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ARTICLE

Pediatrics

Decomposing ethnic differences in body mass index and obesity rates among New Zealand pre-schoolers

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Abstract
Objective To determine the extent to which ethnic differences in BMI *Z*-scores and obesity rates could be explained by the differential distribution of demographic (e.g. age), familial (e.g. family income), area (e.g. area deprivation), parental (e.g. immigration status), and birth (e.g. gestational age) characteristics across ethnic groups.
Methods We used data on 4-year-old children born in New Zealand who attended the B4 School Check between the fiscal years of 2010/2011 to 2015/2016, who were resident in the country when the 2013 census was completed ($n = 253{,}260$). We implemented an Oaxaca–Blinder decomposition to explain differences in BMI *Z*-score and obesity between Māori ($n = 63{,}061$) and European ($n = 139{,}546$) children, and Pacific ($n = 21{,}527$) and European children.
Results Overall, 15.2% of the children were obese and mean BMI *Z*-score was 0.66 (SD = 1.04). The Oaxaca–Blinder decomposition demonstrated that the difference in obesity rates between Māori and European children would halve if Māori children experienced the same familial and area level conditions as Europeans. If Pacific children had the same characteristics as European children, differences in obesity rates would reduce by approximately one third, but differences in mean BMI *Z*-scores would only reduce by 16.1%.
Conclusion The differential distribution of familial, parental, area, and birth characteristics across ethnic groups explain a substantial percentage of the ethnic differences in obesity, especially for Māori compared to European children. However, marked disparities remain.

Introduction

International evidence consistently demonstrates large and persistent ethnic and socio-economic differentials in obesity rates, despite declining trends in obesity for younger children in more economically developed countries [1–3]. Recent evidence from New Zealand confirms large disparities in obesity by ethnic group and deprivation at 4 years of age, with no evidence of change in these disparities over time [4]. The likelihood of being in a poor socio-economic position, or living in a deprived area, varies by ethnicity [5]. However, the extent to which ethnic disparities in child

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obesity rates represent differential socio-economic circumstances of ethnic groups is not clear [6–8].

In New Zealand, the health status of Māori (the indigenous peoples of New Zealand) has been directly undermined by New Zealand's colonial history, which saw sovereignty, land, and other resources taken from Māori, and their subsequent marginalization maintained by new social systems based on European norms and values [9]. Evidence suggests that institutional racism, whereby the policies and practices in place perpetuate avoidable inequalities across ethnic groups, are sustaining the inequities Māori experience in health [10]. Research has found that Māori have lower levels of access to health services, receive a poorer quality and slower service, and are less likely to receive appropriate levels of care [11–14].

There are similar findings for Pacific peoples in New Zealand, whereby Pacific communities also have high levels of unmet need [15, 16]. Pacific people comprise ~7% of the New Zealand population, the result of migration over the past 60–70 years from (primarily) Samoa, the Cook Islands, Tonga, Niue, Fiji, and Tokelau [17, 18]. The Pacific population, and particularly Pacific children, experience relative disadvantage in social and health outcomes, including higher prevalence of obesity [4, 18, 19].

A lack of cultural understanding and the consequent inappropriate design of treatments and interventions help explain, at least in part, why Māori and Pacific have disproportionately higher health needs, and why treatments often fail them [20–22]. Thus, it is unlikely that ethnic differences in rates of childhood obesity in the New Zealand context would be fully attributable to the differential socio-economic conditions experienced by different ethnic groups.

The disentangling of socio-economic circumstance and ethnicity is complex. Focussing on a small number of socio-economic measures (such as income and education) as is common in epidemiological studies, can mask underlying disparities in material resources and accumulated wealth. Access to resources and services may not be equivalent for a given level of education or income. Hence, we need to ensure that we account for a wide variety of socio-economic indicators when attempting to understand the relative contributions of socio-economic factors and ethnicity.

While individual socio-economic circumstances are important, the characteristics of the neighbourhoods in which children live are crucial for understanding determinants of, and implementing initiatives to, reduce obesity and disparities in obesity rates [23]. Neighbourhood deprivation can influence child obesity, above and beyond the influence of familial socio-economic characteristics [24–27]. For example, the neighbourhood of residence influences access to healthy foods and opportunities for physical activity through provision of play areas or green space and perceived safety [28].

As obesity rates (and the associated ethnic and socio-economic inequalities) increase with age [29], and obesity tracks throughout childhood into adolescence and adulthood [30, 31], there has been a greater focus on preventing obesity in early life—particularly in the preschool years. In New Zealand, the only population level screen of childhood obesity takes place at 4 years of age via the B4 School Check (B4SC)–a national programme monitoring child growth and other health and developmental indicators [32]. The introduction of the Integrated Data Infrastructure (IDI) by Statistics New Zealand, a large research database that links individuals and households across administrative data sets and selected social surveys, allows us to link B4SC records to census information (Census 2013) and birth records. Therefore, we can gain information on children's families (e.g. single parent status or family socio-economic status) and parents (immigrants and language use) from the census, link these to birth data, and then to the B4SC for recorded height and weight.

The aim of our study was to determine the extent to which ethnic differences in BMI and obesity rates can be explained by other socio-demographic characteristics taking account of individual, familial and neighbourhood level characteristics. We implement an Oaxaca–Blinder decomposition [33, 34]. The Oaxaca–Blinder decomposes differences between two ethnic groups into those attributable to differences in the covariates (which would be eliminated if the ethnic groups had the same characteristics), and those attributable to the differential associations between the covariates and obesity (which would remain even if both ethnic groups had exactly the same characteristics) [35]. While this method is gaining popularity in the health literature, relatively few studies have applied it to ethnic differences in obesity [36–39].

This is the first study in New Zealand to focus on decomposing ethnic differences in obesity using linked administrative data from a large proportion of the population. The methodology is policy focussed, allowing us to demonstrate the likely impact on obesity rates of addressing differential exposure to social and economic conditions between ethnic groups.

Methods

Participants

We used data on 4-year-old children born in New Zealand who attended the B4SC between the fiscal years (1st July–30th June) of 2010/2011 to 2015/2016, who were resident in the country when the 2013 census was completed. The percentage of the eligible population (all 4-year-old registered with a primary care practitioner, estimated to

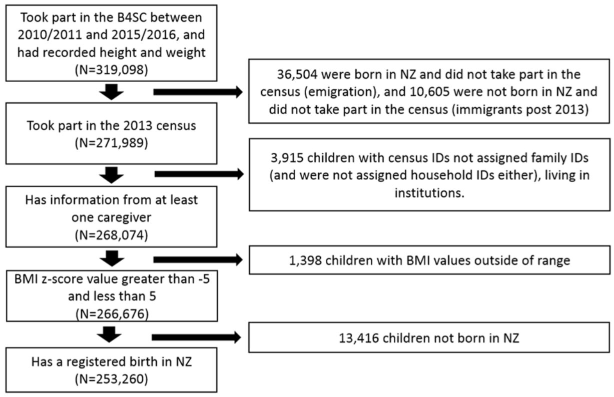

Fig. 1 Flowchart of inclusion and exclusions from the sample. B4SC refers to the B4 School Check. Years run from July 1st to June 30th, so 2010/2011 refers to July 1st 2010 to June 30th 2011. BMI refers to Body Mass Index (weight in klograms/height in metres [2]). NZ refers to New Zealand

be 96% of the total population aged 4 years in 2016) [40] attending the B4SC was 72% in 2010/2011, 79% in 2011/2012, 80% in 2012/2013, 91% in 2013/2014, 92% in 2014/2015, and 92% in 2015/2016. Everyone resident in New Zealand on census night is required to complete a census form, under the Statistics Act 1975. The post-enumeration survey indicates that 97.6% of New Zealand residents were captured in the 2013 census [41].

Participants excluded are shown in Fig. 1. Of the 319,098 four-year-olds that took part in the B4SC between the 2010/2011 and 2015/2016 fiscal years with measures of both height and weight, 253,260 children met the criteria to be included in analyses. To allow for the inclusion of birth information, we restricted the sample to those with a registered birth in New Zealand. Therefore the results may not apply to the full population of 4-year olds, as immigrant children and families may have different characteristics on average than families with children born in NZ.

Following WHO guidelines those with a BMI Z-score ≥5 (or < -5) were excluded from analysis [42].

This study was approved by the University of Otago Human Ethics Committee (D16/088).

Measures

Anthropometric measures

Anthropometric measurements are described in detail elsewhere [4]. Height was measured to the nearest 0.1 cm and weight to the nearest 0.1 kg. The WHO Anthro (version 3.2.2) macro for STATA was used to obtain sex-specific BMI-for-age Z-scores [42], henceforth referred to as BMI Z-score. Children at or above the 95th percentile were classified as obese.

Ethnicity

Parental-reported ethnicity was obtained from the census (the best quality ethnicity information collected) [43]. Using the Ministry of Health's ethnicity data protocols, children were assigned into an ethnic group using the following hierarchy of prioritisation: (1) Māori, (2) Pacific, (3) Asian, (4) Middle Eastern, Latin American, and African (MELAA), and (5) European and others (those self-identifying as "New Zealander") combined [44]. European and others were combined (with the latter making up <1.5% of all children), as they have virtually identical patterns of age, education, income, and socio-economic scores. Asian and MELAA children were not included in this research project.

Covariates

Covariates were derived by linking B4SC records to birth records, census records, and time-stamped address notifications in Statistics New Zealand's IDI [45]. For clarity, these were grouped into the following categories: (1) child demographics, (2) family structure, mobility, and socio-economic characteristics, (3) area characteristics, (4) parental characteristics, and (5) birth weight and gestational age.

1. Child demographics consisted of child's sex and age in months at the time of B4SC.
2. Family structure, mobility, and socio-economic characteristics were derived largely from information available in the census. Family structure included single parent status and number of dependent children in the family, taken from individual information recorded in the census. Family socio-economic characteristics included the number of sources of income support received by the family (unemployment, sickness, domestic purposes [single parent], or invalids benefit, as well as student allowance), grouped family income, employment status of parents, occupation of parents, and parental education taken from family level and parent (individual) level information recorded in the census. Highest level of parental education was derived by taking the highest qualification of either parent, or the sole parent in single-parent families. Mobility was derived from the total number of different addresses lived at from birth to fourth birthday (minus one to give the number of changes), which was calculated from the address notification table in IDI.
3. Area characteristics included area deprivation, urban or rural location, and region of residence at time of B4SC. Area deprivation was assessed using the Index

of Multiple Deprivation (IMD) [46], which measures deprivation at the neighbourhood-level in custom designed data zones that have an average population of 712. The IMD is calculated from seven domains of deprivation: Employment, Income, Crime, Housing, Health, Education, and Access to services. Data zones are ranked from least deprived to most deprived, and these rank scores are divided into deciles.

Whether children resided in urban or rural areas was determined by the child's recorded address at time of the B4SC. Urban included main urban areas (centred on a city or major urban area, population of at least 30,000), secondary urban areas (centred on larger regional centres, population 10,000–29,999), and minor urban areas centred on smaller towns, population 1000–9999). Rural included rural centres (population 300–999) and other rural areas (inlets, islands, inland waters, and oceanic waters). Region of usual residence was also determined by recorded address, there are 16 regions in New Zealand.

4. Parental characteristics included the age of the primary caregiver at the time of B4SC and languages spoken (English only, English and other (not Māori), English and Māori, does not speak English) by the primary caregiver (from census data). Caregiver immigration status, and religious beliefs (categorised as no religion, Christian, other religions, and unclear/not stated) were included for both caregivers, where there were two caregivers in the household.

   Caregivers were identified using self-reported roles in the family nucleus from the census data as: (1) the parent; (2) a grandparent in a parent role; or (3) another person in a parent role. Anybody in a "parent role" with female gender was categorised as the primary caregiver and anybody in a "parent role" with a male gender was the secondary caregiver. However, single parents who were males ($n = 5154$) were classified as the primary caregiver. There were 348 children with same-sex female parents, and 60 children with same-sex male parents, where one partner was classified as the primary and secondary caregiver. In 97% of cases, the person listed as the primary caregiver was a female identifying as the parent (rather than someone else in the parenting role).
5. Birth weight and gestational age were obtained from administrative birth records. Gestational age was categorised into very preterm ($\leq$32 weeks) preterm (33–36 weeks), term (37–41 weeks) and post term ($\geq$42 weeks). Birthweight was categorised into the following groups:< 1500 g (very low birth weight), 1500–2499 g (low birth weight), 2500–3999 g, and >4000 g (high birth weight) [47].

Analysis

All analyses were conducted using Stata version 14 [48]. Data were pooled across the six fiscal years. First, we examined the bivariate associations between the covariates and ethnicity, and between the covariates and BMI *Z*-scores and obesity. Second, we conducted Oaxaca–Blinder decompositions [33, 34]. The Oaxaca–Blinder decomposes differences between two ethnic groups into two: (1) those attributable to differences in the covariates, which would be eliminated if the ethnic groups had the same characteristics (the explained portion); and (2) those attributable to the differential associations between the covariates and obesity, which would remain even if both ethnic groups had exactly the same characteristics (the unexplained portion) [35]. The explained portion is the extent to which differences between groups could theoretically be reduced if differences in the predictor variables were eliminated. Detailed decomposition allows us to assess the variables, or groups of variables, that would account for the greatest proportion of the differences between groups. A detailed but accessible explanation of this methodology as applied to ethnic differences in BMI was given by Sen [36].

We used the '*Oaxaca'* command in Stata using the '*pooled*' regression option for a two-fold decomposition [35]. The pooled model includes a dummy variable for group membership, meaning the results of the decomposition are not dependent upon referent group. Categorical predictor variables were normalised, using the '*normalise*' option, so that the results of the decomposition were independent of the choice of omitted category [49]. For obesity we specified the '*logit*' option. Consistent with the other models presented, we provide detailed decomposition results for groups of variables: demographics; family structure, mobility, and socio-economic characteristics; area characteristics; parent immigration, religion, and language; and birth weight and gestation length. This allowed us to identify the extent to which the grouping of variables contributes to the explained difference. As this analysis is particularly pertinent to policy decisions regarding obesity, the Oaxaca decompositions focused on separate comparisons between Māori and European/Other children and Pacific and European/Other children.

Results

The mean BMI *Z*-score was 0.66 (SD1.04) and 15.2% of the sample were classified as obese. Just over half (55.1%) of children were European/Other ethnicity, 24.9% were Māori, 8.5% were Pacific, 10.4% were Asian, and 1.2% were MELAA (Table 1). There were significant differences in all

Table 1 Distribution of ethnicity and the bivariate relationship with BMI *Z*-score and obesity among 253,260 4-year-old children in New Zealand

	Column %	Mean BMI *Z*-score (95% CI)	Obesity % (95% CI)
Ethnicity			
European/Other	55.1	0.57 (0.56;0.57)	11.41 (11.24;11.58)
Māori	24.9	0.87 (0.86;0.88)	20.41 (20.10;20.73)
Pacific	8.5	1.24 (1.22;1.26)	33.11 (32.49;33.75)
Asian	10.4	0.23 (0.22;0.24)	8.65 (8.32;9.00)
MELAA	1.2	0.57 (0.53;0.61)	13.61 (12.42;14.88)

MELAA refers to Middle Eastern, Latin American, and African

covariates by ethnicity (not shown), with the exception of sex ($p = 0.16$). The distribution of the covariates in the sample, and the relationship between all covariates and BMI *Z*-score and obesity are presented in Supplementary Table 1.

The results of the Oaxaca–Blinder decomposition for Māori compared to European/Other children are shown in Table 2. In total, differential values on the covariates explained 0.119 units, or 40%, of the total 0.297 gap in mean BMI *Z*-score between the two groups. The main contributor to the explained portion was family structure, mobility and socio-economic characteristics which accounted for three quarters of the explained gap. Notably, birth weight and gestational age detract from the explained gap (–0.014). This means if Māori and European/Other children had the same distribution across the categories of birth weight and gestation age, the mean predicted gap in BMI *Z*-score would increase by 0.014.

Within family contributors, family socio-economic circumstances (0.050) had the largest impact (accounting for 42% of the total explained gap). Within area characteristics, there were opposite effects for deprivation and region. Giving Māori children the same scores as European/Other children for deprivation would lead to decreases of 0.037 in the mean predicted gap in BMI *Z*-scores. Whereas, region detracted from the explained gap (−0.017), suggesting the mean predicted gap in BMI *Z*-score would increase by 0.017. As these are summative, this reduced the total area characteristics contribution to 0.020. If Māori children had the same values on the covariates as European/Other children for family structure, mobility and socio-economic characteristics (0.088), area deprivation (0.037), and parental characteristics (0.027), we could reduce the gap in mean BMI *Z*-scores by 0.152 (explaining 51.2% of the total predicted gap).

For obesity, eliminating differences between the two groups on the covariates would reduce obesity rates among Māori by 4.5 percentage points, effectively halving the gap (Table 2). The major contributors to the explained gap were family structure, mobility and socio-economic characteristics (3.2 percentage points), and area level deprivation (1.5 percentage points). Within family contributors, family socio-economic circumstances again had the largest impact (2.2 percentage points).

The results of the Oaxaca–Blinder decomposition for Pacific compared to European/Other children are shown in Table 3. Differential values on the covariates explained 0.108, or 16.1%, of the total 0.671 gap in mean BMI *Z*-score and 0.078, or 35.9%, of the total 0.217 gap in obesity rates between the two groups. Family structure, mobility, and socio-economic characteristics were the largest contributor to the explained portion for both mean BMI *Z*-score (0.074) and obesity rates (0.042), followed by area deprivation and parental characteristics. Of the family characteristics, family socio-economic circumstances were the main contributor to explaining the gap (BMI *Z*-scores: 0.064; obesity proportion: 0.037). The negative coefficients for region and urban indicate that if Pacific children had the same distribution across regions and urban areas as the European/Other children, the gap in mean BMI *Z*-scores would increase by 0.060 points (Region (−0.058) + urban (−0.002)), and the gap in obesity rates would increase by 1.6 percentage points (region(−0.015) + urban(−0.001)).

Discussion

Overall, we found that differences in family socio-economic position, as well as area level deprivation, explained a large percentage of the differences in BMI and obesity rates for Māori children compared to European/Other children. These factors were also important for understanding differences in obesity rates between Pacific and European/Other children. These findings suggest that reducing socio-economic inequalities across ethnic groups would have a large impact on obesity rates among Māori children. While the percentage of the gap that was unexplained in the Oaxaca–Blinder decomposition was larger for the Pacific children, addressing familial socio-economic inequalities would also be beneficial for reducing obesity rates among Pacific children.

These findings have considerable relevance for public health in New Zealand. Our selected measures explained 50% of the disparity in obesity between Māori (20% obese) and European/Other children (11% obese), with familial socio-economic status and area-level deprivation contributing the most. These findings suggest that policies addressing socio-economic disadvantage could potentially halve the ethnic disparity in obesity rates between Māori and European children, and may also reduce ethnic disparities for the many comorbidities that are associated with childhood obesity. However, a large amount of the difference in obesity rates remain unexplained, particularly for

Table 2 Oaxaca–Blinder decompositions for 4-year-old children in New Zealand of Māori ($n = 63{,}061$) versus European/Other ($n = 139{,}546$) ethnicity

	BMI *Z*-score mean (95% CI)	Obesity proportion (95% CI)
Value for European/Other	0.569 (0.564;0.574)	0.114 (0.112;0.116)
Value for Māori	0.866 (0.858;0.875)	0.204 (0.201;0.207)
Total predicted gap	0.297 (0.288;0.307)	0.090 (0.086;0.094)
Explained gap[a]	0.119 (0.113;0.126)	0.045 (0.042;0.047)
Unexplained gap[b]	0.178 (0.167;0.189)	0.045 (0.041;0.049)
Total explained %	40.0%	50.0%
Detailed decomposition[c]		
Demographics	−0.001 (−0.002;0.000)	−0.000 (−0.001;−0.000)
Contribution to the explained gap	−0.8%	0%
Family structure, mobility and socio-economic characteristics[d]	0.088 (0.082;0.094)	0.032 (0.028;0.037)
Contribution to the explained gap	73.9%	71.1%
Family—socio-economic circumstances[e]	0.050 (0.044;0.056)	0.022 (0.019;0.024)
Contribution to the explained gap	42.0%	48.9%
Family—single parent status	0.030 (0.021;0.040)	0.008 (0.004;0.012)
Contribution to the explained gap	25.2%	17.8%
Family—number of times moved	0.007 (0.005;0.009)	0.002 (0.001;0.003)
Contribution to the explained gap	5.9%	4.4%
Family—number of dependent children	0.001 (−0.001;0.003)	−0.000 (−0.000;0.000)
Contribution to the explained gap	0.84%	0%
Area characteristics[d]	0.020 (0.016;0.024)	0.011 (0.009;0.014)
Contribution to the explained gap	16.8%	24.4%
Area—Urban	−0.000 (−0.001;0.000)	−0.000 (−0.001;−0.000)
Contribution to the explained gap	0%	0%
Area—Region	−0.017 (−0.020;−0.15)	−0.004 (−0.005;−0.003)
Contribution to the explained gap	−14.3%	−8.9%
Area—Deprivation (IMD)	0.037 (0.033;0.041)	0.015 (0.013;0.017)
Contribution to the explained gap	31.1%	33.3%
Parental characteristics	0.027 (0.017;0.037)	0.007 (0.003;0.011)
Contribution to the explained gap	22.7%	15.6%
Birth weight and gestational age	−0.014 (−0.016;−0.013)	−0.004 (−0.004;−0.000)
Contribution to the explained gap	−11.8%	−8.9%

Negative coefficients, such as for birth weight and gestational age subtract from the explained gap. This implies that if Māori children resided in areas with the same characteristics as European/Other children, this would actually increase the gap in BMI *Z*-scores, rather than decrease it

[a]The extent to which the total gap would be reduced if Māori children had the same values on the covariates as European/Other children

[b]The gap that would remain even if Māori children had the same values on the covariates as European/Other children

[c]The explained gap is further decomposed into the contribution from each 'block' of the covariates

[d]Family and area 'blocks' are further decomposed into the contributing covariates

[e]Includes sources of income support, grouped family income, highest parental education, parental occupation, and employment status

Pacific children, suggesting that lifestyle- and environmental- based approaches remain warranted.

The unexplained portion is likely attributable to three factors: omitted variables, measurement error, and discrimination. There were a number of variables related to BMI that could not be accounted for and which might vary among ethnicities, such as frequency and importance placed on family meals [50], physical activity levels [51], and parental BMI [52]. In addition, ethnic differences can be explained, at least in part, by genetic differences in the susceptibility to obesity [53]. Unfortunately, these variables were not available in the databases used.

Measurement error refers to systematic differences in what a variable actually measures across ethnic groups. It is possible that different BMI standards may be required for different ethnicities. For example, there is some evidence that the relationship between body fat percentage and BMI differs across ethnic groups, with Pacific children having lower levels of body fat for a given BMI [54], but these findings are not always consistent [55]. Furthermore, measurement error among covariates may exist such that within

Table 3 Oaxaca–Blinder decompositions for 4-year-old children in New Zealand of Pacific ($n = 21{,}527$) versus European/Other ($n = 139{,}546$) ethnicity

	BMI *Z*-score Mean (95% CI)	Obesity proportion (95% CI)
Value for European/Other	0.569 (0.564;0.574)	0.114 (0.112;0.116)
Value for Pacific	1.239 (1.224;1.255)	0.331 (0.325;0.337)
Total predicted gap	0.671 (0.654;0.687)	0.217 (0.210;0.224)
Explained gap[a]	0.108 (0.095;0.122)	0.078 (0.072;0.085)
Unexplained gap[b]	0.562 (0.542;0.583)	0.139 (0.130;0.147)
Total explained %	16.1%	35.9%
Detailed decomposition[c]		
Demographics	0.000 (−0.001;0.001)	0.000 (−0.001;0.001)
Contribution to the explained gap	0%	0%
Family structure, mobility and socio-economic characteristics[d]	0.074 (0.066;0.082)	0.042 (0.038;0.047)
Contribution to the explained gap	68.5%	53.8%
Family—socio-economic circumstances[e]	0.064 (0.054;0.073)	0.037 (0.032;0.043)
Contribution to the explained gap	59.3%	47.4%
Family—single parent status	0.013 (0.006;0.020)	0.005 (0.001;0.008)
Contribution to the explained gap	12.0%	6.4%
Family—number of times moved	0.002 (0.001;0.003)	0.001 (0.000;0.001)
Contribution to the explained gap	1.9%	1.3%
Family—number of dependent children	−0.005 (−0.010;−0.001)	−0.003 (−0.006;−0.001)
Contribution to the explained gap	−4.6%	−3.8%
Area characteristics[d]	−0.012 (−0.020;−0.004)	0.013 (0.007;0.017)
Contribution to the explained gap	−11.1%	16.6%
Area—Urban	−0.002 (−0.004;0.001)	−0.001 (−0.003;−0.000)
Contribution to the explained gap	−1.9%	−1.3%
Area—Region	−0.058 (−0.064;−0.053)	−0.015 (−0.015;−0.008)
Contribution to the explained gap	−53.7%	−19.2%
Area—Deprivation (IMD)	0.048 (0.041;0.055)	0.029 (0.025;0.034)
Contribution to the explained gap	44.4%	37.2%
Parental characteristics	0.037 (0.028;0.047)	0.020 (0.015;0.025)
Contribution to the explained gap	28.7%	25.6%
Birth weight and gestational age	0.016 (0.013;0.018)	0.006 (0.005;0.007)
Contribution to the explained gap	14.8%	7.7%

Negative coefficients, such as for area, subtract from the explained gap. This implies that if Pacific children resided in areas with the same characteristics as European/Other children, this would increase the gap in BMI *Z*-scores, rather than decrease it

[a]The extent to which the total gap would be reduced if Pacific children had the same values on the covariates as European/Other children

[b]The gap that would remain even if Pacific children had the same values on the covariates as European/Other children

[c]The explained gap is further decomposed into the contribution from each 'block' of the covariates

[d]Family and area 'blocks' are further decomposed into the contributing covariates

[e]Includes sources of income support

a category of income, European/Other children may have higher income values than Pacific children, meaning we are not comparing like with like. However, we have alleviated this problem by accounting for a wide variety of socio-economic measures including income, education, employment, sources of income support, and type of occupation.

Another reason for the unexplained gap is discrimination, where differences in the treatment of children and their families based on their ethnicity could influence obesity rates. There is some evidence for institutional racism in New Zealand, whereby the quality of health care received differs by ethnicity [11–14]. Cultural competence is a key issue for the public health system in New Zealand. If public health messaging and interventions are based solely on Anglo-western theory and practise, they may not appear relevant to Māori and Pacific peoples and they risk efficacy if experienced as culturally inappropriate or misdirected [56, 57].

Within the scope of this study, given the data available, it is not possible to disentangle the extent to which these mechanisms contribute to the unexplained gap, and the extent to which the influence of omitted variables, measurement error, and discrimination effect each ethnic group. It is likely that all three factors account for some proportion of the unexplained gap, although at varying degrees for different ethnicities. Disentangling these is a priority for future research.

The Oaxaca–blinder decomposition generated useful information on obesity disparities, which can help guide policy makers, however this is not a causal analysis. The novelty of this study was the ability to link national datasets involving very large numbers of children. The analysis of administrative records is useful for providing information on a large number of people, but it is a limitation that the data used were not collected for research purposes. While we were able to add depth to our data through linkage to census records, the census only happens every 5 years and does not collect all information pertinent to obesity. Census records can be taken up to 2 years and 8 months prior to the B4SC examination, and up to 2 years 3 months after. As a result, the more a variable changed over time, the greater the extent of measurement error included in our estimates. More precise estimates of the covariates would likely improve our ability to explain differences among ethnic groups. Furthermore, while the coverage rates for the B4SC are impressive, children not participating in the B4SC are more likely to be Māori or Pacific, live in more deprived areas, have a parent without any formal qualifications, and have a very young mother [58]. Therefore, these children are at a greater risk of being obese and have a differential distribution across important covariates (such as parental education) than those who attend. Hence, our findings are likely to be applicable only to those who are born in New Zealand and attend the B4SC.

Conclusions

The differential distribution of individual, family, and area characteristics across ethnic groups explained a considerable percentage of the ethnic differences in obesity, especially for Māori compared to European/Other children. However, substantial differences in obesity rates and BMI remained, especially for Pacific children. Our findings clearly illustrate the critical importance of developing culturally appropriate policies and interventions, which could help reduce these gaps even in the face of persisting inequities.

Statistics New Zealand Disclaimer

The results in this paper are not official statistics. They have been created for research purposes from the Integrated Data Infrastructure (IDI), managed by Statistics New Zealand. The opinions, findings, recommendations, and conclusions expressed in this paper are those of the author(s), not Statistics NZ, or The University of Auckland. Access to the anonymised data used in this study was provided by Statistics NZ under the security and confidentiality provisions of the Statistics Act 1975. Only people authorised by the Statistics Act 1975 are allowed to see data about a particular person, household, business, or organisation, and the results in this paper have been confidentialised to protect these groups from identification and to keep their data safe. Careful consideration has been given to the privacy, security, and confidentiality issues associated with using administrative and survey data in the IDI. Further detail can be found in the Privacy impact assessment for the Integrated Data Infrastructure available from www.stats.govt.nz.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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