in DCW2 aligned with the following HOPE broad categories: (2) Developing, playing and learning in safe, stable, protective & equitable environments, and (3) Having opportunities for constructive social engagement and to develop a sense of connectedness. Mothers were asked about child's experiences, activities and places visited since birth, including examples such as the library, beach, zoo, movie theatre, park, church/temple/mosque, Santa parade, art gallery, nature/outdoor walks and cultural festivals with interviewers providing 37 possible experiences. If children

had experienced at least 13 experiences (the number of experiences at the 55th percentile of the sample), they were defined as having this PCE.

'Lived in a home with routines and rules' was part of the following HOPE broad category: (2) Living, developing, playing, and learning in safe, stable, protective, and equitable environments. Children were considered to have home routines and rules if they had rules around TV/screentime at age 2 (or no TV), had family meals together (at least six nights per week) at age 4, and had a mostly consistent bedtime at age 4. A home routine constitutes part of having a safe and stable home, as well as conferring health benefits for sufficient sleep and non-sedentary playtime. The role of this PCE, in several iterations, has been explored in various studies (A Crandall, Jacob R Miller, et al., 2019; Liu et al., 2020; Narayan et al., 2018; Traub & Boynton-Jarrett, 2017).

'Child attended effective early childhood education (ECE)' at DCW4 spanned all three HOPE categories. This PCE was assessed by 10 questions on mother's satisfaction with the effect of ECE on their child across different domains: independence, social skills (playing, joining in, relationships with others), development of language and communication, development of cultural awareness and belonging, pre-writing/writing skills, pre-reading/reading skills, skills with numbers, physical or motor skills, interest in music or singing, interest in learning and exploring. Mother's report of satisfaction of ECE effect on child can be considered a proxy for the quality of ECE. The Likert scales in the tool produced a continuous score; those who scored at or above the 55th percentile were considered to have this PCE. Those who did not attend ECE were marked as not having this PCE. 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 (Larose, Côté, Ouellet-Morin, Maughan, & Barker, 2021; Sciaraffa, Zeanah, & Zeanah, 2018).

PCEs scores

To measure cumulative effects of PCEs, a PCE score (count variable) was calculated, which is an integer between 0 and 6. The cumulative PCEs score is a strength index emphasising the accumulation of PCEs by indicating how many types of positive experiences a child has experienced. We grouped cumulative scores into the categories: 0-1, 2, 3, 4, and 5-6 PCEs experienced to ensure adequate statistical power to detect meaningful associations with ACEs scores and to simplify reporting.

Analytical procedure

Statistical analyses were performed using Stata 15 (StataCorp, 2017). The sample size for Part 2 remained consistent with Part 1, comprising 4,985 participants. However, each individual PCEs variable had less than 4% missing data, except for 'mother interacted well with child PCE,' which had 8.6% missingness, resulting in a smaller sample size for the regression analyses.

First, prevalence of individual and cumulative PCEs were described in the sample, overall and by sociodemographic characteristics (**Tables 11 & 12**). Chi-square tests were used to examine associations between PCEs and sociodemographic characteristics.

The combined overweight/obesity variable was used as the primary outcome in Part 2 of this project as the low numbers for obesity alone compromised data density and statistical significance of analysis when models assessed interactions across both ACEs and PCEs subgroups. Prevalence of overweight/obesity in the whole sample and by sociodemographic characteristics have been previously described in **Table 3**. Distribution of overweight/obesity by individual and cumulative PCEs are presented in **Table 13**. In order to test the predictive validity of PCEs, the association of each individual PCE and PCEs scores with combined overweight/obesity outcome were assessed using logistic regression analyses with unadjusted odds ratio and odds ratios adjusted for sociodemographic characteristics reported (**Table 13**).

Separate multivariable logistic regression analyses were conducted to evaluate the independent associations between individual PCEs and cumulative scores of PCEs and overweight/obesity while adjusting for sociodemographic characteristics and ACEs scores. Results are presented in **Tables 16 & 17**.

To illustrate the combined effect of PCEs and ACEs on overweight/obesity, the prevalence of PCEs scores in the context of ACEs scores are presented in **Supplementary Table 2**. Prevalence of overweight/obesity outcome by each individual PCE for each level of ACEs exposure is presented in **Table 14**.

For cumulative PCEs, we used a series of binary scores instead of the five-category PCEs score used in previous analyses. Given the small sample size for each cell, this enabled us to ensure adequate statistical power to detect meaningful associations/interactions (sliced up by overweight/obesity, ACEs score, and PCEs score). Binarised score groups also simplify reporting of results by narrowing the number of comparative groups. We tried four different ways of binarising PCEs scores to find the optimal number of PCEs with potential to mitigate the impact of ACEs on outcome variable (0-1 vs 2-6, 0-2 vs 3-6, 0-3 vs 4-6, 0-4 vs 5-6). Prevalence of overweight/obesity outcome by PCE score for each level of ACEs exposure is presented in **Table 15** and **Figure 1**.

To explore whether PCEs can moderate the association between ACEs and overweight/obesity in children, interaction terms between individual PCEs and ACEs scores were added to multivariable logistic regressions. These models were further adjusted for sociodemographic characteristics (**Table 16**). Similar analyses were conducted for PCEs score where interaction terms between PCEs scores and ACEs scores were added to multivariable logistic regressions adjusted for confounders (**Table 17**). Interaction analyses were also conducted separately for each ethnic group (**Table 18**). In order to align with ethical considerations and

privacy guidelines, cell sizes less than 10 in tables were suppressed and denoted as <10, while percentages were not reported and replaced with 'NP'.

Results: Part Two

Prevalence of PCEs

Prevalence of exposure to each individual PCE

Table 11 demonstrates the prevalence of each PCE for the whole sample and stratified by sociodemographic characteristics. Of individual PCE types, "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%) and mother interacting well with child (62%). At least half of children had engaged in experiences and activities (53.8%) and a similar proportion had attended an effective ECE (50.2%). The least prevalent exposure category was living in a household with routines and rules (40.6%).

PCEs were widespread across different sociodemographic groups, however, some sub-populations were more likely to experience individual PCEs. For example, while most PCEs had similar prevalence across genders, 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. Girls were more likely to have mothers that interacted well with them and were also more likely to attend an effective ECE. Across ethnic groups, children who were identified as Asian experienced the lowest prevalence of almost all PCEs (except for mother in a committed relationship). Children who were identified as European experienced the highest prevalence of all individual PCEs. PCEs were also less prevalent among children living in the most deprived areas and those living in a food insecure household (**Table 11**).

Table 11. Sociodemographic distribution of individual PCEs (for those with obesity data, n=4,895)

	n (row %)					
	Mother in a committed relationship	Mother interacted well with child	Mother involved in social groups	Child engaged in experiences	Child lived in a home with rules & routine	Child attended effective ECE
	Yes	Yes	Yes	Yes	Yes	Yes
	3,335 (69.6)	2,800 (62.0)	3,425 (71.4)	2,599 (53.8)	1,981 (40.6)	2,359 (50.2)
Missing	101 (2.1)	419 (8.6)	99 (2.0)	69 (1.4)	17 (0.3)	196 (4.0)
Gender						
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)
Girl	1,622 (69.7)	1,422 (64.8)	1,624 (69.7)	1,226 (52.4)	970 (41.1)	1,202 (52.9)
χ^2 (p-value)	0.02 (0.875)	13.6 **(0.001)**	6.3 **(0.012)**	3.9 **(0.048)**	0.4 (0.514)	13.3 **(0.001)**
Child's prioritised ethnicity						
Māori	644 (59.7)	615 (60.1)	751 (69.7)	621 (57.3)	379 (34.6)	547 (51.4)
Pacific	304 (60.7)	267 (56.7)	352 (70.3)	220 (43.3)	158 (30.4)	236 (48.1)
Asian	447 (66.1)	292 (49.0)	407 (60.1)	230 (34.0)	229 (33.0)	265 (39.1)
MELAA	75 (74.3)	57 (63.3)	74 (73.3)	61 (58.1)	43 (40.9)	47 (39.1)
European / NZer	1,837 (77.1)	1,547 (67.5)	1,813 (76.0)	1,449 (60.4)	1,160 (48.2)	1,264 (53.4)
χ^2 (p-value)	136.81 **(0.001)**	79.28 **(0.001)**	69.73 **(0.001)**	178.16 **(0.001)**	113.63 **(0.001)**	45.29 **(0.001)**
Area deprivation level (NZDep2013)						
Least	1,328 (76.9)	1,053 (65.0)	1,289 (74.7)	1,076 (62.2)	801 (46.0)	889 (52.0)
Moderate	1,295 (71.6)	1,091 (63.7)	1,296 (71.7)	988 (54.3)	767 (41.7)	886 (49.9)
Most	692 (56.0)	624 (55.5)	827 (66.9)	517 (41.4)	403 (31.6)	574 (48.3)
χ^2 (p-value)	154.6 **(0.001)**	28.9 **(0.001)**	21.7 **(0.001)**	126.7 **(0.001)**	64.9 **(0.001)**	4.0 (0.134)
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)
Yes	448 (53.0)	436 (55.2)	544 (64.2)	366 (43.1)	269 (31.1)	379 (46.2)
χ^2 (p-value)	142.5 **(0.001)**	23.4 **(0.001)**	31.7 **(0.001)**	57.7 **(0.001)**	47.8 **(0.001)**	8.2 **(0.004)**

The bold font indicates significant $\chi 2$ at $p < .05$

Prevalence of exposure to cumulative PCEs

In the sample, the mean count for the PCEs Index was 2.37, low quartile (25%) was 2, median (50%) was 3, and upper quartile (75%) was 4. Regarding cumulative PCEs scores, our findings indicate that experience of at least 3 PCEs was widespread and reported by 72.1% of the study sample. However, around one in ten (10.9%) experienced zero or only one PCE, and experience of the highest number of PCEs (5-6 PCEs) was only reported by 23% of the sample (**Table 12**).

The percentage of those who experienced multiple PCEs varied across sociodemographic subgroups and showed similar patterns to individual PCEs. Overall, exposure to the highest number of PCEs (i.e., 5-6 PCEs) was significantly more prevalent among those who were identified as European (31.1%), those who lived in the least deprived areas (28.6%), or those living in a food secure household (26.3%) ($p<0.001$) (**Table 12**). In contrast, exposure to the lowest number of PCEs (i.e., 0-1 PCEs) was more prevalent among those identified as Asian (21.6%), those who lived in the most deprived areas (19.6%), or those living in a food insecure household (21.1%). No significant gender differences were found in the experience of low or high number of PCEs.

Table 12. Sociodemographic distribution of PCEs scores (for those with obesity data, n=4,895)

	n (row %)					n(col %)	χ^2 (p-value)
	0-1 PCEs	**2 PCEs**	**3 PCEs**	**4 PCEs**	**5-6 PCEs**	**Total**	
	534 (10.9)	831 (17.0)	1,166 (23.8)	1,237 (25.3)	1,125 (23.0)	4,893 (100)	-
Gender							
Boy	286 (11.3)	441 (17.5)	590 (23.4)	646 (25.6)	558 (22.1)	2,521 (51.5)	4.0 (0.408)
Girl	248 (10.5)	390 (16.4)	576 (24.3)	591 (24.9)	567 (23.9)	2,372 (48.5)	
Child's prioritised ethnicity							
Māori	126 (11.5)	206 (18.7)	279 (25.4)	284 (25.8)	204 (18.6)	1,099 (22.8)	412.8 **(0.001)**
Pacific	89 (16.9)	120 (22.9)	133 (25.4)	104 (19.8)	78 (14.9)	537 (10.8)	
Asian	150 (21.6)	162 (23.3)	185 (26.6)	123 (17.7)	75 (10.8)	695 (14.4)	
MELAA	<10 (NP)	23 (21.9)	20 (19.0)	37 (35.2)	18 (17.1)	105 (2.2)	
European / NZer	124 (5.1)	302 (12.5)	545 (22.6)	686 (28.5)	749 (31.1)	2,406 (49.8)	
Area deprivation level (NZDep2013)							
Least	94 (5.4)	254 (14.6)	386 (22.1)	512 (29.3)	499 (28.6)	1,745 (35.8)	272.9 **(0.001)**
Moderate	184 (10.0)	286 (15.5)	458 (24.9)	467 (25.4)	444 (24.1)	1,839 (37.8)	
Most	251 (19.6)	288 (24.5)	318 (24.8)	246 (19.2)	180 (14.0)	1,283 (26.4)	
Experienced food insecurity							
No	279 (7.6)	552 (15.0)	892 (24.2)	995 (27.0)	969 (26.3)	3,687 (80.9)	207.3 **(0.001)**
Yes	184 (21.1)	183 (21.0)	205 (23.5)	190 (21.8)	109 (12.5)	871 (19.1)	

The bold font indicates significant $\chi 2$ at $p < .05$

NP: Percentages are not provided due to cell sizes being less than 10

Prevalence of PCEs in the context of ACEs

In general, higher numbers of ACEs were accompanied by lower numbers of PCEs, and lower numbers of ACEs were accompanied by higher numbers of PCEs. For example, among children with exposure to 4+ ACEs (n=789), one in five (21.5%) experienced 0 or only 1 PCEs (0-1) and only one in ten (10.9 %) experienced the highest number of PCEs (5-6). The pattern was opposite for those experiencing zero ACEs (n=640) where only one in twenty (4.7%) experienced 0-1 PCEs while one in three (32.5%) experienced 5-6 PCEs. Despite this overall pattern, a substantive subset of the sample experienced both a high number of ACEs and a high number of PCEs. Of those experiencing 4+ ACEs (n=789), almost one in three (29.9%) experienced 4+ PCEs. This number was higher for those with 3 ACEs (n=828) (37.9% reported 4+ PCEs). Finally, a subset of the sample experienced both a low number of ACEs and a low number of PCEs. Of those experiencing 0 or 1 ACEs (n=1995), almost one in five (18.1% and 19.4% respectively) experienced 0 to 2 PCEs (the findings are detailed in **Appendix 2)**.

Exposure to individual and cumulative PCEs and risk of overweight/obesity

Association between PCEs exposure (individually and cumulatively) and the risk of overweight/obesity are presented in **Table 13**. Prevalence of overweight/obesity outcome by each individual PCE for each level of ACEs exposure is presented in **Table 14**. At the individual level, we explored which PCEs sub-types showed significant associations with childhood overweight/obesity after adjusting for potential confounders. We found that four out of six individual PCEs were significantly associated with reduced odds of overweight/obesity at age 8 after adjustment for confounders, including living in a house with a routine (AOR 0.75, 95%CI 0.66-0.86), mother in a committed relationship (AOR 0.83, 95%CI 0.72-0.96), mother interacted well with child (AOR 0.82, 95%CI 0.72-0.95), child engaged in experiences and activities: (AOR 0.86, 95%CI 0.75-0.98). That is, exposure to these PCEs could reduce by between 14% to 25% risk of overweight/obesity. Two individual PCEs (i.e., child attended an effective ECE and mother involved in social groups) were not significantly associated with the odds of overweight/obesity after adjustment for confounders (**Table 13**).

At the cumulative level, the proportion of children with overweight/obesity decreased as the number of PCEs increased (from 45.3% for those with 0-1 PCE to 26.4% for those with 5-6 PCEs). Compared with those reporting 0-1 PCEs, any number of PCEs was significantly associated with reduced risk for overweight/obesity at age 8. A dose-response (step-wise) association was observed for crude associations, with additional PCEs conferring lower point estimates for odds of overweight/obesity (OR reduced from 0.73 for 2 PCEs to 0.43 for 5-6 PCEs). After adjustment for sociodemographic factors, a stepwise association was not clear at the lowest PCEs score (i.e., 2 PCEs), but was

maintained from 3 PCEs (AOR 0.77, 95%CI 0.60-0.98), 4 PCEs (AOR 0.69, 95%CI 0.54-0.88, to 5-6 PCEs (AOR 0.54, 95%CI 0.42-0.69) (**Table 13**).

Table 13. Distribution of overweight/obesity outcome by PCEs and unadjusted and adjusted odds ratios for associations between PCEs score and overweight/obesity

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

OR: Unadjusted odds ratios; AOR: Odd ratios adjusted for child's gender, food insecurity, child's ethnicity

The bold font indicates significant OR/AOR at $p < .05$

Table 14. Prevalence of overweight/obesity by each individual PCE for each level of ACEs score

	Overweight/obesity n(%)											
	Mother in a committed relationship		**Mother interacted well with child**		**Mother involved in social groups**		**Child engaged in experiences & activities**		**Child lived in home with routines & rules**		**Child attended effective ECE**	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
0 ACE	112 (21.1)	23 (25.3)	89 (22.8)	40 (21.1)	98(20.9)	37 (24.0)	84(22.6)	54(21.0)	63 (19.8)	78 (24.9)	80 (24.8)	56 (19.4)
1 ACE	297 (28.6)	86 (29.6)	210 (26.4)	144 (33.0)	292(28.8)	91 (28.9)	205(26.2)	175(31.9)	164(26.1)	222(31.2)	206(30.7)	172(26.8)
2 ACEs	292 (30.5)	128 (38.1)	247 (32.3)	149 (32.0)	306(31.7)	114 (34.6)	225(31.0)	206(35.2)	151(27.5)	285(36.8)	225(33.7)	186(31.1)
3 ACEs	193 (41.1)	122 (38.0)	153 (35.9)	138 (45.4)	205(39.6)	110 (40.3)	146(37.7)	175(42.1)	102(38.4)	22440.9)	146(39.5)	163(39.7)
4+ ACEs	160 (47.1)	222 (52.9)	181 (44.9)	169 (56.2)	232(50.3)	150 (50.2)	163(48.8)	213(50.7)	92 (42.2)	294(53.5)	157(48.0)	212(52.9)

Mitigating effects of PCEs in ACEs-obesity association

Mitigating effects of individual and cumulative PCEs

For this section, we used a series of binary cumulative PCEs scores instead of the five-category PCEs score reported in previous tables. Given the small sample size for each cell, this enabled us to ensure adequate statistical power to detect meaningful associations/interactions (sliced up by overweight/obesity, ACEs score, and PCEs score) and simplified reporting of results.

The lowest overweight/obesity prevalence (23.3%) was observed for children experiencing the lowest number of ACEs (0 ACEs) and the highest number of PCEs (5-6 PCEs). The highest overweight/obesity prevalence (60.2%) was observed for those experiencing the highest number of ACEs (4+ ACEs) and the lowest number of PCEs (0-1 PCEs) (**Table 15** and **Figure 1**). Yet, even among those experiencing the lowest number of ACEs (0), a subset reported a low number of PCEs (0 to 1 PCEs), and this group had greater prevalence of overweight/obesity compared with those reporting 5 to 6 PCEs (40.0% vs 23.3%), indicating that a low number of PCEs is detrimental to children's health (even in the absence of ACEs)(**Table 15** and **Figure 1**).

After controlling for ACEs scores and sociodemographic characteristics, associations between individual and cumulative PCEs with overweight/obesity attenuated but remained significant (**Tables 16 & 17**). When interaction terms between ACEs scores and individual PCEs were added to multivariable logistic regressions, most interactions were non-significant with the exception of two which, given the high number of conducted tests (24 tests), could be well due to the chance (**Table 16**).

When testing interactions between PCEs scores and ACEs scores, we ran four separate analyses to find the optimal number of PCEs which could mitigate the ACEs-obesity association (**Table 17**). Regression models were adjusted for child's gender, child's ethnicity, and household food insecurity status. Significant interactions were found between experiencing at least four of the six included PCEs at all levels of ACEs score (except for 3 ACEs) and reduced risk 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 fewer than 4 PCEs (**Table 17**). Associations were stronger in magnitude for children experiencing 5-6 PCEs than those experiencing 4-6 PCEs. Within 4+ ACEs strata, those experiencing 5-6 PCEs had 64% lower odds of obesity (AOR 0.36, 95%CI 0.18-0.70) while those with 4-6 PCEs had 50% lower odds of obesity (AOR 0.50, 95%CI 0.29-0.86). Within 5-6 PCEs strata, those with the highest number of ACEs (4+ ACEs) experienced lower odds of overweight/obesity (AOR 0.36 95%CI 0.18-0.70) than those with 1 or 2 ACEs (AOR 0.60, 95%CI 0.36-0.99) and (AOR 0.59, 95%CI 0.35-0.98) respectively (**Table 17**).

Table 15. Prevalence of overweight/obesity by ACEs score and binary PCEs score, as in interaction models

ACEs score		Overweight/obesity n (%)
0 ACEs	0-1 PCEs	12 (40.0)
	2-6 PCEs	129 (21.4)
	0-2 PCEs	33 (28.7)
	3-6 PCEs	108 (20.9)
	0-3 PCEs	55 (22.2)
	4-6 PCEs	86 (22.3)
	0-4 PCEs	93 (21.8)
	5-6 PCEs	48 (23.3)
1 ACE	0-1 PCEs	26 (31.7)
	2-6 PCEs	360 (28.6)
	0-2 PCEs	80 (30.7)
	3-6 PCEs	306 (28.3)
	0-3 PCEs	180 (30.7)
	4-6 PCEs	206 (27.3)
	0-4 PCEs	294 (30.5)
	5-6 PCEs	92 (24.3)
2 ACEs	0-1 PCEs	46 (37.1)
	2-6 PCEs	391 (32.5)
	0-2 PCEs	117 (36.5)
	3-6 PCEs	320 (31.8)
	0-3 PCEs	236 (36.6)
	4-6 PCEs	201 (29.5)
	0-4 PCEs	352 (35.3)
	5-6 PCEs	85 (25.9)
3 ACEs	0-1 PCEs	58 (43.9)
	2-6 PCEs	269 (39.3)
	0-2 PCEs	129 (41.8)
	3-6 PCEs	198 (39.0)
	0-3 PCEs	215 (42.3)
	4-6 PCEs	112 (36.3)
	0-4 PCEs	284 (41.2)
	5-6 PCEs	43 (33.6)
4+ ACEs	0-1 PCEs	100 (60.2)
	2-6 PCEs	291 (47.9)
	0-2 PCEs	196 (54.6)
	3-6 PCEs	195 (47.0)
	0-3 PCEs	289 (53.2)
	4-6 PCEs	102 (44.2)
	0-4 PCEs	362 (52.5)
	5-6 PCEs	29 (34.5)

Figure 1. Prevalence of overweight/obesity by PCEs scores for each level of ACE exposure

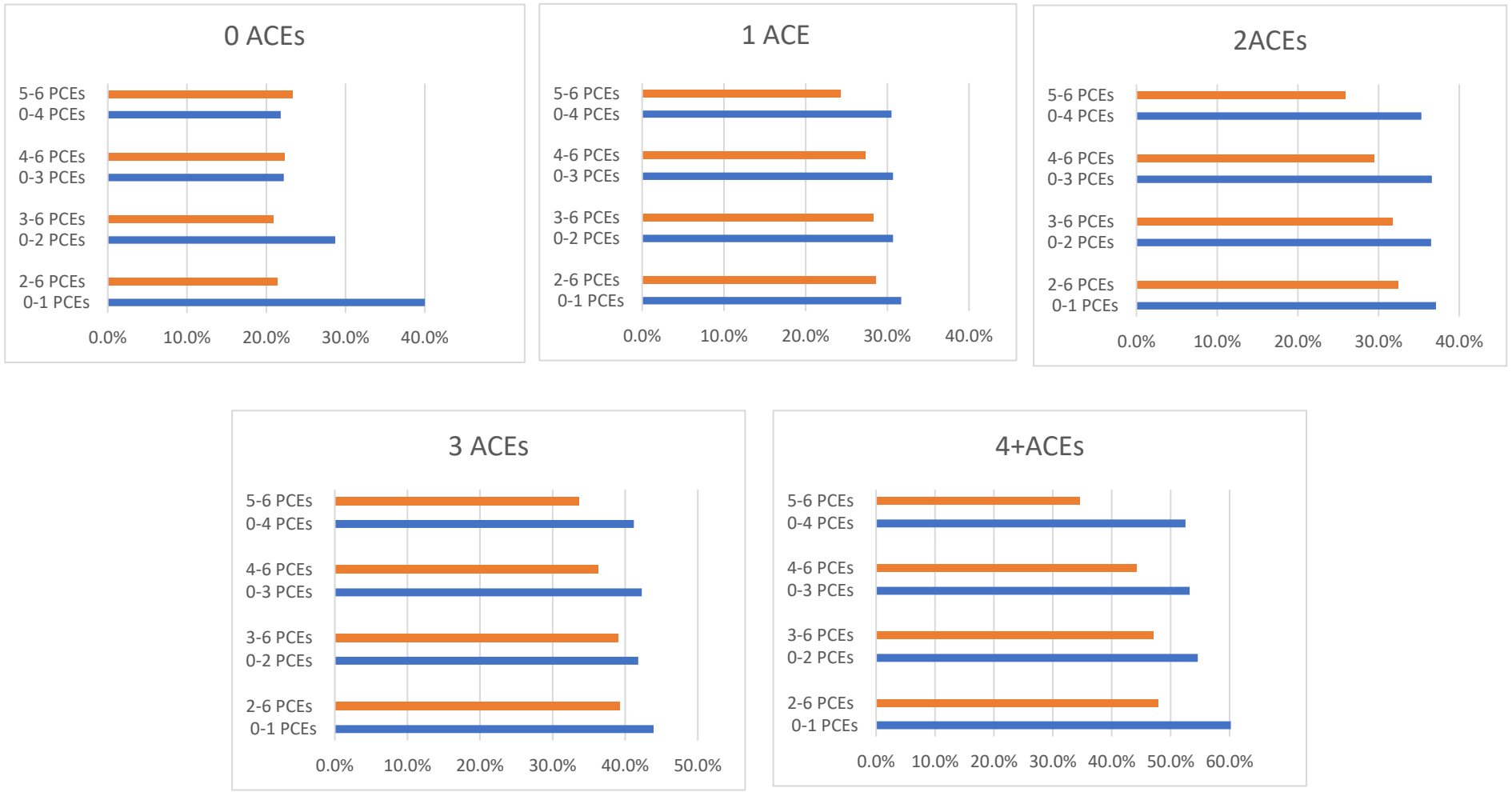

Table 16. Multivariable models of odds of overweight/obesity by ACEs scores adjusted for covariates and by individual PCEs, and individual PCEs/ACEs interaction terms adjusted for ACEs scores and covariates

Overweight/obesity OR/AOR [95%CI]														
	Model 0: Unadjusted for PCE		**Model 1: Mother in a committed relationship**		**Model 2: Mother interacted well with child**		**Model 3: Mother involved in social groups**		**Model 4: Child engaged in experiences & activities**		**Model 5: Child lived in home with routines & rules**		**Model 6: Child attended effective ECE**	
ACE Score (Ref=0)	OR	AOR[a]	OR[b]	AOR[c]	OR[b]	AOR[c]	OR[b]	AOR[c]	OR[b]	AOR[c]	OR[b]	AOR[c]	OR[b]	AOR[c]
1 ACE	**1.41 [1.13-1.76]**	**1.45 [1.14-1.84]**	**1.45 [1.15-1.81]**	**1.47 [1.16-1.87]**	**1.41 [1.12-1.77]**	**1.42 [1.11-1.81]**	**1.46 [1.17-1.83]**	**1.48 [1.17-1.88]**	**1.42 [1.13-1.77]**	**1.44 [1.14-1.83]**	**1.39 [1.12-1.74]**	**1.43 [1.13-1.82]**	**1.42 [1.13-1.77]**	**1.44 [1.13-1.83]**
2 ACEs	**1.72 [1.38-2.14]**	**1.51 [1.19-1.92]**	**1.71 [1.37-2.14]**	**1.51 [1.19-1.93]**	**1.65 [1.31-2.07]**	**1.48 [1.15-1.89]**	**1.73 [1.39-2.17]**	**1.52 [1.20-1.94]**	**1.73 [1.39-2.16]**	**1.51 [1.19-1.92]**	**1.67 [1.34-2.08]**	**1.48 [1.17-1.88]**	**1.68 [1.34-2.10]**	**1.51 [1.18-1.92]**
3 ACEs	**2.34 [1.85-2.95]**	**1.84 [1.43-2.38]**	**2.30 [1.81-2.93]**	**1.85 [1.42-2.40]**	**2.28 [1.78-2.92]**	**1.83 [1.40-2.38]**	**2.37 [1.87-3.01]**	**1.86 [1.44-2.42]**	**2.33 [1.84-2.95]**	**1.86 [1.44-2.41]**	**2.21 [1.75-2.80]**	**1.78 [1.37-2.30]**	**2.30 [1.81-2.92]**	**1.81 [1.39-2.34]**
4+ ACEs	**3.58 [2.83-4.52]**	**2.30 [1.77-3.00]**	**3.45 [2.70-4.40]**	**2.29 [1.74-3.00]**	**3.40 [2.66-4.34]**	**2.21 [1.69-2.91]**	**3.62 [2.85-4.59]**	**2.32 [1.78-3.03]**	**3.45 [2.72-4.38]**	**2.27 [1.74-2.96]**	**3.31 [2.61-4.19]**	**2.20 [1.69-2.87]**	**3.61 [2.84-4.59]**	**2.34 [1.79-3.06]**
Interaction: ACEs x PCE														
PCE x 1 ACE			1.03 [0.54-1.97]		0.60 [0.35-1.02]		0.88 [0.50-1.55]		**0.59 [0.36-0.97]**		0.93 [0.58-1.50]		0.87 [0.54-1.42]	
PCE x 2 ACEs			0.86 [0.45-1.62]		0.88 [0.52-1.50]		0.83 [0.48-1.46]		0.73 [0.45-1.19]		0.77 [0.48-1.25]		0.82 [0.50-1.33]	
PCE x 3 ACEs			1.24 [0.64-2.38]		0.62 [0.36-1.09]		0.97 [0.54-1.73]		0.72 [0.42-1.21]		1.22 [0.72-2.05]		0.73 [0.43-1.22]	
PCE x 4+ ACEs			0.98 [0.51-1.89]		**0.52 [0.30-0.92]**		0.93 [0.52-1.64]		0.77 [0.46-1.30]		0.75 [0.44-1.27]		0.61 [0.36-1.03]	

[a] AOR in Model 0 is adjusted for child's prioritised ethnicity (DCW4), child's gender (DCW0), food insecurity (DCW8).
[b] ORs in models 1-6 are adjusted for that particular individual PCE;
[c] AORs in models 1-6 are adjusted for covariates in Model 0 and for that particular individual PCE
The bold font indicates significant OR/AOR at $p < .05$

Table 17. Multivariable models of odds of overweight/obesity by PCEs scores, ACEs scores, and PCEs/ACEs interaction terms

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

*This row presents PCEs-overweight/obesity models adjusted only for SES covariates (child's prioritised ethnicity, child's gender, food insecurity).

** This row presents PCEs-overweight/obesity models adjusted for SES and ACEs scores

[a] All presented models are adjusted for child's prioritised ethnicity (DCW4), child's gender (DCW0), food insecurity (DCW8).

[b] Model 1 is unadjusted for PCEs.

[C] Models 2-5 are adjusted for covariates in Model 1 and PCEs scores

The bold font indicates significant OR/AOR at $p < .05$

Mitigating effects of PCEs in ACEs-obesity association stratified by ethnicity

To investigate potential ethnic differences in the interactions between PCEs and ACEs scores and associations with overweight/obesity, interaction analyses were repeated separately for each ethnic group. Due to small sample size for each ethnic group, we grouped ACEs scores into the categories: 0, 1-3, 4+ ACEs to ensure adequate statistical power to detect meaningful associations with ACEs and PCEs scores. Significant associations were observed for 1-3 ACEs (and 4+ and 5 + PCEs) for those with European ethnicity, and for 1-3 ACEs and 5+ PCEs for those with Pacific ethnicity (**Table 18**). The direction of most point estimates suggested reduced risk across ethnic groups, however sample size was likely a contributing factor for insignificant results as cell sizes were substantially reduced to assess PCE and ACE interactions for obesity outcomes by ethnic groups. The interpretation of findings in **Table 18** should be exercised with caution due to the small sample sizes, which may not produce meaningful/reliable results.

Table 18. Interactions between PCEs and ACEs scores for association with obesity outcomes, stratified by ethnicity

PCE threshold	ACEs	Māori		Pacific		Asian		NZ European	
		n[a] (%)	AOR [95%CI]	n[a] (%)	AOR [95%CI]	n[a] (%)	AOR [95%CI]	n[a] (%)	AOR [95%CI]
4+ PCEs & overweight / obesity (n=707)	0 ACEs	13 (23.2)	Ref.	<10 (NP)	Ref.	<10 (NP)	Ref.	60 (20.8)	Ref.
	1-3 ACEs	152 (44.3)	1.62 [0.56-4.67]	73 (59.8)	0.24 [0.04-1.43]	34 (22.2)	0.30 [0.08-1.20]	247 (23.0)	**0.53 [0.29-0.96]**
	4+ ACEs	44 (49.4)	0.91 [0.29-2.84]	28 (59.6)	0.28 [0.04-1.81]	<10 (NP)	0.51 [0.10-2.68]	22 (31.4)	0.49 [0.21-1.15]
5+ PCEs & overweight / obesity (n=297)	0 ACEs	<10 (NP)	Ref.	<10 (NP)	Ref.	<10 (NP)	Ref.	34 (21.5)	Ref.
	1-3 ACEs	57 (40.4)	1.56 [0.50-4.87]	26 (52.0)	**0.15 [0.02-0.91]**	14 (22.6)	0.39 [0.06-2.78]	118 (20.9)	**0.55 [0.32-0.96]**
	4+ ACEs	12 (37.5)	0.70 [0.19-2.64]	<10 (NP)	0.14 [0.02-1.11]	<10 (NP)	0.42 [0.03-5.25]	<10 (NP)	**0.34 [0.11-1.06]**

MELAA results were not returned due to small cell sizes.

[a] n (row %) is reported for the percentage of those with overweight/obesity in each cell.

NP: Percentages are not provided due to cell sizes being less than 10

Discussion

Summary

To our knowledge, this is the first New Zealand study to examine the prevalence of a comprehensive list of adverse and positive childhood experiences when GUiNZ children are 8 years of age. Furthermore, this is the first NZ study to also investigate the ACEs-childhood obesity association and the co-occurring positive childhood experiences (PCEs) that could mitigate this association. The ACEs index we developed incorporates and examines the prevalence of a more comprehensive and contextually relevant list of ACEs than has been previously studied in NZ, including across sub-populations. We examined how individual and cumulative ACEs influenced the odds of developing obesity at age 8, and explored mechanisms that may connect ACEs to obesity through examining associations between ACEs and key obesogenic behaviours.

In the second part of this report, we created the first NZ PCEs index, which comprised six individual PCEs and examined the cumulative prevalence of these PCEs and their co-occurrence with ACEs among the cohort and across sub-populations at age 8. Further, we examined how individual and cumulative PCEs were associated with childhood obesity, and whether PCEs could mitigate the negative impacts of ACEs on childhood obesity. Our study goes beyond traditional determinants of childhood obesity and is on-par with emerging fields of knowledge that emphasise the role of toxic stress on biological, physiological, psychological and behavioural development. Further, this study responds to existing criticisms of ACEs research which exclusively focus on deficit models by taking a holistic approach to children's experiences and living environments by considering the positive experiences that often exist concurrently to adversity (A. Crandall et al., 2019).

Prevalence of individual and cumulative ACEs among GUINZ children by age 8

ACEs were common among the GUiNZ cohort. By age 8, 87.1% of children experienced at least one ACE and 16% reported at least four ACEs. These are higher than the 52.8% that were previously reported for the GUiNZ cohort by age 54 months (M. Walsh et al., 2019). These differences could be due to longer exposure time by age 8 (compared to 54 months) and the inclusion of a more comprehensive list of ACEs including those with highest prevalence rates (i.e., exposure to ethnic discrimination and bullying/peer victimisation).

Regarding the prevalence of ACEs, some sub-types, particularly the newly added sub-types (e.g., exposure to ethnic discrimination and peer bullying) had the highest prevalence rates while some others (e.g., parental incarceration) had the lowest prevalence rate. In our study, children living in financially disadvantaged

households and those identified as Māori or Pacific had the highest prevalence of experiencing almost all types of ACEs as well as the higher scores of ACEs.

Comparison of ACEs and PCEs prevalence with other studies

Within the GUINZ cohort, there is a vast amount of information, mainly prospectively collected from mothers and their partners, and children, from various time points and life stages. This vast array of data, considered together, resulted in a higher prevalence of many ACEs than is seen in some other ACEs studies particularly those using retrospectively collected data at a single time point utilising a standardised ACEs questionnaire. For example, in the CDC-Kaiser ACE Study, 64% of American adults reported experience of at least one ACE and 12.5% reported four or more before the age of 18 (CDC, 2016) which is to some extent similar to those found in the New Zealand Family Violence Study (55% and 11.6% of New Zealand adults reported experience of at least one and 4+ ACEs before the age of 18) (Fanslow et al., 2021). Our rates are substantially higher than those reported above but are in range of those reported in international prospective ACEs studies. For example, a US-based study (e.g., Consortium for Longitudinal Studies of Child Abuse and Neglect, LONGSCAN) found that ~90% of children had experienced at least one adversity by age 12, while more than 20% had experienced five or more ACEs (Flaherty et al., 2009).

As another example, a population-based study in England (the Avon Longitudinal Study of Parents and Children) found a similar prevalence of exposure to at least one ACE (84%) in a prospective cohort of children. The prevalence of 4+ ACEs reported in this sample of children was even higher than those found in our study (24% vs 16%) (Houtepen et al., 2020). In sum, studies using a single retrospective questionnaire may be underestimating the prevalence of ACEs. It has been documented that retrospective and prospective reports of ACEs capture largely non-overlapping groups of individuals but that both groups are at risk from adverse outcomes (Baldwin, Reuben, Newbury, & Danese, 2019; Newbury et al., 2018; Reuben et al., 2016).

While comparing ACEs rates can provide valuable insights, directly comparing prevalence rates found in other studies can pose challenges due to methodological inconsistencies within the field. These inconsistencies encompass diverse ACEs definitions and measurements, sample heterogeneity (including variations in demographics, socio-economic status, sociocultural geographic locations variations among studied populations), diverse survey methods (such as prospective versus retrospective designs), and discrepancies between self-reporting and parental reports. Given these complexities, interpreting and generalizing findings across different populations, settings, or studies necessitates careful consideration of these limitations.

All included individual PCEs generated using continuous scores were selected to be reported by at least 50% of the sample. The only exception was living in a

household with routines and rules which was reported by 40.6%, as this was based on three aspects of household routine reported as "most of the time". Similarly to ACEs, we also found that high cumulative counts of PCEs were prevalent among the GUiNZ cohort with 72.1% of children assessed with three or more PCEs and 23% with 5-6 PCEs. Children living in financially advantaged households and those identified as European had the highest prevalence of experiencing all types of PCEs as well as the higher scores of PCEs. Comparison of PCE prevalence rates found in other studies is difficult due to the aforementioned methodological inconsistencies in the field, such as the broad range of PCE thresholds and definitions (including cumulative versus individual PCEs) (Afifi & Macmillan, 2011) and heterogeneity of samples (particularly measurement of PCEs in adulthood) used in the literature (Crandall et al., 2020).

Exposure to individual and cumulative ACEs and the risk of childhood obesity

In this population-based study, children who experienced higher number of ACEs had higher risk of developing obesity by age 8 and these patterns were not fully explained by socioeconomic factors. Even experience of one adversity in childhood was associated with increased risk of obesity in middle childhood. The risk increased as the number of ACEs increased. Experience of four or more ACEs was associated with 3.63 higher odds of developing obesity by age 8 compared with experience of zero ACEs.

Examining individual ACEs revealed an overall pattern mirrored that those of the ACEs scores, however certain ACEs (e.g., physical abuse) related more strongly to obesity than others. Repeated analyses with other indicators of unhealthy weight status (combined overweight/obesity variable and waist circumference to height ratio) yielded similar results. These findings do not support the implicitly accepted assumption in ACEs studies that each ACE has the same magnitude and direction of association with the outcomes. This highlights the importance of studying individual ACEs.

These findings are important as the majority of ACEs literature has focused on retrospective ACE exposure and health outcomes in adulthood. The population-based 2019 New Zealand Family Violence Study gathered retrospective data on experiences of ACEs in adults, and documented long-term health outcomes in adulthood (Fanslow et al., 2021; Hashemi et al., 2021). Our study contributes new information as it examined ACE exposure and weight-related behaviours in children. Our findings suggest that the time course of poor health outcomes and the adoption of unhealthy weight-related behaviours in the setting of ACEs, may in fact become evident in childhood at a time when early intervention and

counselling to address childhood adversities could potentially improve health outcomes.

Associations between ACEs (individual and scores) and obesity outcomes attenuated after adjustment for confounders but remained significant. Estimates of the effects of experiencing 4+ ACEs on obesity attenuated by almost half when adjusting for ethnicity and socioeconomic factors. This suggests that socioeconomic context leads to considerable confounding of the association between ACEs and obesity but these patterns cannot be fully explained by socioeconomic settings in which they are experienced. Our a priori hypothesis was that associations between ACEs and adverse weight outcomes would be weaker in children from high-socioeconomic–position families because other aspects of a high-socioeconomic–position environment could act to mitigate the effects of ACEs. We found no evidence to support this hypothesis; interaction terms were non-significant and associations were either of similar magnitude in families with or without experience of food insecurity and in families living in high, middle, and low levels of deprivation or stronger in less financially disadvantaged groups (results of stratified analyses not shown). Other studies have also found no differences in associations between ACEs and outcomes according to socioeconomic position (Copeland et al., 2018; Houtepen et al., 2020) or race (Björkenstam et al., 2013), and one study found either no difference in ACE–outcome associations according to income or stronger associations in high-income groups (Halfon, Larson, Son, Lu, & Bethell, 2017). Together, these findings support universal ACE prevention or support interventions rather than focusing ACE initiatives only in low socioeconomic population groups.

Possible Mechanisms: obesogenic behaviours as a potential mediator in the ACEs-obesity association

While multifactorial, one potential contributor to the association between ACEs and obesity could be the development of obesogenic or unhealthy weight-related behaviours, a speculation supported by our findings. Our findings demonstrate that an increased count of ACEs is associated with elevated risk for adopting unhealthy weight-related (obesogenic) behaviours in a dose-response manner (albeit with mixed significance levels) for children 8 years of age. Specifically, children exposed to a higher number of ACEs had increased odds of inadequate fruits and vegetable intake, frequent fast food and soft drink intake, excessive screen time, inadequate sleep duration, and sedentary behaviour. The number of ACEs required to reach significance varied across the different obesogenic behaviours; the odds of engaging in unhealthy dietary behaviours were stronger and became significant at 2 ACEs level, while associations between non-dietary behaviours (screen time, sleep duration, and physical inactivity behaviours) became significant at 3 ACEs level. This indicates that ACEs not only have a

statistically significant association with health behaviours, but also a clinically significant association.

As one of the strongest predictors of childhood obesity, a strong association between increased odds of adopting unhealthy dietary behaviours (excessive consumption of fast food and soft drinks and inadequate consumption of fruits and vegetables) and experiencing only 2 ACEs is of particular interest. This finding is in line with previous research which suggests that the accumulation of early stressors in children's family, school and social environments is related to greater psychological distress, which in turn disposes children to appetite modifications with desire for highly palatable 'comfort foods' and eventually increased weight status (Tate, Spruijt-Metz, Pickering, & Pentz, 2015). Research on adult populations has also shown that elevated stress increases cravings for palatable foods (Chao, Jastreboff, White, Grilo, & Sinha, 2017). Importantly, consumption of 'comfort foods' is also driven by structural factors, such as poverty-related distress and geographic and cost inaccessibility of healthful foods for those experiencing material deprivation (Drewnowski, 2012; Pearce, Blakely, Witten, & Bartie, 2007).

ACEs are known to have severely harmful effects in terms of mental health problems, such as depression and anxiety. Once stress, insecurity, and emotional turmoil have been established at an early age, individuals may naturally seek relief from these uncomfortable states through the brain-reward system, with little interference from cognitive processes (Dallman, Pecoraro, & la Fleur, 2005). Given the hedonic properties of junk food, which includes exaggerated energy density (Prentice & Jebb, 2003), binge eating is a readily available form of self-medication, which creates strong habits through changes in the amygdala and hippocampus (Dallman et al., 2005; Tryon, DeCant, & Laugero, 2013). Once established, this cognitive interference renders such habits highly difficult to change. Compared to children who grew up in harmonious families, children in disharmonious (dysfunctional) families are at greater risk of rapidly adopting dysfunctional eating habits where they regularly consume energy dense junk food for emotional and stress-related relief and pleasure (Dallman et al., 2005). In combination with the current toxicity of external environments where fast foods and soft drinks are easily available, cheap, and extensively marketed, unresolved stress and negative emotions in a large segment of our child population will severely limit the success of siloed child obesity prevention plans.

Together, significant associations found between ACEs, obesity, and obesogenic behaviours (and the well-established role of these behaviours in developing obesity found in this study and others (Harada et al., 2021; Wiss & Brewerton, 2020)) support the idea that obesogenic behaviours may mediate associations between exposure to ACEs and increased odds of developing childhood obesity through elevated odds of adopting obesogenic behaviours. Identification of these mediating pathways proposes a risk to the success of traditional weight-loss

interventions that exclusively focus on behavioural change for obesity management. Further, research has shown that ACEs-associated psychopathology (if left unaddressed) may limit ability to effectively participate in obesity interventions and necessitate targeted approaches to engaging children who experienced ACEs in weight management programmes (Fröhlich, Pott, Albayrak, Hebebrand, & Pauli-Pott, 2011).

These findings support the notion of socially patterned frameworks of weight-related behaviours (i.e., unhealthy diet, insufficient sleep, excessive screen time, and physical inactivity), and underscore the importance of addressing individual and social level factors to improve health behaviours among children, especially among those who have experienced ACEs. The American Academy of Pediatrics (AAP) recommend that "the adoption and maintenance of healthful lifestyles must be emphasised as the basis for the prevention of obesity" (Daniels & Hassink, 2015), in line with NZ Ministry of Health guidelines for weight management in children and young people (Ministry of Health, 2019). However, attention must be given to the social and environmental determinants of health, including adversity-related factors that may prevent or impede families from taking up or adhering to these healthful lifestyles.

Aside from obesogenic behaviours partially explaining the mechanisms by which ACEs lead to childhood obesity, our findings are consistent with the strengthening evidence base indicating that exposure to 'toxic stressors', such as childhood adversity, can affect a multitude of health outcomes across the lifespan, including during childhood (Shonkoff & Garner, 2012). Research has found that exposure to adverse experiences in early childhood is associated with stress-related inflammation (via clinical biomarkers) (Rasmussen et al., 2020), biological dysregulation via the HPA axis and allostatic load, and observable differences in brain anatomy, gene expression, and delayed social, emotional, physical and cognitive development (Bethell et al., 2019). Co-occurring stressors in the household (e.g., financial adversity) and wider environment (e.g., exposure to violence at school or neighbourhood or exposure to racism and ethnic discrimination), in the absence of powerful counter-measures that support healthy adaptation and resilience, may promote psychological vulnerability and an emotional overload in children and their families which can further hinder a family's ability to establish household routines and support healthy behaviours.

Exposure to individual and cumulative PCEs and risk of overweight/obesity

In addition to the ACEs, this study examined association between PCEs and childhood overweight/obesity and found that PCEs protected against and reduced the risk of overweight/obesity. These results hold true regardless of the children's ACEs score and socioeconomic position of their families. The protective effects of PCEs were observed across individual and cumulative scores. Our results also

demonstrate that PCEs showed a reverse dose-response association with overweight/obesity, analogous to the cumulative effects of multiple ACEs.

The cumulative protective aspect of the six individual PCEs in our index (mother 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, child attended effective early childhood education) illustrates that multiple domains of children and their family's experiences and environments must be incorporated in conceptions of PCEs, in order for positive implications of PCEs to be observed. This spans various ecological levels, such as individual (child engaged in experiences and activities), mother-child relationship (mother interacted well with child), interparental (mother in a committed relationship), home environment (child lived in a house with routines and rules), community (mother involved in social groups), and in the education system (child attended effective early childhood education). The dose-response association highlighted by our findings illustrates the need for a broad-ranging constellation of efforts to promote PCEs, rather than focusing primarily on highly individualised, and often victim-blaming, approaches often found in child obesity interventions. Furthermore, the qualifying thresholds selected for our PCEs were mostly reported by around the 55th percentile of respondents, or 'slightly better than average'. Thus, our findings suggest that reporting individual PCEs to an extremely high level is not necessary to observe their positive effects.

Mitigating effects of PCEs

Our findings suggest that cumulative PCEs can have a mitigating influence in reducing overweight/obesity risk among those exposed to ACEs, regardless of the count of ACEs. However, the mitigating effects seemed to be present only when the PCEs score was four or above and the effect of ACEs on weight status could not be alleviated when PCEs score was three or less. Similarly, we did not find mitigating effect for individual PCEs. This is consistent with previous studies which found that individual PCEs or a low number of PCEs is not enough to prevent or mitigate negative outcomes (Bellis et al., 2018; Bethell et al., 2019; Crandall et al., 2020). Indeed, research on health outcomes (other than obesity) has shown that among those exposed to ACEs, the protective effect of PCEs on reducing negative outcomes can be observed only when the number of PCEs is markedly higher than the number of ACEs (Crandall et al., 2020).

It is noteworthy that while it was not uncommon for children to have both low PCEs and low ACEs scores, contrastingly low PCEs exposure was accompanied by high ACEs exposure for a considerable section of the sample. For example, in children exposed to 3 or fewer PCEs, 41.5% were exposed to 3+ACEs. The combined effects of high ACEs and low PCEs hit children very hard, with the highest prevalence of overweight/obesity (60%) found among those with such a profile. This might have contributed to non-significant results in interaction

analyses for low PCEs scores. Nonetheless, finding that a high number of PCEs had mitigating effects even in the presence of high ACEs highlights the importance of making available free or affordable and high-quality early childhood education for all children, supporting mother-child relationships, and providing cheap or free opportunities for families to share time together as a way to outweigh detrimental effects of co-occurring adversities even among those with exposure to the highest number of ACEs.

However, it is somewhat confusing that why, among those with highest number of PCEs (5-6), those with higher number of ACEs (4+) experienced lower odds of overweight/obesity than those with 1 or 2 ACEs. This finding is inconsistent with previous research which found that PCEs had stronger associations with health outcomes in participants with fewer ACEs (Xu et al., 2022). A possible explanation for these unexpected and contradictory results could be due to potential differences in types of PCEs between the low and high ACEs exposure groups. As shown in this study, different types of ACEs might have different effects on the risk of obesity (**Table 7**). In logistic regression models with interaction terms, types of ACEs and PCEs were not considered. Therefore, this abnormal association between high level of PCEs, low levels of ACEs and obesity may be a spurious association caused by types of ACEs and PCEs. In the future, the studies on exploring the relationship between ACEs, PCEs and obesity (or wider health outcomes) needs to comprehensively consider the effects of types of ACEs and PCEs. Latent class analyses can be used to examine unique clustering of ACEs and PCEs and the extent to which they influence childhood obesity in the context of each other. Further, the number and duration within each type of ACE occurrence and timing of the ACE occurrence may also be different between people with high and low levels of ACEs, which could account for the interaction of PCEs and ACEs on health outcomes.

Prior research has demonstrated that the timing of traumatic events differentially affects health, with differing effects on health based on whether the event occurred during early, middle, or later childhood (Schalinski et al., 2016). We did not assess the timing of the ACE occurrence in our sample, but it is possible that the timing of ACEs differed on average between those with higher versus lower ACEs, resulting in a differential effect on weight outcomes in the presence of high PCEs.

Relatedly, the number of occurrences (e.g., chronicity or duration) within an ACE category may also be important (A Crandall, R Miller, et al., 2019). For some ACEs indicators, we had information about whether the ACE occurred more than once (albeit with considerable variation in wording across different DCWs). However, since we did not have information on number of occurrences for all ACEs indicators we did not examine whether chronicity of an ACE mattered. Further research on chronicity is merited to better understand the interaction of positive and adverse experiences on health outcomes.

Intersecting inequalities of low socioeconomic status (living in most deprived areas and living in a food insecure household) for those with low PCEs and high ACEs might have also exacerbated obesity risk and contributed to the non-significant mitigation effects for those with low PCEs scores. Owing to the small sample sizes in these subgroups, we were unable to explore these intersections. Another interesting finding of this research was the joint effect of low ACEs and low PCEs on children's obesity outcomes, which were as deleterious as (or even more deleterious than) exposure to a high number of ACEs, even when a high number of PCEs were present. This finding is consistent with limited existing evidence (such as Crandall et al., 2019) which indicates that the lack of PCEs might be more harmful to health than the presence of ACEs. These results demonstrate that as important as decreasing ACEs may be, increasing PCEs may be even more imperative to improving community health, particularly in vulnerable populations with lower PCEs and often simultaneously higher ACEs.

Overall, our findings reinforce the importance of promoting positive experiences across different domains (family, school, communities). Endorsement and support of PCEs like those identified in this research may work towards improving the wellbeing of children, for which one potential outcome may be reduced risk for developing obesity, even among the most at-risk groups. Many of these PCEs, such as providing opportunities for children to have access to effective ECE, or to easily participate in diverse experiences and activities such as sports or other cultural activities, seem to be easily manageable targets for those who work in areas aiming to improve child health and wellbeing at the population and community levels. Research is now beginning to identify associations between PCEs and biological mechanisms for improved health outcomes, such as lower inflammation. For example, evidence has suggested that high levels of parental responsiveness/warmth may be associated with lower levels of inflammation (O'Brien, Loi, Byrne, Zalewski, & Casement, 2021; Priest et al., 2022). In this way, our findings support application of the World Health Organization's definition of health emphasising that health is more than the absence of disease or adversity (Misselbrook, 2014). The positive construct of health promoted by the World Health Organization is aligned with the proactive promotion of positive experiences in childhood, because they are foundational to optimal childhood development.

Policy relevance

With a focus on children's wellbeing and resilience, this research supports the evidence base for the government's Child and Youth Wellbeing Strategy's aspirational objectives that children and young people "are happy and healthy" and "have good mental wellbeing and recover from trauma" (Department of the Prime Minister and Cabinet, 2019). Our findings emphasise the importance of eliminating ACEs, promoting PCEs, and considering the association of PCEs and ACEs with health outcomes in the context of each other. They also underscore the need to target children at-risk of adversity and its health outcomes early, and to identify and facilitate existing PCEs and resiliency factors within families and

communities. This supports the whānau-led, outcomes-based 'early years' system of integrated services and support proposed by the Well Child Tamariki Ora Review (New Zealand Ministry of Health, 2020). By promoting PCEs in communities and embedding PCE-promoting practice in health and education systems, not only will health problems such as obesity be reduced, but general wellbeing will increase at the population level. Focusing on PCEs provides tangible ways for public health and social welfare programmes to intervene in communities or in households at higher risk for ACEs. For example, while we cannot change an ACE that has already occurred, agencies can help families and communities to surround children with positive experiences to help counteract the negative effect of experienced ACEs on health. While the current research found that detrimental impact of ACEs and protective and mitigating effects of PCEs on childhood obesity tended to hold across different ethnic groups, our research primarily sought to identify population-level factors and the following policy recommendations may be applicable to children across Aotearoa / New Zealand.

Policy recommendations

Prevention of ACEs

As with most health-related issues, primary prevention of ACEs is the best course of action to protect children from their effects. The United States' CDC has outlined an evidence-based and comprehensive approach to preventing ACEs, using six strategies: 1) strengthening economic supports for families (e.g., tax credits, family-friendly work policies); 2) promoting social norms that protect against violence (e.g., public education campaigns to support positive parenting, bystander approaches to support healthy relationships); 3) ensuring a strong foundation for early life (e.g., early childhood home visitation, high quality and affordable childcare, ECE enrichment programs); 4) enhancing skills to help parents and youths manage stress, emotions, and everyday challenges (e.g., social emotional learning programs, healthy relationship programs, parenting skill and family relationship approaches); 5) connecting children and adolescents to caring adults and activities (e.g., mentoring, leadership, and after-school programs); and 6) early intervention in ACEs (explored later in discussion).

Structural and environmental factors indicating increased likelihood of experiencing ACEs, including socioeconomic deprivation (as identified in the current study), need to be further disentangled and directly addressed in a way that empowers and strengthens at-risk communities.

In addition to acknowledging the complex ecological and structural causes of ACEs, research has begun to identify initiatives and interventions that may help to prevent and reduce ACEs, including large-scale research by the CDC (Jones, Merrick, & Houry, 2020; Matjasko, Herbst, & Estefan, 2022). Given that the prevention of ACEs requires increasingly nuanced knowledge around which children and families are at high-risk of experiencing adversity, New Zealand-

based initiatives are required for ACEs prevention and promotion of protective factors. Research using the GUiNZ dataset has recently identified some of these protective indicators (including quality of mother-partner relationship and mother's health and wellness) (Walsh, Joyce, Maloney, & Vaithianathan, 2020); policy and practice need to actively promote and support families to create and nurture these factors.

ACEs and PCEs screening is required

Where prevention has fallen short, identification of ACEs is important to ensure appropriate responses can be provided. The high prevalence of impactful ACEs found in this study along with strong associations with childhood obesity and key obesogenic behaviours suggest that children presenting to relevant services with obesity should be evaluated for ACEs, and children presenting with unhealthy weight-related behaviours should also be carefully evaluated for the presence of ACEs.

In many countries around the world (including the UK (Quigg, Selina., & Nadia., 2018; Welsh Government, 2021) and US (Matlin et al., 2019)), ACEs have been used to promote child wellbeing through policy and practice (Crandall et al., 2020). Typical methods include assessing ACEs in clinical and educational settings, facilitating health education and health promotion, and where needed, mitigating the trauma, chronic stress, and behavioural and emotional sequelae associated with exposures to ACEs (Bethell et al., 2017). Currently, healthcare and educational services in NZ are not adequately adversity-informed. Our findings provide impetus for ACEs-informed policies and services that may improve the wellbeing of children in NZ.

This is important because unlike adults who are referred to health services with known clinical diagnoses, children are often referred to these services based on displayed behaviours (O'Connell, Boat, & Warner, 2009) and mainly by caregivers (Finkelhor, Wolak, & Berliner, 2001). However, children who reside in homes with substance abuse, incarceration, or domestic violence may not be identified by their caregivers as in need of behavioural, mental, or physical health services.

Schools can play a crucial role in identifying children who have been exposed to ACEs as they may be the first place where children receive any services for their displayed behavioural issues.

Service providers in health and education settings should be informed and mobilised to screen for childhood adversities in real-time and both identify and support children who are headed for ACE-related adverse outcomes, so that effective assistance to recovery can be provided at the most strategic time.

Considering the protective and mitigating effects of PCEs against obesity found in this research, in addition to broadened screening for ACEs in the healthcare, education, and social services systems serving children and families, integrated assessment of PCEs (such as those assessed here) may align needs and improve

intervention efforts and engagement by leveraging existing assets and strengths (Bethell et al., 2019). Joint assessment of PCEs and ACEs in routinely collected public health surveillance systems, such as the Well Child Tamariki Ora programme (including B4 School checks) and national New Zealand health surveys, will better identify needs, target interventions and enable a focus on building strengths. Inclusion of these measures would also advance knowledge of child development and wellbeing by effectively capturing the heterogeneity of childhood experiences and allow the nation to track progress in the promotion of positive health, such as healthy weight outcomes, despite adversity among children in NZ.

A trauma-informed environment must be established, including trauma-informed care

Where ACEs have occurred and been identified, strong and clear pathways for healing and trauma-informed responses must be readily available to all children. Provision of timely trauma-informed care is a prerequisite and vital strategy to mitigate the negative impact of ACEs on health outcomes and prevent re-traumatisation. This requires those who work in proximity to children, especially those at risk of ACEs, to be trained and prepared to offer trauma-sensitive and effective care.

Of particular significance, our findings highlight the health implications of child exposure to domestic violence. Whether this exposure arises from a child directly experiencing abuse or residing in a household where the mother encounters IPV, these instances underscore critical health concerns. They emphasise the necessity for frontline healthcare professionals to be well-prepared to address domestic violence as a health issue.

Further, trauma-informed care at the individual-level must be embedded within trauma-informed environments, in order to allow for the consideration of personal trauma, as well as social violence in the form of racism and discrimination.

Trauma-informed environments should include trauma informed pedagogy and trauma-sensitive and responsive schools, where children spend a large portion of their time (Erickson & Harvey, 2021; Tabone, Rishel, Hartnett, & Szafran, 2020) and where the effects of adversity may be positively intercepted. Trauma-informed school-based initiatives may also be a key strategy for reducing bullying and ethnic discrimination (Blitz & Lee, 2015), two ACEs with high prevalence and strong associations with obesity in our study. Other considerations include the potential for trauma-informed built environment/neighbourhoods, trauma informed physical and mental healthcare(Schroeder, Noll, Henry, Suglia, & Sarwer, 2021).

In New Zealand, despite the potential for schools to identify and support children exposed to ACEs through trauma-informed approaches, there is a prevalent reluctance. Instead of embracing trauma-informed care, schools often resort to

disciplinary measures like suspension, stand down, or exclusion, thereby deferring the underlying issues associated with ACEs. This hesitancy is exacerbated by limited training on trauma-informed practices during teachers' professional development and resource constraints in terms of time and funding. Overcoming these challenges requires a concerted effort to raise awareness, provide training, allocate resources, and create a culture that values the well-being of students alongside academic achievement.

Childhood obesity reduction efforts should consider ACEs and PCEs

Results of this research suggest that childhood obesity may be partially rooted in ACEs, therefore treating obesity may require trauma-informed approaches more often than is currently recognised. ACEs interventions focus on ensuring child safety, responding to and healing trauma, and addressing health behavioural effects of ACEs (such as emotional or comfort eating); in contrast, obesity interventions traditionally focus on nutrition, physical activity, sleep, and screen time, all of which have been found to be severely affected by ACEs in this research. Thus, there exists untapped potential for integration of ACEs and obesity-focused interventions and collaborations among teams with expertise in child welfare, trauma-informed practices, health behavioural change, and obesity. This is of relevance for social and healthcare services (particularly those that work with families experiencing adversities), intervention programmes, and public policies aimed at preventing or treating childhood obesity, as they may need to shift their focus to understanding the contexts in which weight gain and weight-related behaviours occur.

While society must continue to promote the primary prevention of ACEs; we must also consider the creation, promotion, and nurturing of positive experiences that both reflect and generate resilience within children, families, and communities, particularly for those already overexposed to ACEs. Using a trauma-informed approach to care, in which providers collaborate and engage with, and empower families and communities to build on their strengths to promote PCEs, parallels many evidence-based strategies to support healthy weight behaviours in children (e.g., promoting rules and routines at home, engaging child in various activities).

As informed by the HOPE framework, our research supports contentions that a multi-domain, ecological approach to understanding PCEs is essential (Cicchetti & Toth, 2016); children’s wellbeing is shaped by positive experiences at the individual, family, and community levels and that cumulative but not singular exposure to PCEs may be required to enable mitigation of some of the detrimental effects of ACEs. Thus, there are policy imperatives to creating PCEs-promoting environments for children and those who care for them. Initiatives must be targeted at multiple levels of ecological model to shift away from individualising deficit models. A range of specific interventions, policies, and programmes may

be informed by our exploratory identification of PCEs that cumulatively mitigate effects of ACEs on obesity outcomes.

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. 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 across the life course. As emphasised by the HOPE framework, parental wellbeing is also an important area to address in promoting child health and healthy relationships between parents and children. For example, provision of adequately funded and quality healthy relationship programmes (e.g., Within My Reach in the US (Sterrett-Hong, Antle, Nalley, & Adams, 2018)) may be effective at both preventing some ACEs among families (i.e. prevent children witnessing IPV) or protecting children from the effects of ACEs by providing families with toolkits for having loving and supportive relationships.

Government-funded mental health and educational programmes and support services for parents should be well-funded and targeted to meet needs of different communities. There is evidence that parent-training schemes can influence children's health outcomes at the population level (Kato, Yanagawa, Fujiwara, & Morawska, 2015). The Triple P 'Positive Parenting Programme', which is available in 25 countries including New Zealand, is an example of a population-based parenting support intervention that should be adequately funded, resourced, and ACE-aware (Triple P, 2023). Importantly, culturally-adapted trial versions of this programme have had success in significantly improving child behavioural problems and reduced inter-parental conflict about child rearing among Māori participants in New Zealand (Keown, Sanders, Franke, & Shepherd, 2018). Furthermore, the contextual circumstances for parenting in safe environments should be considered. For example, services for responding to intimate partner violence should include expanded provision of Kaupapa Māori and Pacific-generated programmes in order to ensure that mothers and families who experience violence are well-supported.

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 (Fiese, Rhodes, & Beardslee, 2013; Teevale & Kaholokula, 2018), all of which can be less frequent and more complex in families that face adversity (Evans, Gonnella, Marcynyszyn, Gentile, & Salpekar, 2005). Prevention of and healing responses to ACEs (such as violence)

that may hinder the ability for families to provide safe and stable environments would in turn increase the presence of PCEs in families.

Healthcare, education and social workers who interact with families should be positioned to share evidenced-based behaviours and experiences with those that are at risk of or have experienced adversity, such as promoting community and social engagement for mothers and their children. Importantly, ample investment in community settings, including education and healthcare services, and recreational and social activities (such as libraries, museums, pools, and a range of social groups) is vital to support healthy adaptation and resilience in children and their families, as reflected in the PCEs that we found effective in this study (e.g., mother's and child's engagement in social groups, experiences, and activities, child having access to effective ECE). Community services should be accessible to a wide range of families and should be promoted in settings such as primary healthcare, Whānau Ora services, ECEs, schools, and community settings. Furthermore, policy changes can be leveraged to improve ECE uptake and quality via funding, resourcing, and educator training. Internationally, government-supported mental health promotion programmes in education settings have had proven effectiveness in improving outcomes for children and young people (Hoare et al., 2020). Initiatives that support teacher training, such as the Incredible Years behavioural management programme that is currently available in NZ (Whāraurau Parent & Teacher Team, 2023), should be sufficiently and continually funded in order to ensure that quality and safe schooling is available to all students, including those who may have experienced adversity elsewhere.

Addressing family violence as a health issue

Strong associations found between family violence related ACEs (child experience of physical and emotional abuse, and exposure to IPV against mother) and indicators of unhealthy weight status in this research support evidence based practices in healthcare that consider family/domestic violence as a health issue (Gear, Koziol-McLain, Wilson, & Clark, 2016) suggesting preventing family violence and improving community safety may help reduce childhood obesity. To this end and with increasing recognition of the role of healthcare providers in responding to family violence, imbedded training programs to support frontline healthcare responses are required to facilitate the identification and management of disclosures of family violence(García-Moreno et al., 2015). Strengthening of health systems including protocols, capacity building, effective coordination between agencies, and referral networks as outlined in National Strategy and Action Plans to eliminate family violence and sexual violence in Aotearoa New Zealand (New Zealand Government, 2021) can enable providers to address family violence and to mitigate its detrimental effects on children's health.

Reducing the obesogenic environment

While ACEs and PCEs have been found to be associated with obesity outcomes in childhood, observed prevalence of obesity among some groups, such as those with

low ACEs and high PCEs, indicate that these experiences are not the sole explanatory factors in the development of obesity. Further, the experience of high ACEs or low PCEs in an obesogenic environment likely compounds risk for the development of obesity. It remains imperative to implement population-based measures for reducing the obesogenic environment in order to reduce incidence of childhood obesity, whether or not ACEs or PCEs are present. A broad and well-evidenced range of interventions have been put forward to reduce the obesogenic environment, including those targeted toward child obesity specifically (Gortmaker et al., 2011). These initiatives span regulatory and fiscal policies (including unhealthy food and beverage tax), restricted marketing of energy dense and highly processed foods and beverages (particularly towards children) (Egli et al., 2019), to school-based interventions and food policies which may include banning of junk food retail in and around schools (Chote, McKelvie-Sebileau, Swinburn, Tipene-Leach, & D'Souza, 2022; Vandevijvere, Sushil, Exeter, & Swinburn, 2016) and education programmes for nutrition and physical exercise, and investment in developing safe and walkable neighbourhoods that encourage physical activity and active transport (Swinburn, 2009).

Particular attention should be given to creating and maintaining safe outdoor environments which is a vital component in providing holistic care for children facing adversities. These spaces provide a nurturing and supportive environment where children can heal, grow, and seek comfort while facing their challenges. Ultimately, comprehensive, systems-based approaches are warranted (Gortmaker et al., 2011), and the food and outdoor environment may be a more effective target area for intervention as opposed to individualised responses (Wiss & Brewerton, 2020).

Focus on population-level promotion and accessibility of 'healthy lifestyles', which will require high-level legislative intervention and cultural change, is also important to ensure that obesity-related stereotypes are not further perpetuated through focus on reinforcing 'thinness' ideals as the primary motivator for obesity reduction at the population level (Walls, Peeters, Proietto, & McNeil, 2011).

Directing attention towards neighbourhood and community-level factors for experiencing obesity (such as lack of green/recreational spaces, social/community activities, and access to healthy foods) naturally aligns with ecological approaches to ACEs research (Carrillo-Álvarez, Kawachi, & Riera-Romaní, 2019; K. Schroeder et al., 2021). Therefore, identifying key neighbourhood-level risk factors for both childhood obesity and adversity may help with targeting improvements towards the simultaneous reduction of the obesogenic environment, prevention of ACEs, and promotion of PCEs.

Ethnic and socioeconomic inequities must be addressed

As previously described, we found that the detrimental impact of ACEs and protective and mitigating effects of PCEs on childhood obesity were generally observed across ethnic groups. However, there were some important differences

across child ethnic groups that emphasise the need to ensure interventions are effectively targeted. Higher prevalence rates of ACEs among ethnic minority groups, particularly Māori and Pacific peoples, 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 (Pihama et al., 2017). 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. Further research with enough statistical power/sample size is required to identify PCEs specifically appropriate and responsive to the needs of different ethnic groups.

Similarly, higher prevalence rates of ACEs among those with lower socioeconomic status likely exacerbate inequities in obesity and other health outcomes across the life course. In addition to cost barriers to healthy eating for many families (New Zealand Ministry of Health, 2022), financial constraints likely play a key role in parental abilities to provide some PCEs. For example, the cost likely hinders ability to offer or partake in experiences and extra-curricular activities for both children and parents, and employment pressures may limit available free time. While attempts were made to not create a PCEs Index synonymous with higher socioeconomic status, it is possible that differences may be partially driven by socioeconomic factors. For example, around 26 of the 37 children's experiences and activities listed for selection for the 'Children engaged in experiences and activities' PCE were unlikely to cost money or may have been free for the children at the time of data collection as they were then under 4 years old (e.g., museum), however the remaining 11 listed activities may have cost money (e.g., zoo, swimming lessons). It is important that a wide range of activities are free or affordable for children in NZ, to ensure equity of access to enriching experiences and their positive developmental benefits. Moreover, it is essential to have affordable or no or low-cost activities that cater to both children and adults to ensure that family bonding and quality time are accessible to everyone, regardless of financial constraints.

Nevertheless, the current study found that the significant effects of ACEs on weight status were independent of socioeconomic factors and reinforce previous findings that ACEs are detrimental across all socioeconomic groups (Houtepen et al., 2020), supporting the notion that policy and programmes to address child poverty are important in their own right, but will not fully mitigate the effect of ACEs.

Strengths

This study has several key strengths. A considerable strength of the present study is the use of prospective data on a range of adverse and positive experiences. Our study contributes new information as it examined interplay between ACEs and PCEs exposures, obesity, and obesogenic or weight-related behaviours in children. Rigorous methods used in the present study are particularly well-suited to advancing understanding of how ACEs influence obesity during childhood, in contrast to the majority of research that explores adversity retrospectively in adults. These methods include employing multimethod assessments that prospectively measure ACEs and PCEs (child report, parent report, observation, standardised questionnaires). Using data from multiple questionnaires across a long period of time enabled us to capture a detailed picture of children's experiences of ACEs and PCEs. Furthermore, our study assessed a more comprehensive list of ACEs over a longer time period than previous studies using the GUiNZ dataset.

Our use of objective measurements for assessing obesity is also an important strength. Previous studies that have assessed the relationship between ACEs and child obesity relied mainly on parental-reported measures for determining obesity outcomes (Crouch et al., 2022); the present study derived obesity outcomes from objective anthropometric measurements collected by GUiNZ interviewers. Further, our analysis explored and compared three different approaches for measuring child obesity, to ensure robustness of our outcome measures.

This study also extends previous work by looking at a comprehensive range of key weight-related health behaviours, including nutrition, sleep, screen time, and physical activity. This is unique internationally, as most previous studies have explored the effects of ACEs on only one or limited types of health behaviours (Harada et al., 2021).

Limitations and future directions

Our study has important, unavoidable limitations.

Missingness

Although using data from multiple questionnaires across a long period of time enabled us to capture a detailed picture of the cohort members' experience of ACEs, data missingness became a challenge. As our sensitivity analysis shows, GUiNZ experienced substantial attrition, which was disproportionately observed for Māori and Pacific ethnic groups, as well as for those with lower socioeconomic status. Therefore, the results may not generalise to these groups. Given the decreased participation of groups at higher risk for obesity at age 8 (such as Māori and Pacific children and those with lower SES), it is likely that our findings underestimated the magnitude of associations between ACEs and obesity outcomes in the wider population. Loss to follow-up might also have affected ACEs and PCEs prevalence rates. Thereby, the role of attrition bias should be taken into account in interpretation of our findings.

Unmeasured ACEs

At this stage of the GUiNZ study, no data has yet been collected on sexual abuse. This is important as previous research has shown that sexual abuse may have a greater effect on obesity than other ACEs (McLeod et al., 2018; K. Schroeder et al., 2021). Once data on sexual abuse become available (when children are of the age to self-report on these experiences), analyses can be repeated to include child sexual abuse.

Temporality

While using all available dataset up to age 8 maximised our chance to capture a comprehensive list of ACEs, use of outcome variable in age 8 means there was not enough time between exposure and outcome variables. This is important as research has previously shown that it may take at least two years for ACEs to manifest as unhealthy weight (K. Schroeder et al., 2021). Due to this limitation, and the observational nature of the study, we are unable to comment on the temporal or causational nature of the ACEs-obesity associations. The same applies to ACEs-obesogenic behaviour associations. However, this concern is mitigated by the consistency of findings assessing ACEs and weight outcomes, the dose-response relationship observed, and the articulation of causal pathways by which ACEs can influence health that have been identified through this research and other studies (Wiss & Brewerton, 2020). Further, the interplay between mediators, moderators and enablers is highly likely to be complex, and bidirectionality and circularity in the relationships are highly likely to be present in these associations.

More child-reported data is required in future data collection waves

This study has mainly focused on mother and wherever available partner-reported data on indicators of ACEs and PCEs (child-reported ACEs data was only available

for peer victimisation at age 8), which may have presented social desirability biases for questions, particularly for those related to parenting behaviours as they make invoke feelings of guilt or shame (Guo et al., 2022). Likewise, the measures of health (obesogenic) behaviours were based on mother's responses. It is possible that parents or caregivers may have overestimated health behaviours (Mazza, Bastuji, & Rey, 2020).

This is because it was inappropriate and impractical to collect some data in early waves. Wave Eight was the earliest developmental stage that it was possible to accurately ask questions of the children themselves and certain questions related to ACEs are either too sensitive/or unethical to ask of children if you do not have a pathway to respond, particularly if they report current experience of abuse. Collectively these limitations underscore the need for future GUiNZ waves to collect data pertaining to a range of ACEs, PCEs, and health behaviours which will be of particular use and relevance when children are of the age to self-report on factors that may be prone to bias from parent-reported data, such as parental relationships, parental mental health, or drug abuse. Moreover, this study only covers the first eight years of childhood, including exposure to ACEs in this timeframe. By definition, ACEs are potentially traumatic events that occur prior to the transition to adulthood (up to age 18). Research should continue to capture children's experiences of ACEs as they age into adulthood.

Moreover, this study mainly relied on mother-reported data, as partner data were available only for a sub-group of the cohort.

Extending PCEs index

Our creation of a PCEs Index using GUiNZ data has contributed to a nascent field of research. Given that this is a new and emerging space, our PCEs Index was a primarily exploratory exercise which presented a number of challenges. There was no standardised scale to measure PCEs in the GUiNZ dataset, and hundreds of potential PCEs over numerous DCWs were available for consideration. As described earlier in this report, different methodologies employed for defining and measuring PCEs in the literature were challenging to adapt to the GUiNZ dataset given its prospective nature.

We focused on using realistic and modifiable measures to ensure the practical application of our PCE index. While it is possible that higher thresholds (or 'perfect' scores) may have conferred stronger mitigating effects for obesity and were missed, tests found that the median to 55th percentile thresholds produced strong associations with reduced risk in this sample. Considering that the development of PCEs in our study was tailored specifically to obesity outcome, it is plausible that the PCE index formulated for this intent might not correlate with other markers of social or health-related well-being. Additionally, there is a possibility of unaccounted PCEs absent from our index that could significantly counteract the impact of ACEs on other health outcomes.

Some PCE indicators or scales, for which data were collected in GUiNZ, could not be included in the current study for a number of reasons, including: that they possibly presented a high degree of social desirability bias (e.g., Time Spent with Child scale), had low internal consistency, and some scales or tools lacked predictive validity for use with obesity outcomes by presenting either no association with obesity (e.g., Warmth and Hostility Scale [interparental], PISA Sense of Belonging and Participation) or inverse associations with obesity (Warmth and Hostility scale [with child]).

Furthermore, given the age range of the cohort at the time of this research (i.e., 8 years old), most appropriate PCEs relied on mother-reported measures (partner data was not available for all children). This heavily reliance on mother's actions undermines the father's role in ensuring safe parenting and unfairly accentuates the mother's responsibility for establishing safe and stable environments.

Additionally, it is possible that social desirability biases were present in mothers' responses to standardised questionnaires (which were subsequently not included), particularly for those that may have been perceived as judgements of parenting quality. Other types of positive experiences e.g., those that may be reported first-hand by children and adolescents at later life stages, those centered on the actions of the fathers, or those identified as effective moderators in other ACEs-PCEs studies require further study, highlighting the need to develop and test additional measures of PCEs.

Importantly, we must emphasise that our PCEs Index is not presented as a definitive concept or put forward as comprising the only relevant or important PCEs for mitigating the impact of ACEs on health outcomes. For example, "mother in a committed relationship" is not an infallible construct; mothers may have responded positively to these questions where, for instance, intimate partner violence may have been present, and many children grow up happy and healthy in households with separated parents. While it was not within the scope of our research to disentangle details as such, the cumulative nature of our PCEs Index buffers these limitations as not all PCEs must be present to be 'counted'; thus for children to experience positive health outcomes. Our findings echo previous research (Bethell et al., 2019; A Crandall, Jacob R Miller, et al., 2019; Xu et al., 2022)) which found that the cumulative impact of a sufficient number of PCEs is more important than the individual PCEs themselves.

Culturally sensitive analyses of ACEs and PCEs

When exploring variation in ACEs and PCEs associations with obesity outcomes across different ethnic groups, we could only account for the child's prioritised ethnic group to keep the sample sizes large enough given the complexity of these models. Importantly however, ~30% of the children identified with more than one ethnic group. As a result, we could not consider the full complexity and diversity

of ethnic identification in the cohort. Furthermore, our PCEs Index may have had a Eurocentric bias. Given the lower prevalence of PCEs among some ethnic groups (including Asian children, despite presenting the lowest obesity rates), this shows that our PCEs Index may not be appropriate for Asian ethnic and cultural contexts. However, it was not within the scope of our research to create ethnic-specific PCEs indices. Nonetheless, the fact that most of the associations explored in this study held across groups lends weight to our findings. However, it should be noted that sample size limitations for smaller cell sizes (where data was stratified by factors such as ethnicity or presence of a PCE, in addition to ACEs and overweight/obesity) may have resulted in false-negative findings in sub-group analyses.

Future research must explore the ethnic-specific needs and experiences of ethnic groups in New Zealand, in order to develop understanding of how best to prevent and intervene in pathways between adversity and obesity outcomes. In particular, identification of PCEs that best mitigate this relationship for different ethnic groups is essential for developing culturally aware and appropriate policies and programmes. Furthermore, future research with sufficient data density should explore the intersections between factors such as ethnicity and socioeconomic status with varying groupings of low/high ACEs and PCEs.

Peer victimisation/bullying-obesity two-way association

In this research, peer victimisation or bullying ACEs have been considered as an exposure for obesity outcome however, a two-way bidirectional association may better present bullying-obesity association. Youth with obesity tend to report high rates of social stigma, teasing and rejection from peers (Puhl & King, 2013). These negative experiences have been shown to correlate with low self-esteem, poor emotional wellbeing, and with high BMI and the probability of developing eating disorders, thus creating a vicious cycle (Hayden-Wade et al., 2005; van Geel, Vedder, & Tanilon, 2014). Likewise, there is an ongoing two-way relationship between both problems, making the presence of one of them a risk factor for developing the other (López, Raimann, & Gaete, 2015). Furthermore, we did not disentangle the nature of bullying experienced by children, the content of which may be experienced differently by gender or ethnic groups (Kljakovic, Hunt, & Jose, 2015) and have diverging impacts on obesity outcomes (Griffiths, Wolke, Page, & Horwood, 2006). Similarly, obesity-related bullying may be intensified by gender or ethnicity. Relatedly, stigmatisation of obesity may be tied in to other ACEs; as mothers and children with obesity may experience discrimination, including from healthcare services (Flint, 2015), which may lead to suboptimal healthcare provision and further traumatisation. These experiences may also be compounded by ethnicity and gender, particularly for Māori women in NZ (Gillon 2020).

Other mediators linking ACEs and obesity

As found in this study, health behaviours are implicated as a potential pathway by which ACEs may impact obesity in children. While we explored a wide range of

health behaviours, there are others such as frequency and quality of mealtime, stress induced overeating, food addiction and maladaptive stress coping strategies such as binge eating, which also warrant investigation. Exposure to a high number of adversities may also trigger weight gain-inducing effects through the mediating role of child self-regulatory or disrupted homeostasis of the child's organism (e.g., levels of cortisol, leptin and fat percentage).

The potential mediating or moderating roles of other factors such as mental health (e.g., depression and anxiety) and social support as perceived by the children, also merit further investigation.

Furthermore, the measure of inadequate sleep duration used here reflects only one dimension of sleep health. More nuanced measures of sleep disturbances, for example, those capturing child obesity comorbidities such as obstructive sleep, apnea, sleep disruption and impaired sleep (difficulties falling or staying sleep) should be included in future studies to better unpack the impact of ACEs on sleep (Neal, 2015; Vgontzas, Bixler, Chrousos, & Pejovic, 2008). Interventions can be developed to investigate if intervening to improve health behaviours though trauma-informed interventions can mitigate the effects of ACEs on weight status in children.

Timing and chronicity

Prior research has demonstrated that the timing of traumatic events differentially affects health based on whether the event occurred during early, middle, or later childhood (Schalinski et al., 2016). We did not assess the timing of the ACE occurrence in our sample, but it is possible that the timing of ACEs differed on average between those with higher versus lower PCEs, resulting in a differential effect on obesity. Relatedly, the number of occurrences (e.g., chronicity or duration) within an ACE category may be important. For some ACE indicators, we had information about whether the ACE occurred more than once. However, since we did not have information on number of occurrences for all ACE indicators, further research on chronicity is merited. Future studies should examine the timing and duration (i.e., chronicity) of traumatic and positive childhood events to better understand the interaction of positive and adverse experiences on children's health.

Conclusion

This study adds to the growing evidence base that indicates both negative and positive childhood experiences have profound effects on children's weight status. We found that six potentially preventable adverse childhood experiences (ACEs) and exposure to more than one ACE were significantly associated with the development of obesity among New Zealand children. In addition, cumulative ACEs exposure also showed a positive dose-response relationship with the risk of obesity development. Findings also confirm the hypotheses that ACEs may exert

their association with obesity outcomes through their positive associations with unhealthy weight-related obesogenic behaviours.

On the contrary, we found that four out of six types of assessed PCEs were significant protective factors for children overweight/obesity, cumulative PCEs exposure was negatively associated with the risk of overweight/obesity, and there was also an inverse dose-response relationship between cumulative PCEs exposure and the risk of overweight/obesity. Further, our findings suggest that cumulative PCEs can have a mitigating influence in reducing overweight/obesity risk among those exposed to ACEs. However, mitigating effects were not found for individual PCEs, and were only observed when at least 4 PCEs were reported.

These results hold promise for family, community, and national level efforts to achieve positive health outcomes by promoting the largely untapped potential to promote positive experiences despite adversity. Our findings support new avenues for childhood obesity reduction efforts, which would benefit from a greater focus on preventing and responding to ACEs. In other words, it is crucial for health services to understand and respond to the social determinants of health. Purely focusing on the outcome (in this case obesity), while ignoring their role in lobbying for healthy home and social environments places health services firmly at the bottom of the cliff. Furthermore, even traditional behavioural change interventions which target nutrition, sleep, screen time, and physical activity need to incorporate ACEs-informed services if they are to be successful. Importantly, our research shows that experiences of adversity are not as intractable as they are often perceived.

To realise the potential as described in this research requires an investment in services and systems that are designed to respond to trauma and assist in healing processes, including Kaupapa Māori approaches and services for trauma-informed care (McClintock, Haereroa, Brown, & Baker, 2018; Pihama et al., 2017). Through this, there is the potential to promote PCEs within a child's environment, which will likely also improve downstream health outcomes related to overweight / obesity.

Timely efforts for addressing the effect of ACEs on obesity risk during childhood may be the key to impeding further victimisation and reducing health disparities in adulthood for individuals who experience ACEs. Hence, early detection and intervention can have a positive, lifelong impact on an individual’s health and wellbeing. In many countries around the world, ACE prevention has been used to promote child wellbeing through policy and practice. Perhaps the time has come for New Zealand to implement similar initiatives. The information from this study can be used to inform policymakers, clinicians, programme developers, and other concerned stakeholders where to best target obesity interventions and how to bring together families and communities to not only confront adversity in childhood, but also to leverage community- and family-level assets to nurture positive experiences for the safety, wellbeing, and long-term health of all children.

The results of this study further highlight the role of the wider community in addressing and responding to ACEs, through the development of trauma and violence informed environments (including schools and clinical settings) to address bullying and ethnic discrimination, and support healing.

Appendix 1: Sensitivity analysis

Sociodemographic characteristics of participants with obesity data at DCW8 compared to non-participants in DCW8

	No. (Col %)		Unadjusted odds ratio [95%CI]	
	Children without obesity data at DCW8	**Children with obesity data at DCW8**	**Missing obesity data DCW8**	**Overweight/ obesity at 8Y**
	1,862 (27.56)	4,895 (72.44)		
Child's gender (DCW1)				
Boy	968 (51.99)	2,522 (51.52)	Ref.	Ref.
Girl	894 (48.01)	2,373 (48.48)	0.98 [0.88-1.09]	0.90 [0.80-1.02]
Mother's ethnicity (DCW0)				
Māori	481 (25.83)	764 (15.61)	3.85 [3.31-4.47]	2.77 [2.35-3.27]
Pacific	506 (27.18)	497 (10.15)	6.22 [5.31-7.28]	7.67 [6.19-9.51]
Asian	343 (18.42)	687 (14.03)	3.05 [2.59-3.59]	0.98 [0.81-1.18]
MELAA	61 (3.28)	90 (1.84)	4.14 [2.95-5.81]	1.29 [0.82-2.03]
European/NZer	467 (25.08)	2,853 (58.28)	Ref.	Ref.
Missing	4 (0.21)	4 (0.08)		
Mother's age group at pregnancy (DCW0)				
Less than 20 years	157 (8.43)	168 (3.43)	3.51 [2.76-4.47]	2.11 [1.53-2.90]
20-24 years	420 (22.56)	564 (11.52)	2.80 [2.37-3.30]	2.02 [1.66-2.45]
25-29 years	495 (26.58)	1,153 (23.55)	1.61 [1.39-1.87]	1.40 [1.19-1.64]
30-34 years	442 (23.74)	1,660 (33.91)	Ref.	Ref.
35-39 years	282 (15.15)	1,129 (23.06)	0.94 [0.79-1.11]	1.10 [0.94-1.30]
40+ years	66 (3.54)	221 (4.51)	1.12 [0.84-1.51]	1.03 [0.76-1.40]
Mother's education (DCW0)				
No secondary school qualification	239 (12.84)	239 (4.88)	5.04 [4.03-6.31]	3.35 [2.52-4.44]
Secondary school qualification	568 (30.50)	1,039 (21.23)	2.76 [2.33-3.26]	1.76 [1.48-2.09]
Trade certificate/ diploma	607 (32.60)	1,460 (29.83)	2.10 [1.78-2.47]	1.69 [1.44-1.99]
Bachelor's degree	253 (13.59)	1,275 (26.05)	Ref.	Ref.
Higher degree	185 (9.94)	873 (17.83)	1.07 [0.87-1.32]	0.79 [0.65-0.97]

Missing	10 (0.54)	9 (0.18)		
Mother in relationship (DCW0)				
Yes	1,516 (81.42)	4,262 (87.07)	Ref.	Ref.
No	133 (7.14)	193 (3.94)	1.94 [1.54-2.43]	1.82 [1.36-2.43]
Missing	213 (11.44)	440 (8.99)		
Mother born in NZ (DCW0)				
Yes	1,004 (53.92)	3,333 (68.09)	Ref.	Ref.
No	855 (45.92)	1,558 (31.83)	1.82 [1.63-2.03]	0.91 [0.80-1.03]
Missing	3 (0.16)	4 (0.08)		
Area deprivation level (DCW0)				
Least deprived (NZDep 1-3)	296 (15.90)	1,388 (28.36)	Ref.	Ref.
Moderately deprived (NZDep 4-7)	528 (28.36)	1,941 (39.65)	1.28 [1.09-1.49]	1.09 [0.94-1.27]
Most deprived (NZDep 8-10)	1,037 (55.69)	1,565 (31.97)	3.11 [2.68-3.60]	2.42 [2.07-2.82]
Missing	1 (0.05)	1 (0.02)		
Parental incarceration (DCW9M, 54M, 8Y)				
No	1391 (74.70)	4774 (97.5)	Ref.	Ref.
Yes	46 (2.47)	102 (2.08)	1.55 [1.09-2.20]	1.59 [1.07-2.36]
Missing	425 (22.82)	19 (0.39)		
IPV against mother (DCW9M, 54M, 8Y)				
No	1206 (64.77)	4180 (85.39)	Ref.	Ref.
Yes	288 (15.47)	537 (10.97)	1.86 [1.59-2.17]	1.76 [1.47-2.11]
Missing	368 (19.76)	178 (3.64)		
Overweight/obesity (DCW4.5)				
Thinness/normal	742 (39.85)	4,142 (84.62)	Ref.	Ref.
Overweight/obesity	201 (10.79)	545 (11.13)	2.06 [1.72-2.46]	10.88 [8.70-13.60]
Missing (incl. outliers)	919 (49.36)	208 (4.25)		

Appendix 2: Cross-tabulation of ACE scores with PCEs scores

Count	0 ACE	1 ACE	2 ACE	3 ACE	4+ ACE	Total
0-1 PCEs	30 5.6 4.7	82 15.4 6.1	124 23.2 9.4	132 24.7 16.2	166 31.1 21.5	534 100 10.9
2 PCEs	85 10.2 13.4	179 21.5 13.3	197 23.7 14.9	177 21.3 21.7	193 23.2 24.9	831 100 17.0
3 PCEs	133 11.4 21.0	326 30.3 24.5	324 27.8 24.4	199 17.1 24.4	184 15.8 23.8	1166 100 23.8
4 PCEs	179 14.5 28.3	377 30.5 28.1	353 28.5 26.6	181 14.6 22.2	147 11.9 19.0	1237 100 25.3
5-6 PCEs	206 18.3 32.5	379 33.7 28.2	328 29.2 24.7	128 11.4 15.7	84 7.5 10.9	1125 100 23.0
Total	633 12.9 100	1343 27.5 100	1326 27.1 100	817 16.7 100	774 15.8 100	4893 100 100
χ^2 (p-value)	347.59 (0.001)					

Note. First line is frequency, second line is row percentage, third line is column percentage

References

Abarca-Gómez, L., Abdeen, Z. A., Hamid, Z. A., Abu-Rmeileh, N. M., Acosta-Cazares, B., Acuin, C., . . . Ezzati, M. (2017). Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. *The Lancet, 390*(10113), 2627-2642. doi:10.1016/S0140-6736(17)32129-3

Afifi, T. O., & Macmillan, H. L. (2011). Resilience following child maltreatment: a review of protective factors. *Can J Psychiatry, 56*(5), 266-272. doi:10.1177/070674371105600505

Aram, D., & Levin, I. (2001). Mother–child joint writing in low SES: Sociocultural factors, maternal mediation, and emergent literacy. *Cognitive Development, 16*(3), 831-852. doi:https://doi.org/10.1016/S0885-2014(01)00067-3

Aram, D., & Levin, I. (2004). The role of maternal mediation of writing to kindergartners in promoting literacy in school: A longitudinal perspective. *Reading and Writing, 17*(4), 387-409. doi:10.1023/B:READ.0000032665.14437.e0

Ashwell, M., Gunn, P., & Gibson, S. (2012). Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: systematic review and meta-analysis. *Obes Rev, 13*(3), 275-286. doi:10.1111/j.1467-789X.2011.00952.x

Bachler, E., Frühmann, A., Bachler, H., Aas, B., Nickel, M., & Schiepek, G. K. (2018). The Effect of Childhood Adversities and Protective Factors on the Development of Child-Psychiatric Disorders and Their Treatment. *Frontiers in Psychology, 9*. doi:10.3389/fpsyg.2018.02226

Baldwin, J. R., Reuben, A., Newbury, J. B., & Danese, A. (2019). Agreement Between Prospective and Retrospective Measures of Childhood Maltreatment: A Systematic Review and Meta-analysis. *JAMA Psychiatry, 76*(6), 584-593. doi:10.1001/jamapsychiatry.2019.0097

Baranowski, T., Motil, K. J., & Moreno, J. P. (2019). Multi-etiological Perspective on Child Obesity Prevention. *Curr Nutr Rep*. doi:10.1007/s13668-019-0256-3

Bellis, M. A., Hughes, K., Ford, K., Hardcastle, K. A., Sharp, C. A., Wood, S., . . . Davies, A. (2018). Adverse childhood experiences and sources of childhood resilience: A retrospective study of their combined relationships with child health and educational attendance. *BMC Public Health, 18*(1), 792-792. doi:10.1186/s12889-018-5699-8

Bethell, C., Carle, A., Hudziak, J., Gombojav, N., Powers, K., Wade, R., & Braveman, P. (2017). Methods to Assess Adverse Childhood Experiences of Children and Families: Toward Approaches to Promote Child Well-being in Policy and Practice. *Academic Pediatrics, 17*(7, Supplement), S51-S69. doi:https://doi.org/10.1016/j.acap.2017.04.161

Bethell, C., Jones, J., Gombojav, N., Linkenbach, J., & Sege, R. (2019). Positive Childhood Experiences and Adult Mental and Relational Health in a Statewide Sample: Associations Across Adverse Childhood Experiences Levels. *JAMA Pediatrics, 173*(11), e193007-e193007. doi:10.1001/jamapediatrics.2019.3007

Björkenstam, E., Hjern, A., Mittendorfer-Rutz, E., Vinnerljung, B., Hallqvist, J., & Ljung, R. (2013). Multi-exposure and clustering of adverse childhood experiences, socioeconomic differences and psychotropic medication in young adults. *PLoS One, 8*(1), e53551. doi:10.1371/journal.pone.0053551

Blitz, L. V., & Lee, Y. (2015). Trauma-Informed Methods to Enhance School-Based Bullying Prevention Initiatives: An Emerging Model. *Journal of Aggression, Maltreatment & Trauma, 24*(1), 20-40. doi:10.1080/10926771.2015.982238

Carrillo-Álvarez, E., Kawachi, I., & Riera-Romaní, J. (2019). Neighbourhood social capital and obesity: a systematic review of the literature. *Obes Rev, 20*(1), 119-141. doi:10.1111/obr.12760

CDC. (2016, 06/04/2021). CDC-Kaiser ACE Study.

CDC. (2022, 02/09/2022). Centres for Disease Control and Prevention Fast Fact: Preventing Bullying. Retrieved from https://www.cdc.gov/violenceprevention/youthviolence/bullyingresearch/fastfact.html

Chao, A. M., Jastreboff, A. M., White, M. A., Grilo, C. M., & Sinha, R. (2017). Stress, cortisol, and other appetite-related hormones: Prospective prediction of 6-month changes in food cravings and weight. *Obesity (Silver Spring), 25*(4), 713-720. doi:10.1002/oby.21790

Chen, R., Ji, L., Chen, Y., & Meng, L. (2022). Weight-to-height ratio and body roundness index are superior indicators to assess cardio-metabolic risks in Chinese children and adolescents: compared with body mass index and a body shape index. *Transl Pediatr, 11*(3), 318-329. doi:10.21037/tp-21-479

Chote, B., McKelvie-Sebileau, P., Swinburn, B., Tipene-Leach, D., & D'Souza, E. (2022). Culture of Healthy Eating and Food Environments, Policies, and Practices in Regional New Zealand Schools. *Int J Environ Res Public Health, 19*(11). doi:10.3390/ijerph19116729

Cicchetti, D., & Toth, S. L. (2016). Child maltreatment and developmental psychopathology: A multilevel perspective. In *Developmental psychopathology: Maladaptation and psychopathology, Vol. 3, 3rd ed.* (pp. 457-512). Hoboken, NJ, US: John Wiley & Sons, Inc.

Copeland, W. E., Shanahan, L., Hinesley, J., Chan, R. F., Aberg, K. A., Fairbank, J. A., . . . Costello, E. J. (2018). Association of Childhood Trauma Exposure With Adult Psychiatric Disorders and Functional Outcomes. *JAMA Network Open, 1*(7), e184493-e184493. doi:10.1001/jamanetworkopen.2018.4493

Craigie, A. M., Matthews, J. N., Rugg-Gunn, A. J., Lake, A. A., Mathers, J. C., & Adamson, A. J. (2009). Raised adolescent body mass index predicts the development of adiposity and a central distribution of body fat in adulthood: a longitudinal study. *Obes Facts, 2*(3), 150-156. doi:10.1159/000218092

Crandall, A., Broadbent, E., Stanfill, M., Magnusson, B. M., Novilla, M. L. B., Hanson, C. L., & Barnes, M. D. (2020). The influence of adverse and advantageous childhood experiences during adolescence on young adult health. *Child Abuse & Neglect, 108*, 104644. doi:https://doi.org/10.1016/j.chiabu.2020.104644

Crandall, A., Miller, J. R., Cheung, A., Novilla, L. K., Glade, R., Novilla, M. L. B., . . . Hanson, C. L. (2019). ACEs and counter-ACEs: How positive and negative childhood experiences influence adult health. *Child Abuse & Neglect, 96*, 104089. doi:https://doi.org/10.1016/j.chiabu.2019.104089

Crandall, A., Miller, J. R., Cheung, A., Novilla, L. K., Glade, R., Novilla, M. L. B., . . . Hanson, C. L. (2019). ACEs and counter-ACEs: How positive and negative childhood experiences influence adult health. *Child Abuse Negl, 96*, 104089. doi:10.1016/j.chiabu.2019.104089

Crandall, A., Miller, R., Cheung, A., Novilla, K., Glade, R., Novilla, B., . . . Hanson, L. (2019). ACEs and counter-ACEs: How positive and negative childhood experiences influence adult health. *Child Abuse Negl, 96*, 104089. doi:10.1016/j.chiabu.2019.104089

Crouch, E., Radcliff, E., Kelly, K., Merrell, M. A., & Bennett, K. J. (2022). Examining the influence of positive childhood experiences on childhood overweight and obesity using a national sample. *Preventive Medicine, 154*, 106907. doi:https://doi.org/10.1016/j.ypmed.2021.106907

Dallman, M. F., Pecoraro, N. C., & la Fleur, S. E. (2005). Chronic stress and comfort foods: self-medication and abdominal obesity. *Brain, behavior, and immunity, 19*(4), 275-280.

Danese, A., & Tan, M. (2014). Childhood maltreatment and obesity: systematic review and meta-analysis. *Mol Psychiatry, 19*(5), 544-554. doi:10.1038/mp.2013.54

Daniels, S. R. (2006). The consequences of childhood overweight and obesity. *Future Child, 16*(1), 47-67. doi:10.1353/foc.2006.0004

Daniels, S. R., & Hassink, S. G. (2015). The Role of the Pediatrician in Primary Prevention of Obesity. *Pediatrics, 136*(1), e275-292. doi:10.1542/peds.2015-1558

Davison, K. K., & Birch, L. L. (2001). Childhood overweight: a contextual model and recommendations for future research. *Obes Rev, 2*(3), 159-171. doi:10.1046/j.1467-789x.2001.00036.x

de Onis, M., Onyango, A., Borghi, E., Siyam, A., Nishida, C., & Siekmann, J. (2007). *Development of a WHO growth reference for school-aged children and adolescents*. Retrieved from

Department of the Prime Minister and Cabinet. (2019). *Child and Youth Wellbeing Strategy*. Wellington, New Zealand: Department of the Prime Minister and Cabinet Retrieved from https://dpmc.govt.nz/our-programmes/child-and-youth-wellbeing-strategy#:~:text=The%20Child%20and%20Youth%20Wellbeing,and%20how%20others%20can%20help.

Di Cesare, M., Sorić, M., Bovet, P., Miranda, J. J., Bhutta, Z., Stevens, G. A., . . . Bentham, J. (2019). The epidemiological burden of obesity in childhood: a worldwide epidemic requiring urgent action. *BMC Medicine, 17*(1), 212. doi:10.1186/s12916-019-1449-8

Doidge, J., Edwards, B., Higgins, D., & Segal, L. (2017). Adverse childhood experiences, non-response and loss to follow-up: Findings from a prospective birth cohort and recommendations for addressing missing data. *Longitudinal and life course studies, 8*(4). doi:10.14301/llcs.v8i4.414

Drewnowski, A. (2012). The economics of food choice behavior: why poverty and obesity are linked. *Nestle Nutr Inst Workshop Ser, 73*, 95-112. doi:10.1159/000341303

Egli, V., Zinn, C., Mackay, L., Donnellan, N., Villanueva, K., Mavoa, S., . . . Smith, M. (2019). Viewing obesogenic advertising in children's neighbourhoods using Google Street View. *Geographical Research, 57*(1), 84-97. doi:https://doi.org/10.1111/1745-5871.12291

Erickson, M., & Harvey, T. (2021). A Framework for a Structured Approach for Formulating a Trauma-Informed Environment. *Journal of education (Boston, Mass.)*, 2205742110468. doi:10.1177/00220574211046811

Evans, G. W., Gonnella, C., Marcynyszyn, L. A., Gentile, L., & Salpekar, N. (2005). The role of chaos in poverty and children's socioemotional adjustment. *Psychol Sci, 16*(7), 560-565. doi:10.1111/j.0956-7976.2005.01575.x

Fanslow, J., Hashemi, L., Gulliver, P., & McIntosh, T. (2021). Adverse childhood experiences in New Zealand and subsequent victimization in adulthood: Findings from a population-based study. *Child Abuse Negl, 117*, 105067. doi:10.1016/j.chiabu.2021.105067

Felitti, V. J., Anda, R. F., Nordenberg, D., Williamson, D. F., Spitz, A. M., Edwards, V., . . . Marks, J. S. (1998). Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults. The Adverse Childhood Experiences (ACE) Study. *Am J Prev Med, 14*(4), 245-258. doi:10.1016/s0749-3797(98)00017-8

Fiese, B. H., Rhodes, H. G., & Beardslee, W. R. (2013). Rapid Changes in American Family Life: Consequences for Child Health and Pediatric Practice. *Pediatrics, 132*(3), 552-559. doi:10.1542/peds.2013-0349

Finkelhor, D., Shattuck, A., Turner, H., & Hamby, S. (2013). Improving the Adverse Childhood Experiences Study Scale. *JAMA Pediatrics, 167*(1), 70-75. doi:10.1001/jamapediatrics.2013.420

Finkelhor, D., Wolak, J., & Berliner, L. (2001). Police reporting and professional help seeking for child crime victims: A review. *Child maltreatment, 6*(1), 17-30.

Flaherty, E. G., Thompson, R., Litrownik, A. J., Zolotor, A. J., Dubowitz, H., Runyan, D. K., . . . Everson, M. D. (2009). Adverse childhood exposures and reported child health at age 12. *Acad Pediatr, 9*(3), 150-156. doi:10.1016/j.acap.2008.11.003

Flint, S. (2015). Obesity stigma: Prevalence and impact in healthcare. *British Journal of Obesity, 1*, 14-18.

Fröhlich, G., Pott, W., Albayrak, Ö., Hebebrand, J., & Pauli-Pott, U. (2011). Conditions of long-term success in a lifestyle intervention for overweight and obese youths. *Pediatrics, 128*(4), e779-785. doi:10.1542/peds.2010-3395

García-Moreno, C., Hegarty, K., d'Oliveira, A. F., Koziol-McLain, J., Colombini, M., & Feder, G. (2015). The health-systems response to violence against women. *Lancet, 385*(9977), 1567-1579. doi:10.1016/s0140-6736(14)61837-7

Gear, C., Koziol-McLain, J., Wilson, D., & Clark, F. (2016). Developing a response to family violence in primary health care: the New Zealand experience. *BMC Fam Pract, 17*(1), 115. doi:10.1186/s12875-016-0508-x

Gillon , A. (2020). Fat Indigenous Bodies and Body Sovereignty: An Exploration of Re-presentations. *Journal of Sociology, 56*(2), 213-228. doi:10.1177/1440783319893506

Gortmaker, S. L., Swinburn, B. A., Levy, D., Carter, R., Mabry, P. L., Finegood, D. T., . . . Moodie, M. L. (2011). Changing the future of obesity: science, policy, and action. *Lancet, 378*(9793), 838-847. doi:10.1016/s0140-6736(11)60815-5

Greenway, F. L. (2015). Physiological adaptations to weight loss and factors favouring weight regain. *Int J Obes (Lond), 39*(8), 1188-1196. doi:10.1038/ijo.2015.59

Griffiths, L. J., Wolke, D., Page, A. S., & Horwood, J. P. (2006). Obesity and bullying: different effects for boys and girls. *Arch Dis Child, 91*(2), 121-125. doi:10.1136/adc.2005.072314

Growing Up in New Zealand. (2020). *Growing Up in New Zealand 8 year DCW Technical Document, External Data Release, Data User Guide*. Retrieved from New Zealand: https://growingup.co.nz/sites/growingup.co.nz/files/documents/DCW8%20Data%20User%20Guide%20Final%20September%202020.pdf

Guo, S., O'Connor, M., Mensah, F., Olsson, C. A., Goldfeld, S., Lacey, R. E., . . . Priest, N. (2022). Measuring Positive Childhood Experiences: Testing the Structural and Predictive Validity of

the Health Outcomes From Positive Experiences (HOPE) Framework. *Acad Pediatr, 22*(6), 942-951. doi:10.1016/j.acap.2021.11.003

Gutin, I. (2018). In BMI We Trust: Reframing the Body Mass Index as a Measure of Health. *Soc Theory Health, 16*(3), 256-271. doi:10.1057/s41285-017-0055-0

Halfon, N., Larson, K., Son, J., Lu, M., & Bethell, C. (2017). Income Inequality and the Differential Effect of Adverse Childhood Experiences in US Children. *Academic Pediatrics, 17*(7, Supplement), S70-S78. doi:https://doi.org/10.1016/j.acap.2016.11.007

Harada, M., Guerrero, A., Iyer, S., Slusser, W., Szilagyi, M., & Koolwijk, I. (2021). The Relationship Between Adverse Childhood Experiences and Weight-Related Health Behaviors in a National Sample of Children. *Academic Pediatrics, 21*(8), 1372-1379. doi:https://doi.org/10.1016/j.acap.2021.05.024

Hashemi, L., Fanslow, J., Gulliver, P., & McIntosh, T. (2021). Exploring the health burden of cumulative and specific adverse childhood experiences in New Zealand: Results from a population-based study. *Child Abuse & Neglect, 122*, 105372. doi:https://doi.org/10.1016/j.chiabu.2021.105372

Hayden-Wade, H. A., Stein, R. I., Ghaderi, A., Saelens, B. E., Zabinski, M. F., & Wilfley, D. E. (2005). Prevalence, characteristics, and correlates of teasing experiences among overweight children vs. non-overweight peers. *Obes Res, 13*(8), 1381-1392. doi:10.1038/oby.2005.167

Hays-Grudo, J., & Morris, A. S. (2020). *Adverse and protective childhood experiences: A developmental perspective*. Washington, DC, US: American Psychological Association.

Hemmingsson, E. (2014). A new model of the role of psychological and emotional distress in promoting obesity: conceptual review with implications for treatment and prevention. *Obesity Reviews, 15*(9), 769-779. doi:https://doi.org/10.1111/obr.12197

Hemmingsson, E. (2018). Early Childhood Obesity Risk Factors: Socioeconomic Adversity, Family Dysfunction, Offspring Distress, and Junk Food Self-Medication. *Curr Obes Rep, 7*(2), 204-209. doi:10.1007/s13679-018-0310-2

Hemmingsson, E., Johansson, K., & Reynisdottir, S. (2014). Effects of childhood abuse on adult obesity: a systematic review and meta-analysis. *Obes Rev, 15*(11), 882-893. doi:10.1111/obr.12216

Hoare, E., Thorp, A., Bartholomeusz-Raymond, N., McCoy, A., Butler, H., & Berk, M. (2020). Be You: A national education initiative to support the mental health of Australian children and young people. *Aust N Z J Psychiatry, 54*(11), 1061-1066. doi:10.1177/0004867420946840

Houtepen, L. C., Heron, J., Suderman, M. J., Fraser, A., Chittleborough, C. R., & Howe, L. D. (2020). Associations of adverse childhood experiences with educational attainment and adolescent health and the role of family and socioeconomic factors: A prospective cohort study in the UK. *PLOS Medicine, 17*(3), e1003031. doi:10.1371/journal.pmed.1003031

Johnson, M. P., Caughlin, J. P., & Huston, T. L. (1999). The Tripartite Nature of Marital Commitment: Personal, Moral, and Structural Reasons to Stay Married. *Journal of Marriage and Family, 61*(1), 160-177. doi:10.2307/353891

Jones, C. M., Merrick, M. T., & Houry, D. E. (2020). Identifying and Preventing Adverse Childhood Experiences: Implications for Clinical Practice. *JAMA, 323*(1), 25-26. doi:10.1001/jama.2019.18499

Joy, E., & Beddoe, L. (2019). ACEs, Cultural Considerations and 'Common Sense' in Aotearoa New Zealand. *Social Policy and Society, 18*(3), 491-497. doi:10.1017/S1474746419000046

Kato, N., Yanagawa, T., Fujiwara, T., & Morawska, A. (2015). Prevalence of Children's Mental Health Problems and the Effectiveness of Population-Level Family Interventions. *J Epidemiol, 25*(8), 507-516. doi:10.2188/jea.JE20140198

Keown, L. J., Sanders, M. R., Franke, N., & Shepherd, M. (2018). Te Whānau Pou Toru: a Randomized Controlled Trial (RCT) of a Culturally Adapted Low-Intensity Variant of the Triple P-Positive Parenting Program for Indigenous Māori Families in New Zealand. *Prev Sci, 19*(7), 954-965. doi:10.1007/s11121-018-0886-5

Kljakovic, M., Hunt, C., & Jose, P. E. (2015). Incidence of bullying and victimisation among adolescents in New Zealand / by Moja Kljakovic, Caroline Hunt, and Paul E. Jose. In.

Kosterman, R., Mason, W. A., Haggerty, K. P., Hawkins, J. D., Spoth, R., & Redmond, C. (2011). Positive childhood experiences and positive adult functioning: prosocial continuity and the role of adolescent substance use. *J Adolesc Health, 49*(2), 180-186. doi:10.1016/j.jadohealth.2010.11.244

Larose, M. P., Côté, S. M., Ouellet-Morin, I., Maughan, B., & Barker, E. D. (2021). Promoting better functioning among children exposed to high levels of family adversity: the protective role of childcare attendance. *J Child Psychol Psychiatry, 62*(6), 762-770. doi:10.1111/jcpp.13313

Liu, S. R., Kia-Keating, M., Nylund-Gibson, K., & Barnett, M. L. (2020). Co-Occurring Youth Profiles of Adverse Childhood Experiences and Protective Factors: Associations with Health, Resilience, and Racial Disparities. *Am J Community Psychol, 65*(1-2), 173-186. doi:10.1002/ajcp.12387

Lo, K., Wong, M., Khalechelvam, P., & Tam, W. (2016). Waist-to-height ratio, body mass index and waist circumference for screening paediatric cardio-metabolic risk factors: a meta-analysis. *Obes Rev, 17*(12), 1258-1275. doi:10.1111/obr.12456

López, C. C., Raimann, T. X., & Gaete, M. V. (2015). Prevención de los trastornos de conducta alimentaria en la era de la obesidad: rol del clínico. *Revista médica clínica las condes, 26*(1), 24-33.

Luthar, S. S., Cicchetti, D., & Becker, B. (2000). The construct of resilience: a critical evaluation and guidelines for future work. *Child Development, 71*(3), 543-562. doi:10.1111/1467-8624.00164

Lynch, B. A., Agunwamba, A., Wilson, P. M., Kumar, S., Jacobson, R. M., Phelan, S., . . . Finney Rutten, L. J. (2016). Adverse family experiences and obesity in children and adolescents in the United States. *Prev Med, 90*, 148-154. doi:10.1016/j.ypmed.2016.06.035

Mahoney, J. L., & Magnusson, D. (2001). Parent participation in community activities and the persistence of criminality. *Dev Psychopathol, 13*(1), 125-141. doi:10.1017/s0954579401001092

Matjasko, J. L., Herbst, J. H., & Estefan, L. F. (2022). Preventing Adverse Childhood Experiences: The Role of Etiological, Evaluation, and Implementation Research. *American Journal of Preventive Medicine, 62*(6), S6-S15. doi:10.1016/j.amepre.2021.10.024

Matlin, S. L., Champine, R. B., Strambler, M. J., O'Brien, C., Hoffman, E., Whitson, M., . . . Tebes, J. K. (2019). A Community's Response to Adverse Childhood Experiences: Building a Resilient, Trauma-Informed Community. *Am J Community Psychol, 64*(3-4), 451-466. doi:10.1002/ajcp.12386

Mazza, S., Bastuji, H., & Rey, A. E. (2020). Objective and Subjective Assessments of Sleep in Children: Comparison of Actigraphy, Sleep Diary Completed by Children and Parents' Estimation. *Front Psychiatry, 11*, 495. doi:10.3389/fpsyt.2020.00495

McClintock, K., Haereroa, M., Brown, T., & Baker, M. (2018). *Kia hora te marino – Trauma Informed Care for Māori*. Retrieved from Wellington, New Zealand: Te Rau Matatini.: https://terauora.com/kia-hora-te-marino-trauma-informed-care-for-maori/

McLeod, G. F., Fergusson, D. M., Horwood, L. J., Boden, J. M., & Carter, F. A. (2018). Childhood predictors of adult adiposity: findings from a longitudinal study. *N Z Med J, 131*(1472), 10-20.

Ministry of Health. (2012). *Food and Nutrition Guidelines for Healthy Children and Young People (Aged 2–18 years): A background paper. Partial revision February 2015.* Retrieved from Wellington, New Zealand:

Ministry of Health. (2019). *Clinical Guidelines for Weight Management in New Zealand Children and Young People*. Retrieved from https://www.health.govt.nz/publication/clinical-guidelines-weight-management-new-zealand-children-and-young-people

Ministry of Health. (2020). *Eating and Activity Guidelines for New Zealand Adults: Updated 2020*. Retrieved from Wellington: New Zealand:

Ministry of Health. (2021). Annual Data Explorer 2020/21: New Zealand Health Survey. Retrieved from https://www.health.govt.nz/publication/annual-update-key-results-2020-21-new-zealand-health-survey

Misselbrook, D. (2014). W is for Wellbeing and the WHO definition of health. *British Journal of General Practice, 64*(628), 582. doi:10.3399/bjgp14X682381

MOH, M. o. H. (2008). *Protocol for Collecting Height, Weight and Waist Measurements in New Zealand Health Monitor (NZHM) Surveys.* Retrieved from Wellington: Ministry of Health:

Morton, S., Ramke, J., Kinloch, J., Grant, C., Carr, P. A., Leeson, H., . . . Robinson, E. (2015). Growing Up in New Zealand cohort alignment with all New Zealand births. *Australian and New Zealand Journal of Public Health, 39*(1), 82-87. doi:https://doi.org/10.1111/1753-6405.12220

Morton, S., Walker, G., Gerritsen, S., Smith, A., Cha, J., Atatoa Carr, P., . . . Wall, C. (2020). *Growing Up in New Zealand: A longitudinal study of New Zealand children and their families. Now We Are Eight.* Retrieved from Auckland: Growing Up in New Zealand.:

Narayan, A. J., Rivera, L. M., Bernstein, R. E., Harris, W. W., & Lieberman, A. F. (2018). Positive childhood experiences predict less psychopathology and stress in pregnant women with childhood adversity: A pilot study of the benevolent childhood experiences (BCEs) scale. *Child Abuse Negl, 78*, 19-30. doi:10.1016/j.chiabu.2017.09.022

Neal, J. E. (2015). Childhood Obesity and Sleep Disturbances. *NASN School Nurse, 30*(6), 322-324. doi:10.1177/1942602x15608922

New Zealand Government. (2021). Te Aorerekura: National Strategy to Eliminate Family Violence and Sexual Violence. Retrieved from https://www.tewhatuora.govt.nz/our-health-system/preventative-healthwellness/family-violence-and-sexual-violence/te-aorerekura-national-strategy-to-eliminate-family-violence-and-sexual-violence/#:~:text=Te%20Aorerekura%20is%20the%20National,and%20sexual%20violence%20in%20Aotearoa.

New Zealand Ministry of Health. (2020). *Well Child Tamariki Ora Review Report*. Retrieved from Wellington, New Zealand: https://www.health.govt.nz/system/files/documents/publications/well-child-tamariki-ora-review-report-2020-jul21.pdf

New Zealand Ministry of Health. (2022). *Reports into New Zealanders' eating and drinking habits*. Retrieved from Wellington, New Zealand https://www.health.govt.nz/news-media/news-items/reports-new-zealanders-eating-and-drinking-habits#:~:text=They%20show%20about%20half%20of,a%20healthier%20diet%20than%20men.

Newbury, J. B., Arseneault, L., Moffitt, T. E., Caspi, A., Danese, A., Baldwin, J. R., & Fisher, H. L. (2018). Measuring childhood maltreatment to predict early-adult psychopathology: Comparison of prospective informant-reports and retrospective self-reports. *Journal of Psychiatric Research, 96*, 57-64. doi:https://doi.org/10.1016/j.jpsychires.2017.09.020

O'Brien, J. R., Loi, E. C., Byrne, M. L., Zalewski, M., & Casement, M. D. (2021). The Link Between Positive and Negative Parenting Behaviors and Child Inflammation: A Systematic Review. *Child psychiatry and human development*. doi:10.1007/s10578-021-01224-4

O'Connell, M. E., Boat, T., & Warner, K. E. (2009). *National Research Council (US) and Institute of Medicine (US) Committee on the Prevention of Mental Disorders and Substance Abuse Among Children, Youth, and Young Adults: Research Advances and Promising Interventions. Preventing mental, emotional, and behavioral disorders among young people: Progress and possibilities*. Washington (DC): National Academies Press (US).

Pandita, A., Sharma, D., Pandita, D., Pawar, S., Tariq, M., & Kaul, A. (2016). Childhood obesity: prevention is better than cure. *Diabetes Metab Syndr Obes, 9*, 83-89. doi:10.2147/dmso.S90783

Pearce, J., Blakely, T., Witten, K., & Bartie, P. (2007). Neighborhood Deprivation and Access to Fast-Food Retailing: A National Study. *American Journal of Preventive Medicine, 32*(5), 375-382. doi:https://doi.org/10.1016/j.amepre.2007.01.009

Pihama, L., Smith, L. T., Evans-Campbell, T., Kohu-Morgan, H., Cameron, N., Mataki, T., . . . Southey, K. (2017). Investigating Māori approaches to trauma informed care. *Journal of Indigenous Wellbeing, 2*(3), 18-31. Retrieved from https://hdl.handle.net/10289/11805

Prentice, A. M., & Jebb, S. A. (2003). Fast foods, energy density and obesity: a possible mechanistic link. *Obesity Reviews, 4*(4), 187-194.

Pretty, C., O'Leary, D. D., Cairney, J., & Wade, T. J. (2013). Adverse childhood experiences and the cardiovascular health of children: a cross-sectional study. *BMC Pediatr, 13*, 208. doi:10.1186/1471-2431-13-208

Priest, N., Guo, S., Gondek, D., Lacey, R. E., Burgner, D., Downes, M., . . . O'Connor, M. (2022). The effect of adverse and positive experiences on inflammatory markers in Australian and UK children. *Brain, Behavior, & Immunity - Health, 26*, 100550. doi:https://doi.org/10.1016/j.bbih.2022.100550

Puhl, R. M., & King, K. M. (2013). Weight discrimination and bullying. *Best Pract Res Clin Endocrinol Metab, 27*(2), 117-127. doi:10.1016/j.beem.2012.12.002

Qu, G., Ma, S., Liu, H., Han, T., Zhang, H., Ding, X., . . . Sun, Y. (2022). Positive childhood experiences can moderate the impact of adverse childhood experiences on adolescent depression and anxiety: Results from a cross-sectional survey. *Child Abuse & Neglect, 125*, 105511-105511. doi:10.1016/j.chiabu.2022.105511

Quigg, Z., Selina., W., & Nadia., B. (2018). *Routine Enquiry about Adverse Childhood Experiences Implementation pack pilot evaluation*. Retrieved from Liverpool John Moores University, Liverpool, UK: https://www.gov.uk/government/publications/routine-enquiry-about-adverse-childhood-experiences-implementation-pack-evaluation

Rasmussen, L. J. H., Moffitt, T. E., Arseneault, L., Danese, A., Eugen-Olsen, J., Fisher, H. L., . . . Caspi, A. (2020). Association of Adverse Experiences and Exposure to Violence in Childhood and Adolescence With Inflammatory Burden in Young People. *JAMA Pediatrics, 174*(1), 38-47. doi:10.1001/jamapediatrics.2019.3875

Reuben, A., Moffitt, T. E., Caspi, A., Belsky, D. W., Harrington, H., Schroeder, F., . . . Danese, A. (2016). Lest we forget: comparing retrospective and prospective assessments of adverse childhood experiences in the prediction of adult health. *J Child Psychol Psychiatry, 57*(10), 1103-1112. doi:10.1111/jcpp.12621

Rigby, K. (2003). Consequences of Bullying in Schools. *The Canadian Journal of Psychiatry, 48*(9), 583-590. doi:10.1177/070674370304800904

Schalinski, I., Teicher, M. H., Nischk, D., Hinderer, E., Müller, O., & Rockstroh, B. (2016). Type and timing of adverse childhood experiences differentially affect severity of PTSD, dissociative and depressive symptoms in adult inpatients. *BMC Psychiatry, 16*, 295. doi:10.1186/s12888-016-1004-5

Schroeder, Noll, J., Henry, K., Suglia, S., & Sarwer, D. (2021). Trauma-informed neighborhoods: Making the built environment trauma-informed. *Preventive medicine reports, 23*, 101501-101501. doi:10.1016/j.pmedr.2021.101501

Schroeder, K., Schuler, B. R., Kobulsky, J. M., & Sarwer, D. B. (2021). The association between adverse childhood experiences and childhood obesity: A systematic review. *Obes Rev, 22*(7), e13204. doi:10.1111/obr.13204

Sciaraffa, M. A., Zeanah, P. D., & Zeanah, C. H. (2018). Understanding and Promoting Resilience in the Context of Adverse Childhood Experiences. *Early Childhood Education Journal, 46*(3), 343-353. doi:10.1007/s10643-017-0869-3

Sege, R. D., & Harper Browne, C. (2017). Responding to ACEs With HOPE: Health Outcomes From Positive Experiences. *Academic Pediatrics, 17*(7), S79-S85. doi:10.1016/j.acap.2017.03.007

Shonkoff, J. P., & Garner, A. S. (2012). The lifelong effects of early childhood adversity and toxic stress. *Pediatrics, 129*(1), e232-246. doi:10.1542/peds.2011-2663

Simmonds, M., Burch, J., Llewellyn, A., Griffiths, C., Yang, H., Owen, C., . . . Woolacott, N. (2015). The use of measures of obesity in childhood for predicting obesity and the development of obesity-related diseases in adulthood: a systematic review and meta-analysis. *Health Technol Assess, 19*(43). doi:10.3310/hta19430

Singh, A. S., Mulder, C., Twisk, J. W., van Mechelen, W., & Chinapaw, M. J. (2008). Tracking of childhood overweight into adulthood: a systematic review of the literature. *Obes Rev, 9*(5), 474-488. doi:10.1111/j.1467-789X.2008.00475.x

StataCorp. (2017). Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC.

Sterrett-Hong, E., Antle, B., Nalley, B., & Adams, M. (2018). Changes in Couple Relationship Dynamics among Low-Income Parents in a Relationship Education Program Are Associated with Decreases in Their Children's Mental Health Symptoms. *Children, 5*(7), 90. Retrieved from https://www.mdpi.com/2227-9067/5/7/90

Swinburn, B. (2009). Obesity prevention in children and adolescents. *Child Adolesc Psychiatr Clin N Am, 18*(1), 209-223. doi:10.1016/j.chc.2008.07.015

Tabone, J. K., Rishel, C. W., Hartnett, H. P., & Szafran, K. F. (2020). Examining the effectiveness of early intervention to create trauma-informed school environments. *Children and Youth Services Review, 113*, 104998. doi:https://doi.org/10.1016/j.childyouth.2020.104998

Tate, E. B., Spruijt-Metz, D., Pickering, T. A., & Pentz, M. A. (2015). Two facets of stress and indirect effects on child diet through emotion-driven eating. *Eating Behaviors, 18*, 84-90. doi:https://doi.org/10.1016/j.eatbeh.2015.04.006

Teevale, T., & Kaholokula, J. K. (2018). Using appreciative inquiry methodology to develop a weight management program for obese children in New Zealand. *Australian and New Zealand Journal of Public Health, 42*(1), 7-11. doi:https://doi.org/10.1111/1753-6405.12719

Traub, F., & Boynton-Jarrett, R. (2017). Modifiable Resilience Factors to Childhood Adversity for Clinical Pediatric Practice. *Pediatrics, 139*(5). doi:10.1542/peds.2016-2569

Triple P. (2023). 'Positive Parenting Programme',. Retrieved from https://www.triplep-parenting.net.nz/nz-uken/triple-p/?cdsid=5k75ficlj2qr4ugr46feqdah3e&_ga=

Tryon, M., DeCant, R., & Laugero, K. (2013). Having your cake and eating it too: a habit of comfort food may link chronic social stress exposure and acute stress-induced cortisol hyporesponsiveness. *Physiology & behavior, 114*, 32-37.

van Geel, M., Vedder, P., & Tanilon, J. (2014). Are overweight and obese youths more often bullied by their peers? A meta-analysis on the correlation between weight status and bullying. *Int J Obes (Lond), 38*(10), 1263-1267. doi:10.1038/ijo.2014.117

Vandevijvere, S., Sushil, Z., Exeter, D. J., & Swinburn, B. (2016). Obesogenic Retail Food Environments Around New Zealand Schools: A National Study. *Am J Prev Med, 51*(3), e57-66. doi:10.1016/j.amepre.2016.03.013

Vgontzas, A. N., Bixler, E. O., Chrousos, G. P., & Pejovic, S. (2008). Obesity and sleep disturbances: meaningful sub-typing of obesity. *Arch Physiol Biochem, 114*(4), 224-236. doi:10.1080/13813450802521507

Walls, H. L., Peeters, A., Proietto, J., & McNeil, J. J. (2011). Public health campaigns and obesity - a critique. *BMC Public Health, 11*(1), 136. doi:10.1186/1471-2458-11-136

Walsh, Joyce, S., Maloney, T., & Vaithianathan, R. (2020). Exploring the protective factors of children and families identified at highest risk of adverse childhood experiences by a predictive risk model: An analysis of the growing up in New Zealand cohort. *Children and Youth Services Review, 108*, 104556. doi:10.1016/j.childyouth.2019.104556

Walsh, M., Joyce, S., Maloney, T., & Vaithianathan, R. (2019). Adverse childhood experiences and school readiness outcomes: results from the Growing Up in New Zealand study. *N Z Med J, 132*(1493), 15-24.

Wang, D., Jiang, Q., Yang, Z., & Choi, J. K. (2021). The longitudinal influences of adverse childhood experiences and positive childhood experiences at family, school, and neighborhood on adolescent depression and anxiety. *J Affect Disord, 292*, 542-551. doi:10.1016/j.jad.2021.05.108

Ward, Z. J., Long, M. W., Resch, S. C., Giles, C. M., Cradock, A. L., & Gortmaker, S. L. (2017). Simulation of Growth Trajectories of Childhood Obesity into Adulthood. *New England Journal of Medicine, 377*(22), 2145-2153. doi:10.1056/NEJMoa1703860

Welsh Government. (2021). *Review of Adverse Childhood Experiences (ACE) policy: report*. Retrieved from Walse https://www.gov.wales/review-adverse-childhood-experiences-ace-policy-report-html

Whāraurau Parent & Teacher Team. (2023). The Incredible Years: Parent & Teacher Programmes. Retrieved from https://wharaurau.org.nz/parentandteacher.org/incredible-years

WHO. (2009). *AnthroPlus for personal computers Manual: Software for assessing growth of the world's children and adolescents*. Retrieved from Geneva: WHO: (http://www.who.int/growthref/tools/en/)

WHO. (2020). Healthy diet. Retrieved from https://www.who.int/news-room/fact-sheets/detail/healthy-diet#:~:text=At%20least%20400%20g%20(i.e.,cassava%20and%20other%20starchy%20roots.

Wiss, D. A., & Brewerton, T. D. (2020). Adverse Childhood Experiences and Adult Obesity: A Systematic Review of Plausible Mechanisms and Meta-Analysis of Cross-Sectional Studies. *Physiol Behav, 223*, 112964. doi:10.1016/j.physbeh.2020.112964

World Health Organization. (2018). Adverse Childhood Experiences International Questionnaire (ACE-IQ). Retrieved from https://www.who.int/publications/m/item/adverse-childhood-experiences-international-questionnaire-(ace-iq)

Xu, Z., Zhang, D., Ding, H., Zheng, X., Lee, R. C., Yang, Z., . . . Wong, S. Y. (2022). Association of positive and adverse childhood experiences with risky behaviours and mental health indicators among Chinese university students in Hong Kong: an exploratory study. *Eur J Psychotraumatol, 13*(1), 2065429. doi:10.1080/20008198.2022.2065429

Yoo, E. G. (2016). Waist-to-height ratio as a screening tool for obesity and cardiometabolic risk. *Korean J Pediatr, 59*(11), 425-431. doi:10.3345/kjp.2016.59.11.425

Yule, K., Houston, J., & Grych, J. (2019). Resilience in Children Exposed to Violence: A Meta-analysis of Protective Factors Across Ecological Contexts. *Clin Child Fam Psychol Rev, 22*(3), 406-431. doi:10.1007/s10567-019-00293-1

Zeller, M. H., Noll, J. G., Sarwer, D. B., Reiter-Purtill, J., Rofey, D. L., Baughcum, A. E., . . . Jenkins, T. M. (2015). Child maltreatment and the adolescent patient with severe obesity: implications for clinical care. *Journal of pediatric psychology, 40*(7), 640-648.

Zhou, B., Yuan, Y., Wang, K., Niu, W., & Zhang, Z. (2020). Interaction effects of significant risk factors on overweight or obesity among 7222 preschool-aged children from Beijing. *Aging (Albany NY), 12*(15), 15462-15477. doi:10.18632/aging.103701