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Improving rates of overweight, obesity and extreme obesity in New Zealand 4-year-old children in 2010–2016

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Summary

Background: Prevalence of childhood obesity is high in developed countries, and there is a growing concern regarding increasing socio-economic disparities.

Objectives: To assess trends in the prevalence of overweight, obesity and extreme obesity among New Zealand 4-year olds, and whether these differ by socio-economic and ethnic groupings.

Methods: A national screening programme, the B4 School Check, collected height and weight data for 75–92% of New Zealand 4-year-old children (n = 317 298) between July 2010 and June 2016. Children at, or above, the 85th, 95th and 99.7th percentile for age and sex adjusted body mass index (according to World Health Organization standards) were classified as overweight, obese and extremely obese, respectively. Prevalence rates across 6 years (2010/11 to 2015/16) were examined by sex, across quintiles of socio-economic deprivation, and by ethnicity.

Results: The prevalence of overweight, obesity and extreme obesity decreased by 2.2 [95% CI, 1.8–2.5], 2.0 [1.8–2.2] and 0.6 [0.4–0.6] percentage points, respectively, between 2010/2011 and 2015/2016. The downward trends in overweight, obesity and extreme obesity in the population persisted after adjustment for sex, ethnicity, deprivation and urban/rural residence. Downward trends were also observed across sex, ethnicity and deprivation groups.

Conclusions: The prevalence of obesity appears to be declining in 4-year-old children in New Zealand across all socio-economic and ethnic groups.

Keywords: Obesity, paediatric, socioeconomic, trends.

Introduction

Obesity is one of seven 25 × 25 (reduce by 25% by 2025) risk factors targeted by the World Health Organization's (WHO) 2013–20 Global Action Plan for the Prevention and Control of Non-communicable diseases (1). The high prevalence of childhood obesity in developed countries is a global public health concern (2,3). Recent evidence suggests that the prevalence of childhood overweight and obesity may be stabilizing, or declining, in several European countries, the USA and Australia (4–8). Where data are available, it appears prevalence is decreasing in younger, preschool cohorts and perhaps still increasing in older children. Moreover, some studies suggest obesity rates continue to increase for children of lower socio-economic groups, whereas they are stable or decreasing among children of higher socioeconomic status, potentially increasing the former's disproportionate burden of risk factors (9).

The rates of childhood overweight and obesity in New Zealand are among the highest in the world (10). National Health Survey data estimate that 22% of children aged 2–14 years are classified as overweight, and a further 11% are classified as obese (11). Rates of obesity in New Zealand are particularly high among those living in the most deprived areas (21%), Pacific children (30%) and Māori (the indigenous people of New Zealand) children (15%). However, these data were obtained on relatively small

cohorts of children and adolescents (12), and we know little about trends in obesity among younger children in New Zealand, where it is likely that the first signs of societal change would be seen.

Because childhood obesity is a strong predictor of obesity in young adulthood (13) and is associated with even greater severity of obesity and related co-morbidities in adulthood (14), there has been an increasing focus on preventing obesity in early life, particularly in preschool years. Parents play a crucial role in successful obesity treatment and prevention, but parents of young children frequently underestimate their children's overweight or obese status (15). Population growth monitoring provides an opportunity for the early identification of obese children and to offer appropriate services (5). Population growth monitoring is also a vital step in understanding the patterns and trends in childhood obesity, planning for services and informing public policy (5,16).

Established in September 2008, the New Zealand B4 School Check is a national programme monitoring child growth (as well as other health and developmental indicators) at 4 years of age (17). As the B4 School Check aims to measure anthropometry for every child in New Zealand, this dataset provides a unique opportunity to examine the prevalence of childhood obesity among nearly all 4-year olds in New Zealand. Therefore, the aims of this study were to examine trends in the prevalence of childhood obesity in New Zealand between July 2010 and June 2016, and whether any such changes would be seen in different socio-economic and ethnic groups.

Methods

Participants

The percentage of the eligible population (all 4-year olds registered with a primary care practitioner, estimated to be 96% of the total population aged 4 years in 2016 (18)) attending the B4 School Check was 67% in 2009/2010 (the first fiscal year), 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 (19). In 2009/2010, only 55% of the eligible population residing in areas of high deprivation attended the B4 School Check. In subsequent years, there was little difference between coverage rates overall and for those in areas of high deprivation (75% in 2010/2011, 82% in 2011/2012, 80% in 2012/2013 and over 90% thereafter) (19). In this study, we assessed overweight, obesity and extreme obesity from 2010/2011 to 2015/2016.

Anthropometric measures

Anthropometric measurements were undertaken by registered nurses or nurse practitioners, who received a handbook outlining best-practice protocols (17), including measuring the children while they were wearing light clothing with shoes removed, with the equipment stable on a levelled hard surface. Height was to be measured to the nearest 0.1 cm using a portable stadiometer (either Leicester Height Measure or a SECA 214) and weight to the nearest 0.1 kg using a SECA 862 electronic floor scale or Tanita WB 100 S MA floor scale (or SECA 770 or Tanita HD-351 weighing scale; calibrated at least once every 6 months).

The WHO Anthro (version 3.2.2) Macro for STATA was used to obtain the WHO growth standards including sex specific body mass index (BMI)-for-age *Z*-scores (20), henceforth referred to as BMI *Z*-scores. Children at, or above, the 85th, 95th and 99.7th percentile for age and sex adjusted BMI were classified as overweight, obese and extremely obese, respectively. Overweight includes obese and extremely obese. Obese includes extremely obese.

World Health Organization ideal growth standards are endorsed for New Zealand by the NZ Ministry of Health. They are accepted as the appropriate standard in the UK and Canada and for under 2 years of age in the USA. We accept that International Obesity Task Force standards are recommended for intercountry comparisons, but this paper focusses on changes over time within New Zealand.

Demographic characteristics

Data on sex, birth month/year, and ethnicity were derived by linking records to other administrative data (typically birth records or Census records) in the Statistics New Zealand Integrated Data Infrastructure, a collection of whole-of-population administrative data sources linked at the individual level.

Age was calculated to the nearest month. Ethnicity was based on parental report, where parents could indicate that their child belonged to one or more ethnic groups. Multiple ethnic identification is common in New Zealand (21), (23% of this sample belonged to more than one ethnic group). Children were classified into one or more of the following major ethnic groups: (i) European; (ii) Māori; (iii) Pacific; (iv) Asian; (v) Middle Eastern, Latin American and African and (vi) Other. Ethnic groups are not mutually exclusive and cannot be directly compared. This complies with the statistical standard for reporting ethnicity in New Zealand (21). The denominator is the count of people

for whom ethnicity is available, and comparisons can be made to the New Zealand population (21).

Due to their relatively small numbers, Middle Eastern, Latin American and African and Other are not included in tables and figures. For a subset of the analysis Pacific and Asian ethnic groups were divided into their majority sub groups: Pacific was divided into Samoan, Tongan and Cook Island Māori; Asian into Chinese and Indian. However, unless referring specifically to ethnic subgroups, the analysis included only the major ethnic groups.

Socio-economic deprivation was estimated using the New Zealand Index of Deprivation 2013, based on the deprivation characteristics of 'meshblocks' (small areas with a typical population of 60–110 people) (22). The New Zealand Index of Deprivation 2013 combines 2013 census data relating to income, home ownership, employment, qualifications, family structure, housing, access to transport and communications into a single measure of relative socio-economic deprivation (22). Each meshblock was assigned a score from 1 (least deprived) to 10 (most deprived), with the same number of meshblocks in each of the 10 categories (22). Quintiles of deprivation were created by combining adjacent deprivation deciles. Deprivation scores were available for 99.1% of children in the analytic sample.

The standard classification of urban/rural areas in New Zealand is a five point classification: (i) main urban (centred on a city or major urban area, population of at least 30 000), (ii) secondary urban (centred on larger regional centres, population 10 000–29 999), (iii) minor urban (centred around smaller towns, population 1000–9999), (iv) rural centre (population 300–999) and (v) other rural (inlets, islands, inland waters and oceanic waters) (23). These were collapsed into two groups: urban (main urban, secondary urban and minor urban area) and rural (rural centre and other rural). Urban/rural classification as available for 99.1% of children in the analytic sample.

Statistical analyses

Data were analyzed using Stata version (StataCorp, Texas, USA) 14 (24). Analyses proceeded in two steps:

First, annual prevalence of overweight, obesity and extreme obesity for 2010/2011 to 2015/2016 was calculated for the whole population and separately by sex, deprivation quintile, ethnicity and urban/rural classification. We also calculated the prevalence for Pacific and Asian subgroups.

Second, log-binomial models were used to estimate linear time trends in overweight, obesity and extreme obesity for the full sample. These were also estimated separately by sex, deprivation, ethnicity and urban/rural classification, with results expressed as risk ratios per year. An adjusted linear time trend was calculated for the full sample for overweight, obesity and extreme obesity adjusting for sex, ethnicity, deprivation and urban/rural residence.

As this was a near whole population cohort (75–92%), statistical inference relying on sampling theory is not appropriate. We use a finite population correction factor to adjust standard errors and confidence intervals of prevalence rates. Many confidence intervals presented are, therefore, very narrow (25).

Results

Body mass index Z-scores were calculated for 319 101 children who had height and weight data, were aged between 48 and 60 months, attended the B4 School Check and completed the growth check within the fiscal years (1st July to 30th June) 2010/2011 to 2015/2016. This is 84% of the 379 080 estimated resident population of 4-year olds in New Zealand between 1st July 2010 and the 30th June 2016. One thousand eight hundred three individuals (0.6% of the sample) were excluded because of extreme BMI (<-5 standard deviation score [SDS], >5 SDS), leaving an analytic sample of 317 298 children.

The sociodemographic characteristics of children by survey year are shown in Table 1. Across all years, a disproportionate percentage (24.1–25.0%) of children reside in meshblocks in the highest quintile of deprivation. Over time, there was an increase in the percentage of children attending B4 School Check identifying as Asian, from 9.8% to 15.9%, and a decrease in the percentage that identify as European, from 74.0% to 69.1%.

Table 2 shows prevalence rates for overweight (panel A), obesity (Panel B) and extreme obesity (Panel C) over time, as well as estimated unadjusted linear trends. Overall prevalence for overweight, obesity and extreme obesity lowered by 2.2 [1.8–2.5], 2.0 [1.8–2.2], and 0.6 [0.4–0.6] percentage points, respectively, between 2010/2011 and 2015/2016. There was evidence for a decreasing linear trend for overweight (risk ratio, RR = 0.989 [0.988–0.990] per year), obesity (RR = 0.979[0.977–0.980] per year) and extreme obesity (RR = 0.966[0.962–0.970] per year). This downward trend remained significant for all outcomes after full adjustment of the models (overweight RR = 0.992[0.990–0.994]; obesity

Table 1 Characteristics of analytic sample by year

n[1]	2010/2011 45285	2011/2012 50469	2012/2013 50331	2013/2014 58029	2014/2015 56643	2015/2016 56541
Coverage rate %	72	79	80	91	92	92
Sex %						
Male	50.8	51.3	51.6	51.4	51.1	51.2
Female	49.2	48.7	48.4	48.6	48.9	48.8
Ethnicity[2] %						
European	74.0	72.2	72.5	71.2	69.8	69.1
Māori	27.0	25.9	26.0	25.9	26.1	25.8
Pacific overall	12.5	13.4	13.2	13.9	14.3	14.1
Samoan	6.0	6.7	6.4	6.7	6.7	6.4
Tongan	2.7	3.0	3.1	3.4	3.3	3.4
Cook Island Māori	3.0	3.0	3.1	3.1	3.3	3.2
Asian overall	9.8	11.8	12.2	13.1	14.7	15.9
Indian	3.6	4.2	4.3	4.4	4.6	4.5
Chinese	2.7	3.6	3.8	4.0	4.7	5.1
Area %						
Urban	85.2	86.2	86.2	87.2	87.1	87.4
Rural	14.8	13.8	13.8	12.8	12.9	12.6
Deprivation %						
Quintile 1 (least deprived)	18.3	18.9	19.0	19.3	18.8	19.6
Quintile 2	17.4	18.0	18.3	18.0	18.7	18.5
Quintile 3	18.2	17.9	18.2	18.6	18.2	18.3
Quintile 4	19.0	18.7	19.4	19.3	19.5	19.0
Quintile 5 (most deprived)	25.0	24.7	24.1	24.5	24.6	24.2
Anthropometric measures						
Weight (kg)	18.6	18.5	18.5	18.5	18.4	18.3
(mean: 95% CI)	(18.6,18.7)	(18.5,18.6)	(18.5,18.5)	(18.5,18.5)	(18.4,18.4)	(18.3,18.4)
Height (cm)	106.5	106.3	106.4	106.3	106.0	105.9
(mean: 95% CI)	(106.5,106.5)	(106.3,106.3)	(106.4,106.4)	(106.3,106.3)	(106.0,106.0)	(105.9,105.9)
BMI Z-score	0.71	0.68	0.66	0.66	0.67	0.65
(mean: 95% CI)	(0.70,0.71)	(0.68,0.69)	(0.66,0.66)	(0.66,0.67)	(0.67,0.67)	(0.65,0.66)

[1]Randomly rounded to a base of 3, as per the confidentiality rules of Statistics New Zealand.
[2]Ethnic groups are not mutually exclusive, a child can be classified as belonging to multiple ethnicities.
BMI, body mass index; CI, confidence interval.

RR = 0.980[0.977–0.983]; extreme obesity RR = 0.963[0.956–0.969]).

Children residing in the least deprived areas (quintile 1) experienced greater relative decreases in overweight (RR = 0.988 [0.985–0.991]), obesity (RR = 0.976 [0.970–0.981]) and extreme obesity (RR = 0.956[0.942–0.970]) over the 6 years compared with those residing in the most deprived areas (overweight RR = 0.995 [0.993–0.996]; obesity RR = 0.984[0.982–0.987]; extreme obesity RR = 0.973[0.967–0.979]). However, absolute decreases in the prevalence of overweight (least deprived 1.6[0.9–2.3]; most deprived 1.5[0.9–2.2] percentage points), obesity (least deprived 1.1[0.6–1.7]; most deprived 1.8[1.3–2.5]) and extreme obesity (least deprived 0.3[0.1–0.5]; most deprived 0.6[0.2–0.9]) were similar across deprivation groups. The trends in the prevalence of obesity are presented in Fig. 1.

There was no evidence of a significant decreasing trend in overweight status for children residing in rural areas (RR = 0.997 [0.994–1.001]). Children residing in urban areas experienced a greater relative decrease in overweight (RR = 0.988 [0.987–0.989]) and extreme obesity (RR = 0.963[0.959–0.968]) than children residing in rural areas (extreme obesity RR = 0.983[0.970–0.997]).

All major ethnic groups experienced a downward trend in overweight, obesity and extreme obesity over time (Table 2). Relative to the initial prevalence rates,

Table 2 Year specific prevalence of (A) overweight, (B) obesity and (C) extreme obesity by sociodemographic characteristics

	Overweight[1] (≥ 85th percentile)						
2.A	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	2015/2016	Trend[2]RR
Overall %	35.0	34.3	33.5	33.3	33.6	32.8	0.989
	(34.8, 35.2)	(34.1, 34.5)	(33.3, 33.7)	(33.2, 33.4)	(33.5, 33.7)	(32.7, 33.0)	(0.988,0.990)
Sex %							
Male	39.1	38.1	37.2	36.7	36.9	36.2	0.986
	(38.8, 39.4)	(37.8, 38.4)	(36.9, 37.4)	(36.5, 36.8)	(36.7, 37.0)	(36.1, 36.4)	(0.985,0.988)
Female	30.8	30.3	29.5	29.7	30.3	29.3	0.993
	(30.5, 31.1)	(30.1, 30.6)	(29.3, 29.8)	(29.5, 29.8)	(30.1, 30.4)	(29.2, 29.5)	(0.991,0.995)
Ethnicity %							
European	32.2	31.7	30.8	30.4	31.3	30.8	0.993
	(32.0, 32.5)	(31.5, 31.9)	(30.5, 31.0)	(30.3, 30.6)	(31.2, 31.5)	(30.7, 31.0)	(0.991,0.994)
Māori	42.2	42.0	41.6	41.4	41.9	41.1	0.996
	(41.8, 42.6)	(41.6, 42.4)	(41.2, 42.0)	(41.1, 41.6)	(41.6, 42.1)	(40.9, 41.3)	(0.994,0.998)
Pacific overall	55.4	54.0	54.6	54.8	53.4	52.4	0.991
	(54.7, 56.0)	(53.5, 54.5)	(54.1, 55.1)	(54.5, 55.2)	(53.1, 53.7)	(52.1, 52.7)	(0.989,0.993)
Samoan	57.2	56.9	56.3	56.9	55.7	56.2	0.996
	(56.3, 58.2)	(56.1, 57.6)	(55.5, 57.1)	(56.4, 57.3)	(55.2, 56.1)	(55.7, 56.7)	(0.993,0.999)
Tongan	63.1	58.3	62.5	61.9	58.0	57.1	0.985
	(61.7, 64.4)	(57.2, 59.4)	(61.4, 63.6)	(61.3, 62.5)	(57.4, 58.7)	(56.5, 57.7)	(0.982,0.989)
Cook Island Māori	52.7	51.4	49.6	49.8	48.5	48.9	0.985
	(51.3, 54.0)	(50.2, 52.5)	(48.5, 50.7)	(49.1, 50.5)	(47.9, 49.2)	(48.3, 49.6)	(0.981,0.99)
Asian overall	22.8	23.0	21.0	21.4	20.8	20.4	0.977
	(22.2, 23.4)	(22.5, 23.5)	(20.5, 21.4)	(21.1, 21.7)	(20.6, 21.1)	(20.2, 20.6)	(0.973,0.981)
Indian	19.1	21.1	19.3	20.3	18.5	19.5	0.991
	(18.2, 20.1)	(20.3, 21.9)	(18.6, 20.0)	(19.8, 20.7)	(18.0, 18.9)	(19.1, 19.9)	(0.983,0.999)
Chinese	24.3	22.6	19.7	20.3	22.0	21.1	0.984
	(23.1, 25.5)	(21.8, 23.5)	(18.9, 20.5)	(19.8, 20.7)	(21.6, 22.5)	(20.7, 21.6)	(0.976,0.991)
Area %							
Urban	35.3	34.6	33.7	33.5	33.7	32.8	0.988
	(35.0, 35.5)	(34.4, 34.8)	(33.5, 33.9)	(33.4, 33.7)	(33.6, 33.9)	(32.7, 33.0)	(0.987,0.989)
Rural	33.8	32.5	32.3	31.4	33.0	33.0	0.997
	(33.2, 34.4)	(32.0, 33.1)	(31.7, 32.8)	(31.1, 31.8)	(32.7, 33.3)	(32.7, 33.3)	(0.994,1.001)

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Table 2 (Continued)

	Overweight[1] (≥ 85th percentile)						
2.A	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	2015/2016	Trend[2]RR
Deprivation %							
Quintile 1 (least deprived)	27.7	27.1	26.2	25.4	26.1	26.0	0.988
	(27.2, 28.1)	(26.7, 27.5)	(25.8, 26.6)	(25.2, 25.7)	(25.9, 26.3)	(25.8, 26.3)	(0.985,0.991)
Quintile 2	30.5	29.3	28.4	27.9	28.8	27.9	0.986
	(30.0, 31.0)	(28.9, 29.8)	(28.0, 28.8)	(27.7, 28.2)	(28.5, 29.0)	(27.7, 28.2)	(0.983,0.988)
Quintile 3	33.3	32.0	31.0	30.7	31.2	30.5	0.986
	(32.8, 33.8)	(31.6, 32.5)	(30.6, 31.4)	(30.4, 31.0)	(30.9, 31.4)	(30.2, 30.7)	(0.983,0.988)
Quintile 4	36.2	36.1	35.0	35.1	34.8	34.6	0.991
	(35.7, 36.7)	(35.7, 36.6)	(34.6, 35.4)	(34.9, 35.4)	(34.6, 35.1)	(34.4, 34.9)	(0.989,0.994)
Quintile 5 (most deprived)	44.1	43.9	43.9	43.8	44.0	42.6	0.995
	(43.7, 44.6)	(43.5, 44.3)	(43.5, 44.3)	(43.6, 44.1)	(43.8, 44.3)	(42.4, 42.8)	(0.993,0.996)
	Obese[3] (≥ 95th percentile)						
2.B	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	2015/2016	Trend[2]RR
Overall %	16.9	16.1	15.6	15.3	15.5	14.9	0.979
	(16.7, 17.0)	(15.9, 16.2)	(15.4, 15.7)	(15.2, 15.4)	(15.4, 15.6)	(14.8, 14.9)	(0.977,0.980)
Sex %							
Male	19.6	18.5	17.9	17.4	17.6	17.1	0.976
	(19.3, 19.8)	(18.2, 18.7)	(17.7, 18.1)	(17.3, 17.5)	(17.5, 17.8)	(16.9, 17.2)	(0.974,0.978)
Female	14.1	13.5	13.1	13.0	13.2	12.5	0.982
	(13.9, 14.3)	(13.3, 13.7)	(12.9, 13.3)	(12.9, 13.1)	(13.1, 13.3)	(12.4, 12.7)	(0.979,0.985)
Ethnicity %							
European	14.2	13.5	12.8	12.5	13.2	12.7	0.983
	(14.0, 14.3)	(13.3, 13.6)	(12.6, 13.0)	(12.4, 12.6)	(13.1, 13.3)	(12.6, 12.8)	(0.981,0.985)
Māori	22.2	20.9	21.0	20.4	20.9	20.0	0.985
	(21.8, 22.6)	(20.6, 21.2)	(20.6, 21.3)	(20.3, 20.6)	(20.7, 21.1)	(19.8, 20.2)	(0.982,0.988)
Pacific overall	33.5	31.8	32.9	31.8	30.1	30.2	0.980
	(32.8, 34.1)	(31.3, 32.3)	(32.4, 33.4)	(31.5, 32.1)	(29.9, 30.4)	(29.9, 30.5)	(0.977,0.983)
Samoan	34.5	33.3	33.8	32.8	31.7	33.2	0.990
	(33.6, 35.4)	(32.6, 34.1)	(33.0, 34.5)	(32.4, 33.3)	(31.2, 32.1)	(32.8, 33.7)	(0.986,0.994)
Tongan	42.6	37.2	40.0	38.6	34.7	35.0	0.966
	(41.2, 44.0)	(36.1, 38.3)	(38.9, 41.1)	(38.0, 39.3)	(34.1, 35.3)	(34.4, 35.6)	(0.96,0.971)

(Continues)

Table 2 (Continued)

	Obese[3] (≥ 95th percentile)						
2.B	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	2015/2016	Trend[2]RR
Cook Island Māori	29.8 (28.6, 31.1)	28.3 (27.2, 29.3)	27.4 (26.4, 28.4)	27.4 (26.8, 28.0)	26.7 (26.1, 27.3)	26.9 (26.4, 27.5)	0.982 (0.975,0.988)
Asian overall	10.9 (10.4, 11.3)	10.8 (10.5, 11.2)	10.3 (9.9, 10.6)	9.3 (9.1, 9.5)	8.8 (8.7, 9.0)	8.1 (7.9, 8.3)	0.938 (0.932,0.944)
Indian	10.7 (9.9, 11.4)	10.9 (10.2, 11.5)	10.7 (10.1, 11.3)	9.7 (9.4, 10.1)	8.9 (8.6, 9.2)	9.2 (8.9, 9.5)	0.961 (0.951,0.972)
Chinese	11.5 (10.7, 12.4)	10.1 (9.5, 10.7)	8.4 (7.8, 8.9)	7.6 (7.2, 7.9)	8.6 (8.3, 8.9)	6.6 (6.4, 6.9)	0.912 (0.901,0.923)
Area %							
Urban	17.1 (17.0, 17.3)	16.4 (16.3, 16.6)	15.9 (15.7, 16.1)	15.6 (15.5, 15.7)	15.7 (15.6, 15.8)	15.1 (15.0, 15.1)	0.978 (0.976,0.980)
Rural	15.4 (14.9, 15.9)	13.7 (13.3, 14.1)	13.5 (13.2, 13.9)	13.0 (12.8, 13.2)	14.2 (13.9, 14.4)	13.5 (13.3, 13.7)	0.981 (0.976,0.987)
Deprivation %							
Quintile 1 (least deprived)	10.8 (10.5, 11.2)	10.6 (10.3, 10.9)	9.8 (9.6, 10.1)	9.6 (9.4, 9.8)	9.6 (9.5, 9.8)	9.7 (9.5, 9.9)	0.976 (0.97,0.981)
Quintile 2	13.1 (12.8, 13.5)	12.5 (12.1, 12.8)	11.7 (11.4, 12.0)	11.2 (11.0, 11.3)	11.8 (11.7, 12.0)	10.9 (10.7, 11.1)	0.969 (0.964,0.974)
Quintile 3	15.5 (15.1, 15.8)	13.4 (13.1, 13.8)	13.8 (13.5, 14.1)	13.0 (12.8, 13.2)	13.7 (13.5, 13.9)	12.9 (12.7, 13.1)	0.976 (0.971,0.980)
Quintile 4	17.9 (17.5, 18.3)	17.0 (16.6, 17.3)	16.4 (16.1, 16.7)	16.8 (16.6, 17.0)	16.6 (16.4, 16.8)	16.2 (16.0, 16.4)	0.985 (0.981,0.989)
Quintile 5 (most deprived)	24.3 (23.9, 24.7)	24.1 (23.8, 24.5)	23.8 (23.4, 24.1)	23.3 (23.0, 23.5)	23.3 (23.1, 23.5)	22.4 (22.2, 22.6)	0.984 (0.982,0.987)
	Extremely obese (≥ 99.7th percentile)						
2.C	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	2015/2016	Trend[2]RR
Overall %	3.5 (3.4, 3.5)	3.4 (3.4, 3.5)	3.2 (3.2, 3.3)	3.2 (3.2, 3.3)	3.0 (3.0, 3.1)	2.9 (2.9, 3.0)	0.966 (0.962,0.970)
Sex %							
Male	4.0 (3.9, 4.1)	4.0 (3.9, 4.1)	3.7 (3.6, 3.8)	3.7 (3.7, 3.8)	3.4 (3.4, 3.5)	3.2 (3.2, 3.3)	0.957 (0.952,0.962)

(Continues)

Table 2 (Continued)

	Extremely obese (≥ 99.7th percentile)						
2.C	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	2015/2016	Trend²RR
Female	2.9	2.8	2.7	2.7	2.6	2.6	0.978
	(2.8, 3.0)	(2.7, 2.9)	(2.6, 2.8)	(2.6, 2.7)	(2.6, 2.7)	(2.5, 2.6)	(0.972,0.984)
Ethnicity %							
European	2.3	2.2	2.1	2.1	2.0	2.0	0.976
	(2.2, 2.3)	(2.1, 2.3)	(2.0, 2.2)	(2.1, 2.2)	(2.0, 2.0)	(2.0, 2.1)	(0.97,0.982)
Māori	5.0	4.7	4.6	4.3	4.5	4.2	0.970
	(4.8, 5.1)	(4.5, 4.9)	(4.5, 4.8)	(4.2, 4.4)	(4.4, 4.6)	(4.1, 4.3)	(0.963,0.976)
Pacific overall	10.0	9.7	9.7	8.8	8.2	7.9	0.949
	(9.6, 10.4)	(9.4, 10.1)	(9.4, 10.0)	(8.6, 9.0)	(8.0, 8.3)	(7.7, 8.0)	(0.943,0.956)
Samoan	10.2	10.2	10.6	9.1	9.0	9.0	0.969
	(9.6, 10.8)	(9.8, 10.7)	(10.1, 11.1)	(8.9, 9.4)	(8.8, 9.3)	(8.7, 9.2)	(0.96,0.978)
Tongan	14.5	11.9	11.3	11.8	10.1	9.3	0.927
	(13.4, 15.4)	(11.1, 12.6)	(10.3, 11.7)	(11.6, 12.5)	(9.5, 10.3)	(8.7, 9.5)	(0.917, 0.938)
Cook Island Māori	8.4	7.2	7.6	6.3	6.6	6.9	0.963
	(7.7, 9.2)	(6.6, 7.8)	(7.0, 8.1)	(6.0, 6.7)	(6.3, 6.9)	(6.6, 7.3)	(0.948,0.978)
Asian overall	2.7	2.5	2.5	2.4	2.0	1.8	0.920
	(2.5, 2.9)	(2.3, 2.7)	(2.3, 2.7)	(2.3, 2.5)	(1.9, 2.1)	(1.7, 1.8)	(0.908,0.932)
Indian	3.3	3.3	3.1	3.4	2.4	2.6	0.948
	(2.9, 3.7)	(2.9, 3.6)	(2.7, 3.4)	(3.2, 3.6)	(2.3, 2.6)	(2.4, 2.7)	(0.928,0.968)
Chinese	1.5	1.8	1.4	1.4	1.5	1.1	0.919
	(1.1, 1.8)	(1.5, 2.1)	(1.2, 1.7)	(1.3, 1.6)	(1.3, 1.6)	(0.9, 1.2)	(0.892,0.948)
Area %							
Urban	3.6	3.6	3.4	3.4	3.1	3.0	0.963
	(3.5, 3.7)	(3.5, 3.6)	(3.3, 3.5)	(3.3, 3.4)	(3.1, 3.1)	(3.0, 3.1)	(0.959,0.968)
Rural	2.4	2.5	2.3	2.1	2.6	2.2	0.983
	(2.2, 2.6)	(2.3, 2.7)	(2.1, 2.4)	(2.0, 2.2)	(2.5, 2.7)	(2.1, 2.3)	(0.97,0.997)
Deprivation %							
Quintile 1 (least deprived)	1.5	1.4	1.4	1.1	1.2	1.2	0.956
	(1.4, 1.7)	(1.3, 1.6)	(1.3, 1.6)	(1.1, 1.2)	(1.2, 1.3)	(1.2, 1.3)	(0.942,0.97)
Quintile 2	1.9	2.1	1.8	2.0	1.8	1.6	0.968
	(1.7, 2.0)	(2.0, 2.2)	(1.6, 1.9)	(1.9, 2.1)	(1.7, 1.9)	(1.5, 1.7)	(0.956,0.981)

(Continues)

Table 2 (Continued)

2.C	Extremely obese (≥ 99.7th percentile)						
	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	2015/2016	Trend[2]RR
Quintile 3	2.9	2.4	2.5	2.5	2.4	2.4	0.975
	(2.7, 3.1)	(2.3, 2.5)	(2.4, 2.7)	(2.4, 2.6)	(2.3, 2.5)	(2.4, 2.5)	(0.965,0.986)
Quintile 4	4.0	3.9	3.6	3.7	3.3	3.3	0.960
	(3.8, 4.2)	(3.7, 4.0)	(3.4, 3.8)	(3.6, 3.8)	(3.2, 3.4)	(3.2, 3.4)	(0.951,0.968)
Quintile 5 (most deprived)	6.0	6.3	6.1	6.0	5.6	5.4	0.973
	(5.7, 6.2)	(6.1, 6.5)	(5.9, 6.3)	(5.9, 6.1)	(5.5, 5.7)	(5.3, 5.5)	(0.967,0.979)

[1]Overweight also includes obese and extremely obese groups.
[2]Results from unadjusted log binomial regression with year entered as a continuous variable. Standard errors corrected using finite population correction factor. Risk ratios (RR) represent average change in prevalence per year. These are relative measures of change.
[3]Obese also includes extremely obese group.

Asian children experienced the largest decrease in the prevalence of overweight (RR = 0.977[0.973–0.981]), obesity (RR = 0.938[0.932–0.944]) and extreme obesity (RR = 0.920[0.908–0.932]) across the 6 years. Changes in observed obesity prevalence were largest for Pacific (3.3 [2.4–4.2] percentage points) and Asian (2.8 [2.1–3.5] percentage points]) children, and smaller for European (1.4 [1.1–1.7] percentage points) children as compared to the overall population.

All ethnic subgroups experienced a downward trend in prevalence rates. Within the Pacific subgroups, Tongan children experienced the largest relative decrease in the prevalence of obesity (RR = 0.966[0.960–0.971]) and extreme obesity (RR = 0.927[0.917–0.938]) across the 6 years. Cook Island Māori and Tongan had similar relative decreases in overweight (Cook Island Māori RR = 0.985 [0.981–0.990]; Tongan RR = 0.985 [0.982–0.989]). Within the Asian subgroups, there was little difference in the relative decreases in overweight and extreme obesity. Relative to the initial prevalence rates, Chinese children experienced greater decreases in the prevalence of obesity (RR = 0.912[0.901–0.923]) compared with Indian children (RR = 0.961[0.951–0.972]) across the 6 years.

Discussion

These data indicate that the prevalence of overweight, obesity and extreme obesity declined over the past 6 years in New Zealand 4-year-old children. The results suggest decreasing prevalence across sex, deprivation, urban/rural and ethnic groups, with the exception of overweight prevalence among rural children. These findings are consistent with findings from the USA, Singapore, some parts of Europe and UK, whereby overweight and obesity prevalence are decreasing among younger children (4,5).

In contrast to the international evidence, we do not find evidence for widening socioeconomic differentials in child overweight or obesity rates. This could reflect different ages of the children across studies. Previous research demonstrating increasing inequalities refers to older children (age 10 plus) or includes children in age bands, e.g. ages 5–10 (9). Where different age groups have been compared using population level data, there was no evidence for increasing socio-economic inequalities among 4–5 year olds (26). It may be that socioeconomic inequalities are widening among school-aged children but not among preschool aged children.

The overall decreasing trends in prevalence rates were not explained by the changing composition of

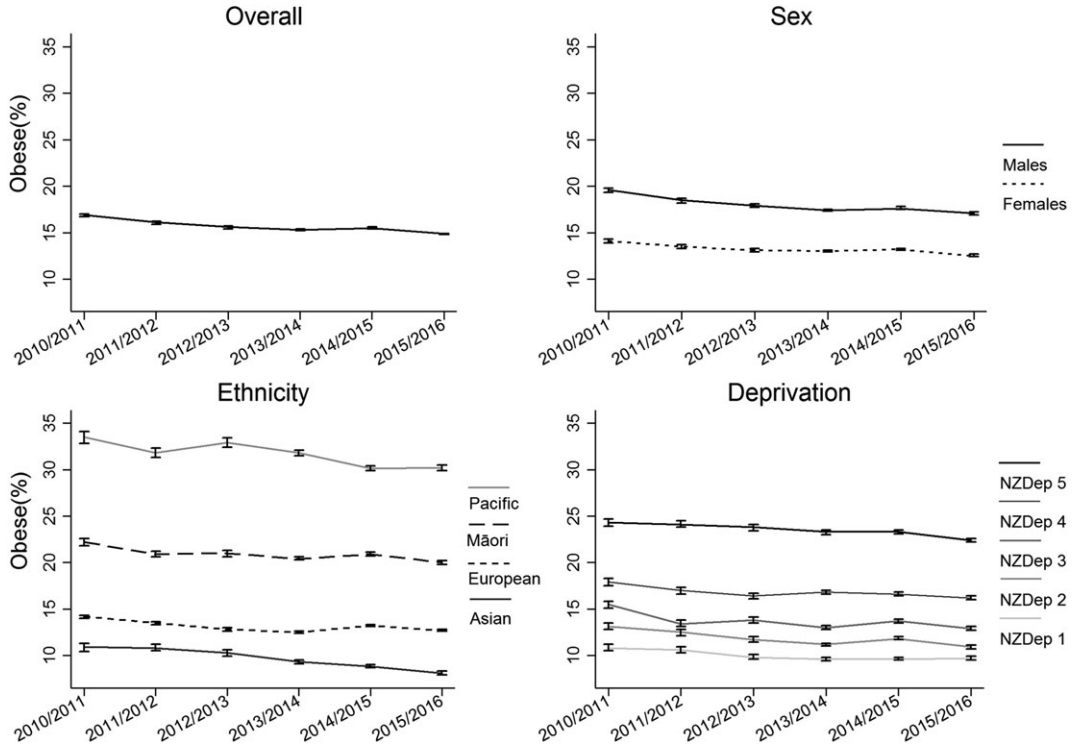

Figure 1 Trends in the prevalence of obesity (>95th percentile) in New Zealand children at the B4 School Check overall and according to sex, deprivation and ethnicity. All trends depicted here were statistically significant linear downward trends. Area level deprivation was measured using New Zealand Index of Deprivation 2013 (NZDep2013).

the population. In the last 20 years, there have been large increases in the number of Asian immigrants (27), and this is reflected in the proportion of Asian children undertaking the B4 School Check. However, decreasing prevalence rates were observed across all ethnic groups, so the overall decreasing trends from 2010/11 to 2015/16 cannot be explained purely by increases in the Asian population in New Zealand during this time.

As the downward trends occurred across ethnicities and levels of deprivation, it suggests a community-wide change. Large scale data on physical activity, diet and sleep among children are not available. We speculate that improved diet and increased activity levels have contributed to this trend, as there is no evidence that rates of prepregnancy maternal overweight and obesity have declined in New Zealand (12). Thus, change is likely driven by post-natal factors.

Strengths and limitations

Using the Integrated Data Infrastructure, we were able to link children's growth records from the B4 School Check to census records, birth records and address change information. This allowed us to present evidence on prevalence trends for a near-whole population cohort of 4-year olds and to examine differences by ethnic subgroups.

As data were collected by practitioners working in clinical settings, we are unsure of the extent to which protocols for measuring children's height and weight were adhered to. While this might introduce random measurement error, reducing the precision of the estimate, it should not systematically bias the estimates in either direction. The exclusion of individuals with extreme BMI, in adherence to the WHO protocols, will have removed a small number of real cases from the analysis. We investigated the extent to which retaining children up to +7SDS would influence the results. Reanalysis including up to +7SD did not change the overall prevalence rates to the nearest one decimal place, and estimated prevalence rates by ethnicity and deprivation were within estimated confidence intervals presented in the main paper.

There is evidence that Māori and Pacific children have different body compositions for a given BMI as compared with other ethnic groups in New Zealand (28), including NZ European. As such, our figures may overestimate obesity in these populations.

However, any misclassification of BMI for Māori or Pacific should affect data from all years similarly so should not affect the overall downward trend.

Although coverage rates for the B4 School Check was better from 2010/2011 onwards, there was still approximately one fifth of the eligible population that did not take part in 2010/2011 and 2011/2012. Therefore, the sample could be selective, especially in the earlier years. Information on attendance at B4 School Check by area level deprivation suggests that between 2010/2011 and 2015/2015 uptake rates were similar for those living in deprived and non-deprived areas, hence, the sample does not appear to be selective by deprivation (19).

Nonetheless, we conducted a sensitivity check considering what would happen to the overall trends if those who did not attend had a 50% higher obesity rate than those who did attend. As attendance rates were lower in the earlier years, this exaggerates the downward trend with obesity decreasing from 19.3% in 2010/2011 to 15.5% in 2015/2016. We also considered what would happen with a 50% lower obesity rate among non-attendees. This resulted in stable prevalence estimates across time from 14.5% in 2010/2011 to 14.3% in 2015/2016. While the former scenario is more likely, given evidence that children not captured during population screening have higher BMI's (29), the latter demonstrates that obesity trends in New Zealand have not increased.

In the 2010/2011 fiscal year, there was very low (35%) uptake of the B4 School Check in the area covered by the Auckland District Health Board (DHB), New Zealand's most populated urban area. This can be explained partially by the large population served by Auckland DHB, increasing the required resources, and because discussions around, and piloting of, three different delivery models led to a slower uptake. The Auckland DHB uptake rate increased to 65% in 2011/2012 and climbed rapidly to 95% in 2015/2016. Therefore, the prevalence for urban children may not be accurate in 2010/2011, if the children that attended B4 School Check in the Auckland DHB differ from non-attendees. Based on the characteristics we measured (ethnicity, deprivation and sex), the composition of the 2010/2011 sample appears to be very similar to later years.

We present a large number of estimated trend values with confidence intervals. As this is still a sample of the population albeit a very large one, there may be an inflated risk of type I errors.

We only captured 6 years of data, and longer follow-up will provide more confidence in the estimates of change over time. However, these data support international reports of decreasing child obesity prevalence from developed countries such as the USA, Singapore, some parts of Europe and UK (4,5). This analysis was descriptive in nature and focussed on the trends in prevalence. Future research will concentrate on explaining differentials in prevalence rates across demographic groups and communities.

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Conflicts of interest statement

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