Original Article

Availability and price of healthier food choices and association with obesity prevalence in New Zealand Māori

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Background and Objectives: Examine availability and price of healthier foods-vs-regular counterparts and their association with obesity. **Methods and Study Design:** A cross-sectional survey of weight and height among Māori in 2 urban and 96 rural areas in the Waikato/Lakes Districts-NZ (year 2004-06) was undertaken. Concurrently, availability of 11 'healthier' food in fast-food-outlets was examined by location (urban vs rural) and median income (high-low). In supermarkets, five-specific 'regular' foods were scored against 'healthier' counterparts (white-vs-wholemeal bread, with-skin-vs-skinless chicken, regular-vs-trim meat, standard-vs-trim milk, sugar-sweetened-beverages vs-water) for in-store availability and price according to the Nutrition Environment Measures Survey. **Results:** Overall, 3,817 Māori (BMI: women: 32.9±7.8 kg/m^2; men: 33.1±6.7 kg/m^2) were included with 451 food-outlets in two urban-clusters and 698 food-outlets in 96 rural-clusters. Fast-foods: The availability of healthier food choices was higher for 8/11 items in rural and low-income areas than urban and high-income areas. Multivariate analysis considered location and income as cofactors. No association between number of fast-food-outlets/cluster and healthier foods/cluster with obesity prevalence (General/Māori BMI cut-offs) was observed. Supermarkets: Water was cheaper than sugar-sweetened-beverages and negatively associated with obesity prevalence (General r=-0.53, p=0.03; Māori r=-0.53, p=0.03); high availability scores for trim milk compared to standard milk correlated with higher obesity prevalence (General r=0.49, p=0.04; Māori r=0.57, p=0.01). **Conclusions:** Bottled water vs sugar-sweetened-beverages prices were inversely associated with obesity. This supports the argument to regulate the availability and price of sugar-sweetened-beverages in NZ. The positive association of the availability of trim milk with the prevalence of obesity warrants investigation into individual's dietary and food-purchase behaviour.

Key Words: fast-foods, supermarkets obesity, sugar-sweetened beverages, Māori

INTRODUCTION

Approximately 2.1 billion people globally or about 30% are obese or overweight.[1] New Zealand is no exception and has the third highest adult obesity prevalence in the Organization for Economic Development (OECD) countries.[2] In New Zealand, two in five deaths are attributable to nutrition-related non-communicable disease, and obesity is shown to be a major contributor to ill health, disability and shortened life expectancy.[3-5] In addition the prevalence of obesity in New Zealand is almost twice (1.77x) as high for Māori, the indigenous people of New Zealand, than Non-Māori and one and a half times (1.53x) higher for those living in the most deprived quintile of neighbourhood deprivation compared to those living in the least deprived.[6]

The aetiology of obesity is complex. According to the well-defined Analysis Grid for Environments Linked to Obesity (ANGELO) framework, obesity is driven by a complex set of micro and macro-environmental determinants.[7] It is well known that the macro-environmental determinants of obesity include nutritional quality of food available in food outlets (fast-food and supermarkets), food prices (healthier foods vs regular counter parts), and access to food stores (urban vs rural settings).[7]

The nutritional quality of a food is determined from its energy-density, saturated fat, salt and sugar content (obesity promoting factors) and protein, fibre and fruit and vegetable content (obesity protective factors) as accepted internationally in food-based dietary guidelines.[8] Nutritional quality of food has been examined with reference to food outlets (fast-food and supermarkets). The New Zealand Health and Lifestyle Survey (2012) reported that one in three New Zealanders purchased 'fast-food' and

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Manuscript received 03 April 2018. Initial review completed 29 May 2018. Revision accepted 27 August 2018.
doi: 10.6133/apjcn.201811_27(6).0023

14% used 'dine-in venues' at least weekly.[9] For meals prepared at home most food supplies are purchased at supermarkets which in New Zealand control 92% of the grocery market share.[10] Supermarkets have been reported as food outlets where healthier foods choices are available. In contrast, takeaways are perceived as an easy access point for nutrient-poor, energy-dense food.[11] However, foods offered in fast-food outlets are shifting to healthier choices being made available to attract customers.[12]

Food prices (healthier foods vs regular counter parts) will also limit which foods can be purchased, where from and how often. A systematic review (total studies N=56) reported four cross-sectional studies from the United States that observed healthier baskets to be more expensive than their regular counterpart.[13] Similarly, we have previously shown that the weekly family cost of a 'healthier' food basket (without sugar) was 29% more expensive than the 'regular' basket ($New Zealand 176 v. $ New Zealand 136).[14] However, evidence has been inconsistent as intervention-based studies have suggested that improvements in diet quality could be achieved without increasing spending (e.g. substitute plant-based protein foods such as soy for animal-based protein foods such as meat).[15,16]

With respect to access to food stores (urban vs rural settings), a large proportion of the literature has focused on studying the availability of healthier food choices in urban as compared to rural locations. In a systematic review of 47 studies, predominantly cross-sectional, from the United States and Canada only two studies were conducted in a rural setting, 14 were an urban setting and 31 studies were conducted in a mixed environment were urban/rural settings were not differentiated.[11]

Overall, the literature reports a need to examine the availability of healthier food choices not only in urban but also in rural settings. Furthermore, there is limited evidence from New Zealand investigating the association of availability and price of healthier foods with obesity. Our previous cross-sectional study on 1454 Australian residing in rural Victoria examined availability of fast-food outlets and the frequency of fast-food consumption with the prevalence of obesity.[17] The present study adds further depth by studying the food environment in New Zealand by examining the association between foods outlets (supermarket, fast-foods) and obesity as per availability of food choice (healthier vs regular) and their price.

The present study aims to (1) examine the in-store availability of healthier food choices in fast-food outlets as per location (rural vs urban) and socioeconomic status (low vs high median income); (2) investigate whether number of fast-food outlets per cluster and number of healthier food items available per fast-food outlet clusters is associated with obesity prevalence among Māori adults; (3) develop composite supermarket in-store availability scores and affordability scores (i.e. availability and price of specific healthier food items vs their regular choices) and examine its association with obesity prevalence among Māori adults.

METHODS

This study is part of the Te Wai o Rona: Diabetes Prevention Strategy carried out in Waikato and Lakes Districts of New Zealand (May 2004-March 2006). We covered 98 geographical locations across the region. Food outlets were 'mapped' by researcher-defined (the Waikato and Lakes District Councils' databases, the New Zealand Business Directory database obtained commercially online) and resident-defined (consensus from consultation with Māori community health workers) neighbourhood boundaries. Based on previous literature food outlets were divided in two categories: supermarket, which we defined as household grocery items purchasing outlets for home preparation (multinational supermarkets, dairies, bakeries, service stations, groceries) and fast-food outlets, which we defined as ready-to-eat food outlets (multinational takeaways, independently owned restaurants, dine-in venues and cafes).[14,17] A non-experimental survey design mapped the location of food outlets and each store was visited by one of two trained Māori community health workers and in-store food availability and price were recorded using a bespoke questionnaire[18] based upon prior work in the Māori community.[19] The survey records were cross-checked first by the health workers and then by the researchers to identify any missing data or errors. In total, information was available from N=1149 outlets (n=392 supermarkets, n=757 fast-food outlets) within n=2 urban locations (defined as areas within Hamilton) and 96 rural locations (defined as areas out of Hamilton).[14] Institutional review board ethics approval was obtained from the Waikato and Bay of Plenty Ethics Committees.

Healthier food choices were defined following the New Zealand food-based dietary guidelines as less energy-dense, lower in saturated fat, salt and sugar and higher in protein, fibre and fruit and vegetable content than their regular counterparts.[20] In-store availability of 11 'healthier' food items, namely: trim milk, low fat spread, low fat yoghurt, low fat ice-cream, fruit (fresh/canned in water), sugar-free beverages, water, higher fibre cereal, baked potato w/o butter, wholemeal bread, canned fish in water choices were recorded in supermarkets and fast-food outlets as published previously.[14,17] This paper describes the in-store availability of 'healthier' foods choices in fast-food outlets (urban n=322, rural n=435). In-store availability of healthier foods in supermarkets has been published previously.[14] However, this paper examines supermarkets with respect to mapping the in-store availability and price (New Zealand $ per Litre or per kilogram) of five specific 'healthier' foods as compared to their comparable 'regular' counterparts (white vs wholemeal bread, with skin vs lean chicken, regular vs trim meat, standard-3.25% fat vs trim milk-0.5% fat (apparent fat commercially removed), sugar sweetened beverages (SSBs) vs water). These five food items were chosen as they are commonly available in supermarkets across New Zealand and have well-defined healthier vs regular alternatives, foods not having clear unhealthier alternatives were excluded (fruits, vegetables or fish).

The five specific supermarket food items (regular choice vs healthier choice) were scored according to the Nutrition Environment Measures Survey in Stores (NEMS-S) scoring system.[21] NEMS-S is not developed to provide a standardised benchmark to facilitate comparison across studies, but is a validated tool and has been

developed with a purposeful intention of adapting the tool to best capture the unique foci of different store types within neighbourhoods. Therefore, previous literature has extensively adapted the NEMS-S scoring system to best meet individual study objectives across various study settings.[22-24] For example, Hiller et al., included several cultural specific food items which could be purchased on Women, Infants, and Children (WIC) stamps (fresh plantain, mango), and excluded food items which were originally part of the NEMS-S, but not relevant to their study population (e.g. baked goods and baked chips).[22] Similarly, we decided to include food items with definite healthier food alternative (e.g. regular choice: white bread vs healthier choice: wholemeal bread). This was in line with our overarching objective which was to examine the in-store availability of healthier foods in food outlets across New Zealand. NEMS-S assigns points for availability, price and a composite score for availability and price of the healthier food choices compared to the regular counter parts.[21] Availability points indicated whether or not stores stocked the healthier food items. For each of the five food items, if the healthier choice was available 2 points were allocated, if not, zero points. Price points reflected whether the price for the healthier food items was more expensive (-1 point), less expensive (2 points), or the same price (1 point) as for regular alternative. The composite score for all five food items ranged from: 0-10 points (availability), -5 to 10 points (price) and -5 to 20 points (availability and price). The scoring system is in line with the NEMS-S scoring system suggested by the original authors.[21]

The mean obesity prevalence among Māori participants was available for each cluster (n=98, urban: n=2, rural: n= 96) and obtained from the Te Wai o Rona: Diabetes Prevention Strategy data.[25] The overall mean BMI has already been reported for the 3817 eligible Māori, mean BMI was 32.9±7.8 kg/m^2 (women) and 33.1±6.7 kg/m^2 (men).[26] Briefly, subjects were invited to participate in Te Wai o Rona: Diabetes Prevention Strategy data as previously described.[25] Height without shoes was measured using a stadiometer (to the nearest 0.5 cm) and weight was measured in light clothing and without shoes to the nearest 0.1 kg (Wedderburn TI-BWB800 Personal scales), up to 200 kg for oversize participants. Obesity prevalence for each cluster was calculated as per general BMI cut-offs (≥30.0 kg/m^2) and Polynesian BMI cut-offs (≥32.0 kg/m^2).[27] Both are shown to serve as a sensitivity analysis.[28] Median income (above median income: ≥$24,400.01 vs below median income: ≤$24,400.00) and location (urban vs rural) was sourced from 2006 Census of Population and Dwellings in New Zealand.[29]

The general and Polynesian obesity prevalence (BMI cut-offs kg/m^2) were treated as the dependent variables. Fast-food outlets: The food outlet (1. number of fast-food outlet clusters, 2. number of healthier food items available in each fast-food outlet cluster) was treated as the independent variable. Supermarkets: Number of supermarket clusters where the healthier vs the regular item is available, the proxy healthier food item scores (1. availability score, 2. price score, 3. Availability and price score) were treated as the independent variables. The independent variables and the outcome variables were not normally distributed. Log transformation of the variables did not significantly alter the present findings; thus, results are reported using non-parametric tests. The descriptive results are shown as median (25th-75th inter quartile range: IQR) or frequencies (percentages) for continuous and categorical variables as appropriate. Goodman and Kruskal's gamma test was used to examine the in-store availability of 'healthier' food in fast-food outlets as per location (urban vs rural) and income (above median income: ≥$24,400.01 vs below median income: ≤$24,400.00). Bivariate analysis between the independent variables and the dependent variable was conducted using Spearman's correlation coefficient and multivariate analysis using Spearman's partial correlation coefficient adjusted for location (urban vs rural) and median income. Statistical significance was taken at the 5% level and all tests were two-tailed. Data analysis was conducted using SPSS version 24 (SPSS Inc., Chicago, USA).

RESULTS

Obesity prevalence was calculated for the 98 clusters (urban n=2, rural n=96). The median obesity prevalence was 61% (IQR: 50%, 69%) and 48% (IQR: 38%, 55%) using general and Polynesian BMI thresholds respectively. In the rural areas, there were 698 food outlets. The food outlets comprised of 263 supermarkets, between 1-23 (range: minimum-maximum) supermarkets per rural cluster and 435 fast-food outlets, between 1-85 fast-food outlets per rural cluster. In the urban areas, there were 451 food outlets. The food outlets comprised of 129 supermarkets, between 1-120 supermarkets per urban cluster and 322 fast-food outlets, between 1-307 fast-food outlets per urban cluster.

Overall, the in-store availability of healthier food choices in fast-food outlets was above 50% for 5 of the 11 items (trim milk, fruit (fresh/canned), sugar free beverages, water and wholemeal bread). In-store availability of healthier food choices was significantly higher in rural areas than urban areas for 8 of the 11 items (trim milk (mean difference: -15.5%), low fat spread (-8.2%), low fat yoghurt (-7.8%), low fat ice-cream (-10.7%), high fibre cereal (-35.6%), baked potato w/o butter (-19.6%), wholemeal bread (-0.2%), canned fish in water (-25.8%)) (Table 1). Similarly, in-store availability of healthier food choices was significantly higher in low income than high income areas, for 8 of the 11 items (trim milk (mean difference: -61.6%), low fat spread (11.1%), low fat yoghurt (12.2%), low fat ice-cream (9.3%), fruit (fresh/canned) (12.9%), high fibre cereal (28%), baked potato w/o butter (17.1%), canned fish in water (18.4%)) (Table 2). In-store availability of healthier foods in supermarkets has been published previously.[14]

With respect to supermarkets, highest in-store availability scores were noted for the availability of wholemeal bread (median: 2.00, IQR: 1.75-2.00) and lowest for the availability of lean chicken (0.88, 0.40-1.54). Similarly, highest price scores (higher scores-lower price for healthier vs regular food alternatives) were observed for wholemeal bread in comparison to white bread (1.50, 1.36-1.70) and water in comparison to sugary drinks (1.50, 1.33-1.67). Lowest price scores were recorded for lean

Table 1. Availability of 'healthier' food[†] in fast-food outlets by location

Variables	All n (%)	Urban n (%)	Rural n (%)	Difference (%)[‡]	*p* value[§]
Trim milk	436 (60.2)	165 (51.6)	271 (67.1)	-15.5	<0.001
Low fat Spread	307 (43.7)	125 (39.2)	182 (47.4)	-8.2	0.03
Low fat yoghurt	162 (25.0)	67 (21.0)	95 (28.8)	-7.8	0.02
Low fat ice-cream	94 (13.9)	26 (8.2)	68 (18.9)	-10.7	<0.001
Fruit (fresh/canned)	369 (52.2)	164 (51.4)	205 (52.8)	-1.4	0.71
Sugar free beverages	639 (87.4)	284 (88.8)	355 (86.4)	2.4	0.34
Water	690 (93.6)	294 (91.9)	396 (95.0)	-3.1	0.09
High fibre cereal	287 (43.6)	81 (25.3)	206 (60.9)	-35.6	<0.001
Baked potato w/o butter	794 (29.2)	61 (19.1)	133 (38.7)	-19.6	<0.001
Wholemeal bread	421 (58.6)	187 (58.4)	234 (58.6)	-0.2	0.96
Canned fish in water	190 (28.7)	49 (15.3)	141 (41.1)	-25.8	<0.001

[†]Healthier foods: Defined as per the New Zealand food-based dietary guidelines-less energy-dense, lower in fat, salt and sugar and higher in fibre.[20]
[‡]Difference: % availability in urban fast-food outlets-% availability in rural fast-food outlets. Negative value: Greater availability of healthier food options in rural than urban fast-food outlets.
[§]Goodman and Kruskal's gamma test: n (%).

Table 2. Availability of 'healthier' food[†] in fast-food outlets by median income[‡]

Variables	Low income n (%)	High income n (%)	Difference (%)[§]	*p* value[¶]
Trim milk	224 (66.7)	191 (53.1)	61.6	<0.001
Low fat Spread	154 (48.7)	135 (37.6)	11.1	0.004
Low fat yoghurt	87 (32.1)	70 (19.9)	12.2	0.001
Low fat ice-cream	53 (18.0)	31 (8.7)	9.3	<0.001
Fruit (fresh/canned)	195 (60.7)	171 (47.8)	12.9	0.001
Sugar free beverages	303 (88.3)	317 (88.1)	0.2	0.91
Water	331 (94.8)	331 (91.9)	2.9	0.12
High fibre cereal	155 (57.2)	105 (29.2)	28	<0.001
Baked potato w/o butter	107 (38.4)	76 (21.3)	17.1	<0.001
Wholemeal bread	204 (60.5)	201 (56.8)	3.7	0.32
Canned fish in water	101 (36.7)	66 (18.3)	18.4	<0.001

[†]Healthier foods: Defined as per the New Zealand food-based dietary guidelines-less energy-dense, lower in fat, salt and sugar and higher in fibre.[20]
[‡]Median income: New Zealand $ 24,400.00.[29]
[§]% Difference: % availability in urban fast-food outlets-% availability in rural fast-food outlets. Negative value: Greater availability of healthier food options in rural than urban fast-food outlets.
[¶]Goodman and Kruskal's gamma test: n (%).

chicken in comparison to chicken with skin (-1.00, -1.00-, -0.25) (Table 3).

With respect to fast-food outlets, bivariate analysis highlighted an inverse association between number of fast-food outlets clusters and obesity prevalence using both general BMI (r=-0.33, *p*=0.02) and Polynesian BMI cut-offs for obesity (r=-0.38, *p*=0.02) (Table 4). This association however became non-significant after controlling for location (urban vs rural) and median income; general BMI (r=-0.05, *p*=0.72) and Polynesian BMI cut-offs for obesity (r=-0.07, *p*=0.65) (Table 5). No association ($p<0.05$) at a bivariate or a multivariate level was observed between number of healthier food choices available in fast-food outlets and obesity prevalence (Table 4 and 5).

With regards to supermarkets, bivariate analysis showed that high in-store availability of wholemeal bread per cluster compared to white bread was associated with lower obesity prevalence using Polynesian BMI cut-offs only (r=-0.31, *p*=0.04) (Table 4). This association however became non-significant (r=-0.02, *p*=0.95) after controlling for covariates (Table 5). Multivariate analysis highlighted that high price scores for water (water cheaper than sugary drinks) was associated with lower obesity prevalence in general (r= -0.53, *p*=0.03) and Polynesian (r=-0.53, *p*=0.03) BMI cut offs (Table 5). High in-store availability scores for trim milk compared to standard milk was associated with higher obesity prevalence when international (r=0.49, *p*=0.04) and Polynesian (r=0.57, *p*=0.01) BMI cut-offs were applied (Table 5) and controlling for location and income.

DISCUSSION

Our findings report that the in-store availability of healthier food choices was significantly higher in rural vs urban locations, and low-income vs high income areas. Inconsistent findings have been reported by previous literature. A systematic review from the United States examined the association between availability of healthier foods by urban vs rural location (n=6) and income status (n=27).[11] In contrast to our study, all studies equivocally reported that the availability of healthier foods was lower among deprived neighbourhoods (rural, low income, minority settlements).[11] However, evidence outside of the United

Table 3. Availability and price of proxy healthier food items scores[†] in supermarket

Food items Median (IQR)	n	Number of clusters	n	Availability score[‡]	n	Price score[§]	n	Availability and price score
White vs wholemeal bread	47	8.00 (4.00, 17.00)	47	2.00 (1.75, 2.00)	47	1.50 (1.36, 1.70)	47	3.37 (3.16, 3.60)
With skin vs lean chicken	24	8.50 (5.25, 14.75)	24	0.88 (0.40, 1.54)	23	-1.00 (-1.00, -0.25)	24	0.26 (-0.57, 1.00)
Regular vs trim meat	30	8.00 (5.00, 12.75)	30	1.07 (0.79, 1.57)	29	0.13 (-1.00, 1.23)	29	1.42 (0.56, 2.29)
Full cream vs trim milk	51	6.00 (3.00, 16.00)	51	1.40 (1.12, 1.75)	51	0.04 (-0.25, 0.73)	51	1.74 (1.00, 2.15)
Sugary drinks vs water	53	9.00 (5.00, 27.50)	53	1.20 (0.98, 1.60)	53	1.50 (1.33, 1.67)	53	2.83 (2.53, 3.16)
All items	55	6.50 (3.50, 16.20)	55	5.00 (4.50, 6.45)	54	3.00 (2.00, 4.00)	55	8.12 (7.06, 9.55)

[†]Proxy healthier food item scores: Adapted from NEMS-S scoring system.[17]
[‡]Availability score: 2 points if available, 0 points if not available. High score-greater availability of healthier vs regular food items.
[§]Points score: 2 points if cheaper than regular item, 1 point for same price, -1 point for expensive than regular. Higher score means lower price of healthier vs regular food items. Negative value indicates healthier option more expensive ($) than regular option.

Table 4. Spearman's correlation between healthier vs regular alternatives and obesity prevalence[†]

	Obesity General				Obesity Polynesian			
Super-markets (n=20)[‡]	Number of clusters	Availability score	Price score	Availability and Price score	Number of clusters	Availability score	Price score	Availability and Price score
White vs whole bread	r=-0.18 *p*=0.23	r=-0.02 *p*=0.89	r=0.02 *p*=0.91	r=-0.04 *p*=0.78	r=-0.31 *p*=0.04	r=0.01 *p*=0.97	r=-0.03 *p*=0.87	r=-0.08 *p*=0.57
With skin vs lean chicken	r=-0.01 *p*=0.95	r=-0.31 *p*=0.16	r=-0.07 *p*=0.75	r=-0.29 *p*=0.18	r=-0.23 *p*=0.29	r=-0.02 *p*=0.93	r=-0.15 *p*=0.50	r=-0.13 *p*=0.55
Regular vs trim meat	r=-0.18 *p*=0.34	r=-0.28 *p*=0.14	r=0.11 *p*=0.54	r=0.02 *p*=0.90	r=-0.32 *p*=0.09	r=-0.07 *p*=0.70	r=0.05 *p*=0.80	r=0.09 *p*=0.96
Full cream vs trim milk	r=-0.01 *p*=0.50	r=0.11 *p*=0.08	r=-0.17 *p*=0.23	r=0.14 *p*=0.36	r=-0.21 *p*=0.15	r=0.12 *p*=0.07	r=-0.08 *p*=0.59	r=0.03 *p*=0.79
Sugary drinks vs water	r=-0.03 *p*=0.82	r=-0.06 *p*=0.68	r=-0.23 *p*=0.06	r=-0.05 *p*=0.73	r=-0.08 *p*=0.56	r=0.01 *p*=0.90	r=-0.12 *p*=0.08	r=-0.14 *p*=0.33
All items	r=-0.01 *p*=0.92	r=-0.07 *p*=0.63	r=-0.06 *p*=0.68	r=-0.05 *p*=0.74	r=-0.19 *p*=0.18	r=0.17 *p*=0.22	r=-0.04 *p*=0.74	r=0.12 *p*=0.39
	Number of clusters		Number of healthier foods		Number of clusters		Number of healthier foods	
Fast-food out-lets[§] (n=47)	r=-0.33 *p*=0.02		r=0.09 *p*=0.52		r=-0.38 *p*=0.02		r=0.13 *p*=0.36	

[†]Dependent variable: Obesity prevalence as per the general and Polynesian BMI cut-offs.
[‡]Independent variables: Number of cluster, availability score, price score, availability+price scores of healthier foods vs their regular counter parts in super-markets.
[§]Independent variables: Number of cluster and number of healthier foods available in fast-food outlets.

States reports mixed results. Cross-sectional studies from Australia (N=48 food outlets),[30] New Zealand (N=2930)[5] and the United Kingdom (N=942)[31] supports findings from the United States that low income areas have poor availability to healthier food choices. Whereas, other cross-sectional studies conducted in Australia (N=325),[32,33] New Zealand (food outlets not reported),[34,35] Canada (N=822),[36] Scotland (N=246),[37] the United Kingdom (N=451)[38] and Denmark (N=802)[39] reported low-income neighbourhoods and rural areas to have equal, if not, better access to healthier food choices, which is in line with our observations.

Differences in neighbourhood contextual factors may explain the inconsistent findings observed generally between the United States vs other countries (Australia, New Zealand, Canada, and Europe) in reference to availability of healthier foods in urban vs rural and low vs high income areas. Residential segregation according to income status and ethnicity may be prominent in the United States.[11,40] For example, in New Zealand low and high income suburbs are located in relatively close proximity to each other, which may support lower discrepancy over availability of healthier foods based on socioeconomic strata.[41] Secondly, high availability of healthier and unhealthier foods in low income areas may be because of population density i.e., a large proportion of people need to be served, thus resulting in overall greater food availability and turnover.[34] Low income disparities in developed countries other than US may further explain the availability of healthier foods in low income areas. For instance, the Gini Index of the United States (0.41) indicates greater disparity between low and high incomes, in

Table 5. Spearman's Partial correlation between healthier vs regular alternatives and obesity prevalence[†]

	Obesity General				Obesity Polynesian			
Super-markets (n=20)[‡]	Number of clusters	Availability score	Price score	Availability and Price score	Number of clusters	Availability score	Price score	Availability and Price score
White vs whole bread	r=0.02 p=0.92	r=0.16 p=0.52	r=-0.13 p=0.59	r=-0.01 p=0.98	r=-0.02 p=0.95	r=0.18 p=0.28	r=0.01 p=0.95	r=0.19 p=0.45
With skin vs lean chicken	r=-0.11 p=0.66	r=-0.16 p=0.52	r=-0.19 p=0.43	r=-0.21 p=0.41	r=-0.09 p=0.37	r=-0.15 p=0.95	r=-0.06 p=0.81	r=-0.05 p=0.86
Regular vs trim meat	r=-0.23 p=0.45	r=-0.22 p=0.37	r=0.19 p=0.44	r=0.11 p=0.64	r=-0.15 p=0.60	r=-0.15 p=0.56	r=0.11 p=0.67	r=0.06 p=0.81
Full cream vs trim milk	r=0.22 p=0.93	r=0.49 p=0.04	r=-0.15 p=0.55	r=0.19 p=0.46	r=0.02 p=0.93	r=0.57 p=0.01	r=-0.18 p=0.47	r=0.21 p=0.39
Sugary drinks vs water	r=0.03 p=0.91	r=-0.02 p=0.84	r=-0.53 p=0.03	r=-0.27 p=0.28	r=0.04 p=0.89	r=0.04 p=0.98	r=-0.53 p=0.03	r=-0.21 p=0.39
All items	r=-0.01 p=0.99	r=0.01 p=0.96	r=-0.06 p=0.81	r=-0.05 p=0.85	r=-0.01 p=0.56	r=0.18 p=0.45	r=-0.07 p=0.79	r=0.06 p=0.80
	Number of clusters		Number of healthier foods		Number of clusters		Number of healthier foods	
Fast-food outlets (n=47)[§]	r=-0.05 p=0.72		r=0.26 p=0.09		r=-0.07 p=0.65		r=0.08 p=0.07	

[†]Dependent variable: Obesity prevalence as per the general and Polynesian BMI cut-offs. Covariates: Adjusted for location (urban vs rural) and median income (above vs below median income).
[‡]Independent variables: Number of cluster, availability score, price score, availability + price scores of healthier foods vs their regular counter parts in super-markets.
[§]Independent variables: Number of cluster and number of healthier foods available in fast-food outlets.

comparison to New Zealand (0.33), Australia (0.35) and the United Kingdom (0.36).[39] Literature on neighbourhood mapping should be acknowledged considering that factors such as historical settlement, geographical landscape, political governance, agricultural policies, food processing techniques and food product marketing strategies may partly explain the discrepancies in findings observed.[42]

Our findings highlight no association between number of fast-food outlets with cluster and obesity prevalence after adjusting for income and location. This finding is similar to a cross-sectional study (N=182 fast-food outlets) conducted in rural Victoria, Australia that reported no association between number of fast-food outlets and obesity prevalence.[17] Similarly, a systematic review (N=35 studies, predominantly cross-sectional) from the United States and Canada reported the majority of the associations (67% of the 106) between fast-food outlets and adult obesity as null.[11] The literature has acknowledged that food outlets have started providing healthier food choices to their customers,[12] which in turn has shown null associations with weight status[40,43] or favourably associated with lower weight status.[44] These findings are strengthened by state-wide health policies. The Western Sydney health district in Australia has developed a program for small to medium independent food outlets (e.g. restaurants) to improve the quality of cooking oils (switch from palm oil, animal fat to canola oil).[45] Whilst, there are numerous contextual factors (marketing strategy using by fast-food outlets, geographical location) that may be responsible for the null association between fast-food outlets and obesity prevalence, the nutritional quality of food items (not examined in the present study scope) provided in fast-food outlets could be speculated to reflect the null association between fast-food outlets and obesity prevalence observed. However, investigation is warranted to study this association (food quality in fast food outlets and obesity prevalence). In addition, transience of residents, unemployment statistics and changing cost of food items should be considered in future investigations.

Our results showed that lower prices for bottled water compared to SSBs were associated with lower obesity prevalence. This observation is supported by a meta-analysis (N=9, predominantly cross-sectional studies from the United States) which reported that higher prices for SSBs are associated with their lower demand (negative price elasticity: −1.2, 95% CI: -1.1, -1.5) and an increased demand for alternative beverages (fruit juice, milk and sugar-free beverages).[46] Prospective analysis on the United States national health data (N=103,000 women, N=21988 men, 1986-2007) reported that replacing one serving/day of SSBs for one cup/day of water was associated with 0.49 kg (95% CI: 0.32–0.65) less weight gain over four years.[47] In summary, strategies (e.g. lower bottled-water prices) which favour lower consumption of SSBs should be promoted due to the global burden of diseases secondary to SSBs intake; in Australia and New Zealand 560 million (95% CI: 440, 700) deaths/year are related to SSBs consumption.[48] To regulate the consumption of SSBs, the Department of Health, New Zealand has banned SSBs in all hospitals and District Health Boards since September 2015.[49] The Department of Health, New Zealand is now considering additional 20% tax on SSBs, which has shown success in other countries such as France and Mexico.[50] A cost-analysis review from Australia estimated that 20% tax on SSBs would reduce incidence of diabetes by 800 cases/year, and 25 years after there would be 4,400 fewer cases of heart disease and 1,100 fewer cases of stroke. The tax was predicted to result in revenue of AUD400 million/year.[51]

We reported that the in-store availability of trim milk was higher among clusters with higher obesity prevalence.

A previous meta-analysis (N=29 RCT) reported no significant effect of dairy (serving 240 mL) consumption on weight status between the intervention and control groups long term (≥ one year).[52] Furthermore, we speculate that the consumer's attitude and beliefs about trim milk may partly explain our findings. Earlier cross-sectional literature from Australia (N=345)[53] and New Zealand (N=720)[54] studying adult consumer's perception about milk and milk products highlighted that drinking trim milk for weight control purposes was an important belief which promoted its consumption.[49,50] This is supported by a cross-sectional study (N=24604 adults) which reported that obese Finish participants compared to their non-obese counterparts were more likely to choose trim/skim milk over whole milk. The authors explained that this could be due to the participants' belief system that trim milk will assist in their weight control and that low-fat products can be consumed in larger quantities.[55] In summary, irrespective of individual beliefs regarding milk, dairy is one of the four essential food groups recommended by the food and New Zealand Dietary Guidelines,[20] and two serves of trim/skim milk and milk products are recommended for adult consumption. Therefore, considering the current literature it is encouraging to know that the in-store availability of trim milk is higher in clusters with higher obesity prevalence.

An extensive literature search suggests that this is the first time the number of healthier food choices available in fast-food outlets has been examined. This takes us a step beyond the pre-conceived notion that fast-food outlets simply represent a source of energy dense, nutrient poor food choices. Our sample size is our strength; we covered 98 geographical locations across the Waikato and Lakes regions of New Zealand, comprising 1149 food outlets (supermarkets and fast-food outlets). Our methodology is strengthened by measuring direct food availability (in-stores surveys for measuring availability and price of healthier vs regular foods) rather than simply labelling food outlets (supermarkets, fast-food outlets) as proxy indicators for healthier and unhealthier food items. To our knowledge ours was the first study in the New Zealand setting to pilot proxy healthier food item scores (availability and price scores) to measure the food environment using the widely adapted and validated NEMS-S scoring system.[21] Furthermore, recent literature had cited the need to examine the association between food environment scores and health outcomes.[56] Our preliminary research has revealed that the price of water in comparison to the price of SSBs is directly associated with obesity prevalence. Similarly, in-store supermarket availability scores for trim milk are positively associated with clusters with higher prevalence of obesity. Moreover, these findings were consistent for both, obesity defined as per general or Polynesian-specific BMI cut-offs therefore,[27] emphasising the generalisation of our results across populations.

There is no gold-standard for mapping food outlets, but it is recommended that a combination of measures be used to reduce errors (low sensitivity and low specificity).[11] We therefore have used a combination of both, council and commercially available lists and cross-validated it with local knowledge from Māori community health workers. We mapped all registered food outlets; however, we may have missed unregistered outlets (e.g. roadside stalls). We studied in-store availability and price of five specific food items with well-defined healthier vs regular alternatives, foods not having clear unhealthier alternatives were excluded (fruits, vegetables or fish). Due to incomplete and/or missing data food variety was not considered (e.g. variety of trim milk available such as skim, reduced fat milk). In-store food availability and price were recorded using a bespoke questionnaire.[18] The questionnaire was developed based upon prior categorisation between frequently consumed energy dense foods and healthier alternatives among New Zealanders including Māori in a previously validated questionnaire.[19] However, we recommend further validation of the questionnaire within the context of mapping food outlets as a macroenvironmental determinant of obesity. We piloted the NEMS-S scoring system to measure proxy healthier food item scores (availability and price scores), however further work is warranted to validate the NEMS-S tool within the New Zealand setting. Our findings should be interpreted in the context that 'mapping food outlets' (availability and price) is one of the several neighbourhood food environmental factors which determines exposure such as age, reduced mobility-age related, gender, income, professional/domestic workload-time, ethnicity-culturally acceptability, transport ownership (private vs public), transport cost-proximity of residential areas to food venues, urbanisation and population density.39 We examined and adjusted for income (lower vs higher) and location (urban vs rural), however extended socio-cultural and socio-economic variables were not recorded due to resource constraints, however could be considered by future studies. We examined the association between the number of healthier foods available in fast-food outlets and obesity prevalence; however due to limited 'within category' counts, for analysis, the types of fast-food outlets were not further segregated. Previous literature has highlighted that full-service as compared to limited service restaurants are more likely to provide healthier food choices and thus have favourable implications on body weight.[12] The present is cross-sectional and therefore cannot determine causality.

In conclusion, our study showed that the in-store availability of healthier food choices in fast-food outlets is higher in rural vs urban locations and lower income vs higher income areas, consistent with previous work originating for New Zealand.[5,35] As food outlets (number of fast-food outlets/cluster) were not associated with obesity, future research could investigate other factors such as physical activity outlets, dietary quality of fast-foods and their association with obesity. We showed bottled water prices vs SSBs were inversely associated with obesity, which further encourages ongoing government regulation in New Zealand to regulate the availability and prices of SSBs. Lastly, our results highlighted that the availability of trim milk was directly proportional to obesity which should be investigated further. Future studies could investigate whether individuals dietary and food purchase behaviours and household food diversity could explain the direction of the relationship between food availability (trim milk) and health outcomes (obesity); whether die-

tary patterns (quantity and quality) are antecedents to or consequences of obesity.

ACKNOWLEDGEMENTS

We also thank the investigator group, Kaitiaki, Māori Community Health Workers, Te Wai o Rona: Diabetes Prevention Strategy project team, and local health service staff for their varied contributions to the study.

AUTHOR DISCLOSURES

The authors declare no conflicts of interest.

Funding was provided by Health Research Council, Waikato District Health Board, Lakes District Health Board, Ministry of Health, Sport and Recreation New Zealand, Southern Trust, Waikato Local Diabetes Team and Merck, Sharp and Dohme. Support in kind was provided by Roche Diagnostics, Pathlab, Medlab, University of Auckland, Auckland University of Technology, Wintec, Te Hotu Manawa Māori, Eggs Inc, Vodafone, Rivermill Bakers and Sun Fruit.

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