

# Healthiness of foods and non-alcoholic beverages according to store type: A population-based study of household food and drink purchases in New Zealand

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## ABSTRACT

**Background:** Obesity and diet-related noncommunicable diseases (NCDs) account for the largest proportion of disease burden worldwide, and an unhealthy food environment is a key driver. Food retailers play an important role in food environments through the availability and purchases of healthy food products at various stores.

**Objectives:** To assess whether the healthiness of food and non-alcoholic drink product purchases vary according to retail store type.

**Methods:** We undertook a cross-sectional analysis of Nielsen New Zealand Homescan® panel data, which is a nationally representative sample of 2500 households in terms of certain key household demographic and socioeconomic characteristics. Panel members were asked to record all food and beverage products that were purchased and brought back to the home between October 2018 and October 2019. Household food and non-alcoholic drink purchases were linked with two food composition databases (Nutritrack, a New Zealand packaged food composition database, and the FOODfiles New Zealand Food Composition Database) to extract data on the nutrient profile of products purchased. We developed a store classification tool, and classified stores as supermarkets, grocery stores, convenience stores, fruit and vegetable stores, meat and fish stores, or bakeries. We estimated the Health Star Rating (HSR) for all products and defined a product with HSR  $\geq 3.5$  as 'healthy'. We computed estimated mean HSR and conducted multivariate regression analyses.

**Results:** In total, 3,940,458 product purchases were included in the analyses, consisting of 20,491 unique products purchased at different stores over the one-year period by 1800 panellist households. Supermarket products made up the majority of household food and drink purchases (3,545,141 of 3,940,458; 90%). Overall, the estimated mean HSR was 3.5 stars. In comparison to the reference group of supermarkets, the odds ratio for healthy products purchased at fruit and vegetable stores was 4.62, at grocery stores it was 2.36, and at meat and fish stores it was 1.99. In contrast, the odds ratios from convenience stores and bakeries were 0.58 and 0.03. Except for convenience stores, these differences were statistically significant ( $p < 0.05$ ).

**Discussion:** We found significant differences in household purchases of healthy food and beverages according to food retail store type, with healthier food much more likely to be purchased from fruit and vegetable stores, meat and fish stores and grocery stores, and much less likely to be purchased from bakeries and convenience stores as compared with supermarkets.

**Conclusion:** Policies to improve healthy food retailing should consider all retail store types and focus particularly on increasing the availability of healthy food options at convenience stores and bakeries. Given that supermarkets are the source of most household food purchases (both healthy and unhealthy), strategies are also warranted to increase the relative availability and purchases of healthy foods from supermarkets.

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## Key messages

To improve the retail food environment in New Zealand, policies need to be developed and actions exerted with the aim of improving the availability and sales of more healthy food across all store types, particularly convenience stores and bakeries.

## Introduction

The global incidence of obesity, metabolic diseases (e.g. type 2 diabetes), cardiovascular disease (CVD) and cancer is increasing at an alarming rate ("Third United Nations High-level Meeting on NCDs. September 2018,"), and unhealthy food environments are a key driver (Swinburn et al., 2011; Swinburn, Sacks, & Ravussin, 2009; Vandevijvere, Chow, Hall, Umali, & Swinburn, 2015). Unhealthy food environments are characterised mainly by ready availability and affordability of relatively inexpensive but heavily promoted energy-dense and nutrient-poor food (Swinburn et al., 2011). Population exposure to unhealthy food environments has increased worldwide, and it appears that unhealthy food environments create a supplier-induced demand for unhealthy food (Swinburn et al., 2013). The production, supply and marketing of unhealthy food have disproportionately dominated the market (Stuckler, McKee, Ebrahim, & Basu, 2012), and food supply systems have largely contributed to the current unhealthy food environment worldwide (Neal et al., 2013). Unhealthy food environments not only have limited consumer choice of healthier food, but also have influenced consumers to buy more unhealthy food at the expense of healthy options (Andreyeva, Long, & Brownell, 2010; Maia et al., 2020). Creating healthier food environments is crucial in order to reduce diet-related Non-Communicable Diseases (NCDs) and related inequalities (Swinburn et al., 2013).

A recent study in New Zealand (NZ) found that overall, 54% of all foods offered at hospitals are unhealthy, and 53% of sport and recreation centres sell sugar-sweetened beverages (Vandevijvere, Mackay, D'Souza, & Swinburn, 2019). In supermarkets the length of shelf space allocated for unhealthy versus healthy food had an overall ratio of 1:0.42, and only 27% of supermarkets had at least one in five checkouts free of "junk" food. Junk foods was defined as energy-dense and nutrient-poor food and beverage products (Vandevijvere et al., 2019). In supermarkets, 53% of end of aisle promotions were for "junk" foods, and in weekly supermarket circulars, 25% of promotions were for "junk" foods. Another study found that, on average, price promoted products constituted 50% of all unique annual household grocery items purchased in NZ (Zorbas et al., 2020). The proportions of purchases that were price promoted were significantly higher for processed (59%) and ultra-processed foods and beverages (55%) compared to unprocessed food (45%) (Zorbas et al., 2020).

Food supermarkets and retailers play an important role in food environments (Hawkes, 2008). According to a survey conducted in 2009 in the US, Han et al. (2012) classified food stores into supermarkets, grocery stores, convenience stores, and speciality stores. A US study found that supermarkets, grocery stores and convenience stores were the food purchase locations for 60%–70% of daily energy intake in the US diet (Drewnowski & Rehm, 2013). Research in the US also shows significant differences in the availability of healthier food according to store type (Block & Kouba, 2006; Connell et al., 2007; Glanz, Sallis, Saelens, & Frank, 2007; Sallis, Nader, Rupp, Atkins, & Wilson, 1986, pp. 216–219). Higher consumption of fruit and vegetables was reported among consumers who shopped at fruit and vegetable stores and supermarkets than those who shopped mainly at grocery stores (Zenk et al., 2005). In NZ over 86% of households purchased food at supermarkets, and nearly 14% of households purchased food at fruit and vegetable stores, Asian stores, and other stores (Zorbas et al., 2020). In a study, which used data from the 2002–3 NZ Health Survey, Pearce, Hiscock, Blakely, and Witten (2008) examined associations between intakes of fruit and vegetables and proximity of households to supermarkets and convenience stores.

The authors found no associations between distance of households to supermarkets and consumption of fruit and vegetables; but found a negative association between proximity of households to convenience stores and intakes of fruit and vegetables.

In NZ to our knowledge no study has been conducted to use household data from a nationally representative sample to examine variability in purchases of healthy vs. unhealthy food and beverage products according to store type. Considering this gap in knowledge, the objective of this study was to examine whether there are differences in purchases of healthy foods and non-alcoholic beverages according to store type in NZ. We hypothesized that foods and non-alcoholic beverages purchased from supermarkets and fruit and vegetable stores would be healthier than those purchased from meat and fish stores, grocery stores, convenience stores, and bakeries.

## Methods

### Study design

We undertook a cross-sectional analysis of NZ household food and beverage purchasing data collected between October 2018 and October 2019. Data on foods and non-alcoholic beverages purchased by 1800 households, supplemented with food composition data, were used. The purchasing data were obtained from the Nielsen NZ Homescan® panel, which is a nationally representative sample of NZ households in terms of key household demographics and major geographic locations. The Nielsen NZ Homescan® database was linked with two national food composition databases (Nutrtrack and FOODfiles) to extract data on the nutrient profile (energy, total sugar, sodium, saturated fat, dietary fibre, protein, and fruit, vegetable, nut and legume content) of the foods and beverages purchased.

Data in Homescan® represented purchases from a variety of food retail stores across NZ. Nielsen Homescan® is one of the four largest commercial food purchasing datasets globally, and it contains up to date data that are used to monitor consumer purchases as well as sales of products in several high-income countries (Bandy, Adhikari, Jebb, & Rayner, 2019). Panel households are incentivised through a point-earning system that enables conversion of earned points to monetary rewards. Nielsen NZ Homescan® is an open cohort recruiting households continuously to ensure the panel households represent New Zealanders socioeconomically and demographically each year. Detailed information on the demographic characteristics and geographic location of the household are collected at recruitment. Demographic data include the main household shopper's age and sex, household composition, life stage, household size, household income. When a product is purchased and brought home, the panel member enters the quantity purchased, price of product, whether it was on promotion, the store shopped at, and scans the barcode. Information of the full item description, product category, pack size, unit (e.g. gram, kg, lit, ml), brand, and product department is derived from the product barcode. Information in the product department is coded on the Nielsen item master as beverages, chilled foods, fresh foods, frozen foods, general grocery, and snack foods and confectionary. For purchases of products that do not have barcodes (e.g. fresh produce), the panellist chooses a corresponding barcode from a supplied booklet. Homescan® data exclude foods and drinks purchased for consumption away from home such as from restaurants, takeaway stores, fast food outlets, and cafés.

Data in the Nutrtrack food composition database are collected by trained field workers from four major supermarket stores in Auckland each year. These supermarket stores include a large range of packaged foods and beverages and are owned and managed by the two major NZ supermarket retailers (Foodstuffs NZ and Woolworths NZ), which together comprise 89% of the national grocery market share ("Euro-monitor International. Supermarkets, New Zealand 2020,"). Using a customised smartphone application, field workers scan the barcodes of each packaged food and beverage displaying a Nutrition Information

Panel (NIP) available in the supermarket at the time of the survey. For each product, photos of all package surfaces are taken and uploaded into a web-based database. The 2018 and 2019 data including product barcode, product name, food group and category, pack size, recommended serving size, Health Star Rating (HSR) displayed on the product, and NIP information were extracted and used for data analysis. The NIP data were used to extract information on the average amount of energy, total sugar, sodium, saturated fat, protein, and dietary fibre per 100 gr/ml of each product. The FOODfiles dataset is the main component of the NZ Food Composition database, which is updated and released online every two years. The database is the most comprehensive collection of generic food composition data for foods commonly consumed in NZ. The latest update of the database was released in 2018, and FOODfiles 2018 was used in this study ("Plant & Food Research. New Zealand Food Composition Database, 2018,").

#### Exclusion criteria

Products were excluded in two steps. Firstly, the following products were excluded: (i) purchases made from pet stores or stores with only home delivery or only online services, (ii) purchases made from stores where food constitutes a small part of total sales (e.g. department stores), (iii) purchases made from stores with no recorded name, (iv) Easter and Christmas products, (v) products not required to display a NIP (e.g. tea, unflavoured coffee, artificial sweeteners, chewing and bubble gums, gelatine, salt, flour, corn flour, self-raising flour, vinegar, herbs and spices, herb tubes and pastes, cream of tartar, mustard, pepper, baking soda, baking powder, tartaric acid, citric acid, cooking ingredients, ice, curry powder, yeast, bicarbonate of soda, and (vi) special products (baby foods, protein bars, protein powders, and fitness or diet products). Alcoholic beverages and products purchased at liquor stores were also excluded. We also excluded products from a retail brand store, because just 4 unique products were purchased from the store over the one-year period, and the retail brand store served only in one geographic location. Secondly, infrequently purchased products were excluded. Criteria for infrequently purchased products are described in the data linkage section below.

#### Data linkage to food composition data

Product barcode details were used to match products between Nutritrack and Nielsen NZ Homescan®. For products that could not be matched in this way, the following four-step approach was used.

- (i) a list was prepared of the products purchased by Nielsen NZ Homescan® panellists which could not be matched by barcode, and products were ranked based on total units purchased over one-year period;
- (ii) products with fewer than 12 total units purchased over the one-year period (i.e. less than one purchase per month on average across the entire dataset of NZ households) were excluded, on the basis that any such product is an infrequently purchased item;
- (iii) FOODfiles was used to extract food composition data for fresh produce that do not normally display NIP information including fresh fruits, fresh vegetables, fresh meats, fish and seafoods, and prepacked salads. For each product, its best match product was identified by a nutritionist (KEB). Uncertainties regarding appropriate matching were resolved through discussion with a second nutritionist (CNM).
- (iv) for the remaining unmatched packaged products, product category-average food composition values were calculated, using the product category nutrient content of Nutritrack products. For example, for a yoghurt product in Nielsen NZ Homescan® for which nutrient content data were not available in Nutritrack, we assigned the average nutrient composition of all Nutritrack yoghurt products. The nutrient content data used were: energy

per 100gr/ml, saturated fat, total sugar, sodium, protein, calcium, dietary fibre per 100gr/ml, and the fruits, nuts, vegetables and legumes (fvnl) content of products. Estimated product fvnl points data were available in Nutritrack database.

Fig. 1 illustrates 31,470 unique products, of which 23,020 (23,020/31,470 = 73.1%) products were eligible for inclusion after the first exclusion step. Following the second exclusion step, 89.0% of all eligible products (20,491/23,020 = 89.0%) were matched to food composition data and included in our analyses. In the second exclusion step, 11% (2525/23,020) were uncommon products, and 4 products were purchased from a retail brand only in one location for the one-year period; therefore, these products were excluded.

#### Classification of stores

We used the Australia New Zealand Standard Industrial Store Classification ("The Australian and New Zealand Standard Industrial Classification (ANZSIC) 2006,"), and methods employed in similar international studies (Connell et al., 2007; Han et al., 2012; Morland, Wing, Roux, & Poole, 2002; Stern, Ng, & Popkin, 2016), to develop store classification criteria. We identified the variety of fruit and vegetables purchased by NZ Nielsen Homescan® panellists from different stores over the one-year period. We applied the criteria in two steps and classified stores as supermarkets, grocery stores, convenience stores, fruit and vegetable stores, meat and fish stores, and bakeries. At the first step, the variety of fruit and vegetables purchased were used to classify supermarkets, grocery stores, and convenience stores. At the second step, criteria on the availability of fresh milk, breads, and fresh meats were applied (Table 1). Meat products, including fish, seafood and poultry products, and bakery products were defined according to the Nutritrack food classification system which is based on the Global Food Monitoring Food Classification (Webster, Dunford, & Neal, 2010).

#### Healthiness of products and HSR estimation

The healthiness of foods and beverages was based on their nutritional composition. Nutrient profiling classifies or ranks foods according to their nutritional composition ("WHO Regional Office for Europe nutrient profile model, World Health Organization 2015,"). Nutrient profiling has an important role in labelling and marketing of foods and beverages in the OECD countries (Hamlin & McNeill, 2016; Lobstein & Davies, 2009; Roberto et al., 2012; Watson et al., 2014). The NZ and Australian Health Star Rating (HSR) labelling system is based on nutrient profiling. HSR is a front of pack (FOP) nutrition labelling model, and it provides interpretive FOP nutrition labels to assist consumers make healthier choices. HSR labelling standards were developed by Food Standards Australia New Zealand, and the HSR system was launched as a voluntary FOP labelling policy in mid-2014 ("The Health Star Rating system in New Zealand 2014–2018, Auckland UniServices Ltd., August 2018,"). Since only a minority of eligible products display HSR, we estimated HSR for all products in four steps, using the Guide for industry - Health Star Rating System, Version 6 uploaded March 28, 2018,").

At step one, we categorised all products into one of six categories: (i) Category 1 (beverages other than dairy beverages), (ii) Category 1D (dairy beverages), (iii) Category 2 (all foods other than those included in Category 1, 1D, 2D, Category 3 or 3D), (iv) Category 2D (dairy foods other than those included in Category 1D or 3D), (v) Category 3 (edible oil, edible oil spreads, margarine, and butter), and (vi) Category 3D (cheese and processed cheese with calcium content >320 mg/100 gr). At step two, using per 100gr/ml of energy content (kJ), saturated fat, sugar, and sodium content of each product, we employed the published algorithms and calculated baseline points for all products. At step three, using per 100 g/ml of protein content and dietary fibre content of each

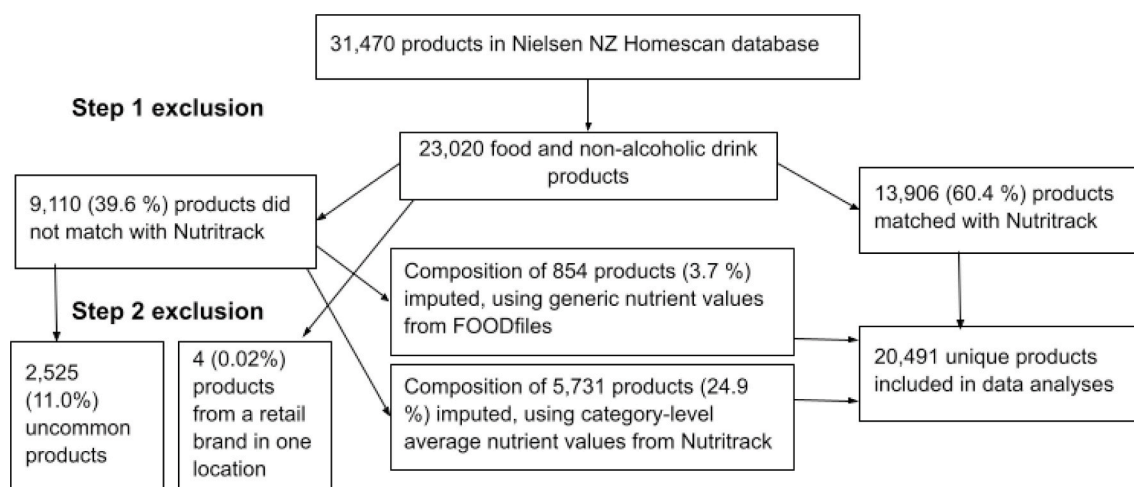


Fig. 1. Flow diagram showing number of products included in the study.

Table 1

Criteria and classification of stores, using Nielsen NZ Homescan® panel data, Oct 2018–Oct 2019.

Store type	Criteria	Number of retail brands per category
Convenience store (Service stations)	Retails food products, <10 varieties of fruit and vegetables, sells fresh milk, and is not a specialty food store	9
Grocery store (Corner store/ Dairy)	Retails food products, ≥10 - <30 varieties of fruit and vegetables, sells fresh milk and breads, and is not a specialty food store	1 <sup>a</sup>
Supermarket	Retails food products, ≥30 varieties of fruit and vegetables, sells fresh meats, fresh milk and breads and is not a specialty food store	8
Fruit and vegetable store	Retails food products, ≥30 varieties of fruit and vegetables, and does not sell fresh meats	4
Meat and fish store	Retails food products, and ≥ 50% of sales are meat products	4
Bakery	Retails food products, and ≥ 50% of sales are bakery products	2

<sup>a</sup> Although panellists record purchases from a grocery store (corner store/dairy) under one label, most grocery stores are independently owned and operated.

product, we used the published algorithms and calculated protein points and dietary fibre points where appropriate. The baseline points, calculated at step two, were modified by subtracting protein points, dietary fibre and fvnl points from the baseline points. Fvnl points were calculated for products based on their content of fruit, vegetable, nuts, and legumes ("New Zealand Food Safety. Guide for industry - Health Star Rating System, Version 6 uploaded March 28, 2018,"). Using the published algorithms and calculators, the modified points as described in step three above, were transformed into Health Star Ratings, ranging from 0.5 stars to 5.0 stars in half-star increments ("New Zealand Food Safety. Guide for industry - Health Star Rating System, Version 6 uploaded March 28, 2018,").

#### Statistical analyses

To examine the healthiness of foods and beverages purchased from stores across NZ between October 2018 and October 2019, we used

generalised linear models (GLM) with binomial distribution. The unit of analysis was each unique product, the store type was the main predictor variable, and the outcome variable was defined as the healthiness of foods and beverages purchased. Specifically, products with a HSR  $\geq 3.5$  were considered to be 'healthy', and products with HSR  $< 3.5$  stars were considered 'unhealthy', in line with a technical report on the alignment of New South Wales healthy food provision policy with the HSR system (Dunford, Cobcroft, Thomas, & Wu, 2015). That report found that products classified as Green by the Traffic Light criteria on average received a HSR of  $\geq 3.5$  stars; while products classified as Amber or Red on average had a HSR  $\leq 3$  stars. We examined estimated mean HSR with 95% confidence interval (CI) across store types, and obtained odds ratios on the purchases of healthy products at different store types compared to the reference category, using the GLM. Since purchases were made at the household level, we considered household as a cluster in our model estimates. In order to address the cluster effect of data at household level, we added a random cluster effect in our model estimates to adjust standard errors and 95% CI for means and odds ratios. Supermarkets were used as the reference category because this category of stores represented the highest percentage of products purchased. The analyses were adjusted for household demographics (age of main household shopper (<34, 35–39, 40–49, 50–65, >65 years), sex of household main shopper (male, female), number of family members (1–2, 3 and more), equivalised household income level (tertiles of low, medium, and high), and geographic location (Auckland, Bay of Plenty and Waikato, Wellington, rest of North Island, Canterbury, rest of South Island), average product price, and average proportion of promoted purchases of products. Equivalised household income was generated, applying the OECD equivalence factors. This approach was used in a recent study (Zorbas et al., 2020). Income was estimated based on the midpoint of ten categorical income groups available in the Nielsen NZ database. The OECD equivalence scales were used to calculate equivalised household income, using the following equivalence factors: 1 for the first adult, 0.5 for each additional adult, 0.3 for each child within the household. To calculate the average product price, for each unique product, the mean unit price was computed over all purchases made for the product. To compute average proportion of promoted purchases, for each unique product, the total units of the product purchased on promotion over time was divided by total units of the product purchased over time. All analyses were performed using STATA version 13.

#### Validity of estimated HSR

Supplementary table shows the concordance between the displayed HSR and estimated HSR. It shows that out of 2948 products that

displayed HSR, the agreement (overall) was 88.2% (2600/2948) and the Kappa statistic was 0.74 ( $p < 0.001$ ), showing a substantial level of concordance (McHugh, 2012).

## Results

Table 2 presents Nielsen NZ Homescan® household demographic and socioeconomic characteristics. Out of 1800 households, the majority of household main shoppers were in the older age categories of 40–49 years, 50–65 years, and > 65 years (86.9% combined), and most were female (75.8%). In terms of geographic region, most households were located in North Island (over 75%) with 29.4% of the households in the Auckland region. Less than 25% of households were located in South Island with 15.2% of the households in the Canterbury region. The distribution of Nielsen NZ Homescan® panel households across the country reflects the population density of North Island and South Islands. Most households consisted of 1–2 persons (58.2%), followed by 3 persons or more person households (41.8%). The average monthly household expenditure by store type was highest for supermarkets (median = NZ\$ 446, and mean = NZ\$ 487), and lowest for grocery stores (median = NZ\$ 22, and mean = NZ\$ 32).

Fig. 2 shows that 90.0% of all food and non-alcoholic drink purchases were from supermarkets. In total, there were 3,940,458 product purchases made over the 12-month period.

Fig. 3 shows that for products purchased at bakeries, the unadjusted estimated mean HSR was 2.6, and for products purchased at fruit and vegetable stores was 4.3. Overall, the unadjusted estimated mean HSR was 3.53 (95% CI 3.40–3.67) which was similar to that of supermarkets

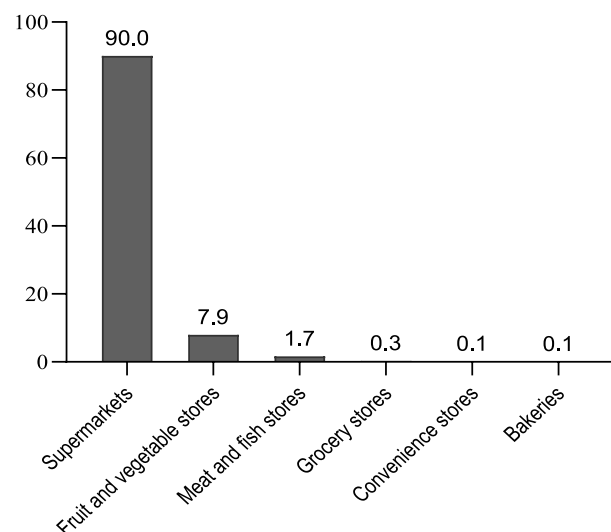


Fig. 2. Percentage of product purchases by store type.

at mean HSR 3.47 (95% CI 3.31–3.62).

Table 3 presents odds ratios on the quantity of purchases of healthy products according to store type. Compared with supermarkets (reference group), the odds ratio for the quantity of purchases of healthy products from fruit and vegetable stores was 4.62 (95% CI 3.54–6.01), from grocery stores was 2.36 (95% CI 1.39–4.01), and from meat and fish stores was 1.99 (95% CI 1.72–2.31). In contrast, the odds ratio for the quantity of purchases of healthy products from convenience stores was 0.58 (95% CI 0.30–1.11), and from bakeries was 0.03 (95% CI 0.01–0.07).

## Discussion

In this study of household purchases from 1800 New Zealand households over a one-year period, we found that food and non-alcoholic drinks purchased by NZ households for consumption at home had an average HSR of 3.5 (out of a maximum of five) stars. The vast majority (90%) of food and drink products were purchased from supermarkets. The objective of our study was to examine variability in quantity of purchases of healthy vs. unhealthy food and non-alcoholic beverage products by store type. We found significant differences in the quantity of purchases of healthy foods and beverages by store type; compared to supermarkets, healthy products were much more likely to be purchased from fruit and vegetable stores (OR = 4.62), grocery stores (2.36), and meat and fish store (OR = 1.99), and much less likely to be purchased from bakeries (OR = 0.03), and convenience stores (OR = 0.58).

The store classification criteria that we developed for this study was based on the availability of a variety of food groups including fruit and vegetables, which aligns with criteria used by several studies conducted in the US (Block & Kouba, 2006; Connell et al., 2007; Glanz et al., 2007; Sallis et al., 1986, pp. 216–219). Block and Kouba (2006) found that supermarkets offered more fruit and vegetables than grocery stores. Sallis et al. (1986, pp. 216–219) also found that there was greater variety of fruit and vegetables available at supermarkets than grocery stores and convenience stores, but a greater variety of fruit and vegetables at grocery stores than convenience stores. Connell et al. (2007) found that the availability of fruit and vegetables at supermarkets was significantly greater than small/medium stores, and convenience stores. Glanz et al. (2007) also reported more variety and availability of fruit and vegetables at grocery stores than convenience stores. These studies used data which were collected over a shorter period of time and from fewer geographic locations as compared with our study. Therefore, seasonal and geographic variability in the availability of fruit and vegetables in

Table 2

Demographic and socioeconomic status of Nielsen NZ Homescan® panel households, Oct 2018–Oct 2019.

Household character		Number of households	
Sex of household main shopper	Male	436	24.2%
	Female	1364	75.8%
Age of household main shopper	<34 years	105	5.8%
	35–39 years	131	7.3%
	40–49 years	357	19.8%
	50–65 years	711	39.5%
	>65 years	496	27.6%
Geographic region of households	Auckland	530	29.4%
	Bay of Plenty and Waikato	292	16.2%
	Wellington	242	13.5%
	Rest of North Island	289	16.1%
	Canterbury	274	15.2%
	Rest of South Island	173	9.6%
	Low income	643	35.7%
Equivalised household income	Middle income	553	30.7%
	High income	604	33.6%
Household size (number of persons)	1–2	1047	58.2%
	≥3	753	41.8%
Monthly household expenditure by store type	Mean NZ\$		Median NZ\$
	Supermarkets	487	446
	Meat and fish stores	104	79
	Fruit and vegetable stores	96	72
	Convenience stores	57	30
	Bakeries	35	24
	Grocery stores	32	22

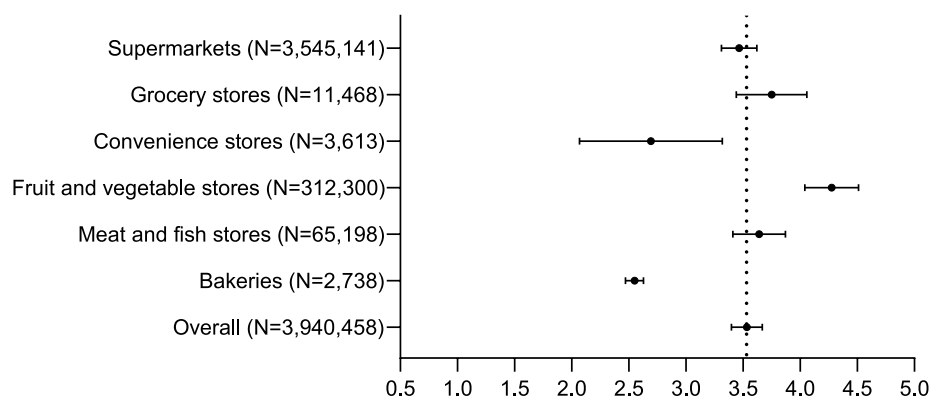


Fig. 3. Estimated mean HSR and 95% CI store type.

Table 3

Purchases of healthy food and beverages by store type, October 2018–October 2019.

Store type	Odds ratio	(95% CI)	P value
Supermarkets (reference)	1.00		
Fruit and vegetable stores	4.62	(3.54–6.01)	<0.0001
Grocery stores (Corner stores)	2.36	(1.39–4.01)	0.001
Meat and fish stores	1.99	(1.72–2.31)	<0.0001
Convenience stores (Service stations)	0.58	(0.30–1.11)	0.10
Bakeries	0.03	(0.01–0.07)	<0.0001

The number of product purchases was 3,940,458, which consists of 20,491 unique products.

these studies may not be inclusive of the variety of fruit and vegetables in the context of US as compared to the variety of fruit and vegetables that our study identified in the context of NZ.

Several studies conducted in the US, UK, Australia, Japan, and New Zealand have examined the relationships between household consumption of healthy food and the proximity or presence of different store types in the household neighborhoods (Ball, Crawford, & Mishra, 2006; Layte et al., 2011; Morland et al., 2002; Murakami et al., 2009; Pearce et al., 2008; Timperio et al., 2008; Zenk et al., 2005). Whilst we found that healthy products were much more likely to be purchased from grocery stores and fruit and vegetables stores compared to supermarkets, in a US study, Morland et al. (2002) found that households' fruit and vegetable consumption increased with the presence of supermarkets as compared with that of grocery stores in the household neighborhoods. In another US study, Zenk et al. (2005) found that women who shopped at supermarkets and fruit and vegetable shops consumed fruit and vegetables more often than those who shopped at grocery stores. In a study from Australia, Ball et al. (2006) reported that presence of fruit and vegetable stores and supermarkets in household neighborhoods was not associated with the intakes of fruit and vegetables among women. In a study in Japan, Murakami et al. (2009) found no associations between fruit and vegetable intakes and household's proximity to fruit and vegetable stores, grocery stores or supermarkets. Unlike these two studies from Australia and Japan, in a study in the Republic of Ireland, Layte et al. (2011) reported that household proximity to food stores or the presence of supermarkets and other food stores in household neighborhoods was positively associated with greater intake of healthy food; however, the proximity of households to convenience stores or the presence of convenience stores was not associated with greater consumption of healthy food. In a study in Australia, Timperio et al. (2008) found that the presence of fast food outlets and convenience stores in household neighborhoods had inverse associations with consumption of fruit and vegetables among children; however, children's intake of fruit and vegetables increased the farther children lived from a supermarket or a fast-food outlet. In New Zealand, Pearce et al. (2008) found no

positive associations between the proximity of households to a supermarket and the consumption of fruit and vegetables; but found negative associations between the proximity of households to convenience stores and intakes of fruit and vegetables. Our study examined purchases from different store types rather than proximity to store types. In addition, in our study, we investigated the purchases of both packaged and unpackaged healthy products (as defined by a HSR  $\geq 3.5$ ) rather than using only the purchases or availability of fruit and vegetable products, which was the case in most of the previous studies. In addition, these studies used self-administered questionnaires to collect data on household consumption of healthy food, mainly fruit and vegetables, which may have introduced measurement error.

Our study is the first to quantify purchases of healthy products by store type in NZ, and one of few studies internationally to examine purchases of both packaged and unpackaged products across a range of food retail settings. Our study is also one of just a few studies to use nationally representative household food purchasing data to examine the healthiness of food by store type, as opposed to simply reporting on availability of food in-store. Measuring product healthiness using HSR both for packaged and unpackaged food and beverage products, including fresh produce, is a strength of our study. This is despite the fact that for some products (e.g. fresh produce) it is not required that food manufacturers provide a NIP ("New Zealand Food Safety. Guide for industry - Health Star Rating System, Version 6 uploaded March 28, 2018, "), thus making it challenging to use HSR as a measure of product healthiness. In our study, however, we estimated HSR for all products. Another strength of our study is the broad generalizability of our findings. This is because we used data on commonly purchased products from a nationally representative sample of households who collected data over a period of one full year. A third strength is the objective store classification criteria developed and used. These classification criteria could be modified and used in future studies.

There are some limitations of our study that should however be noted. Although the Nielsen NZ Homescan® sample is representative of New Zealand in terms of certain key household demographics and geographic locations, it is not recruited to be representative in terms of ethnicity and we did not have information of the ethnicity of the household main shopper; therefore, it is unclear whether our results reflect the household purchases of all ethnic groups in New Zealand. In addition, although we had information on the store name where purchases were made, we were not able to distinguish the actual geographic location of the store where purchases were made. Given this limitation, it is not possible to investigate purchases of healthy food by proximity of households to different store types.

One potential area for future research is to examine the household purchases or availability of sugar-sweetened beverages (SSBs) according to various store types in NZ, as this has important policy implications. It is possible to examine household purchases or the availability of SSBs by store type using the Nielsen NZ Homescan® data; however, this was

outside the scope of the present study. Household purchases or the availability of SSBs at different stores is an important research area to investigate, because SSBs is a key driver of obesity and NCDs (Keller & Bucher Della Torre, 2015), and research on household purchases or on the availability of SSBs by store type may identify areas to be targeted for policy development and priority actions in order to improve the retailer food environment, since the retailer food environment influences population diet and health (Engler-Stringer, Le, Gerrard, & Muhajarine, 2014; Glanz, Bader, & Iyer, 2012). Another area for future research is to examine household purchases or consumption of healthy food in relation to household distance to different stores and food outlets (or density of stores and food outlets) in the household neighborhoods in NZ. This is important because the only study in New Zealand which examined the associations between household intakes of fruit and vegetable products and household distance from a supermarket or convenience store used data from the 2002-3 NZ Health Survey. Apart from the potential errors in recalling dietary intakes, and the misclassification of stores (e.g. only supermarkets and convenience stores were used), the findings from the study refer to the data collected nearly 20 years ago.

### Policy and practice relevance

Our findings have the potential to inform policy, action, and practice to improve population diet and health. Policymakers, community-based organisations, and food industry may opt to use our findings to improve the availability and sales of healthy products across different store types, especially convenience stores and bakeries wherever such stores exist. Policy makers should ensure that residents have equal or better access to healthy food retailer stores through improving in-store food environments of convenience stores, bakeries and through establishing supermarkets or fruit and vegetable stores in neighborhoods where residents do not have access to healthier food retailers. In NZ, 90% of foods are purchased from supermarkets so, whilst unhealthy products may be more likely to be purchased from convenience stores and bakeries, it is important to also consider ways to make supermarket food offerings healthier. Such strategies might include greater availability and more promotions of healthier supermarket foods. Shoppers may use our findings when considering where to shop – knowing that shoppers at supermarkets, and fruit and vegetable stores may have more opportunity to purchase a greater variety of fruit, vegetables, and other healthy foods.

### Conclusion

In conclusion, in this nationally representative sample of households who purchased food from a range of stores across New Zealand over a full one-year period, it was found that the vast majority of product purchases was made from supermarkets, followed by fruit and vegetable stores, meat and fish stores, grocery stores, convenience stores, and bakeries. Households were much less likely to purchase healthy products from convenience stores, and bakeries compared with supermarkets. Given the fact that there is considerable room to improve the availability and sales of healthy food and beverage products, food policies and actions should be directed towards enhancing the availability of more healthy food options across stores, particularly convenience stores and bakeries. Since most household food purchases are from supermarkets, strategies and actions should also be directed towards improving supermarkets food environment. Such strategies might include increased availability and promotion of healthier supermarket foods. This can enable consumers to purchase more of healthy foods and beverages from all store types in New Zealand.

### Declaration of competing interest

None.

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### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmph.2021.100784>.

### Ethics application waiver

We used secondary data in this study. Therefore, an ethics application was not required.

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