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The PEAR Tool: evaluating portion sizes of food and beverages in food advertising to children using Google Street View

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Abstract

Previous research has established where and what types of advertising are in children's neighbourhoods. However, no prior research has evaluated the portion sizes in advertisements or how these compare with national dietary recommendations. This study aimed to evaluate portion sizes in advertising on bus shelters surrounding schools in Auckland, New Zealand using images captured on Google Street View. Portion sizes for 265 foods or beverages in 172 advertisements on bus shelters within 500 m of Auckland schools were analysed to determine the discrepancy with nutritional guidelines. School type, decile, distance from school boundary, Walk Score® and Transit Score were analysed. Advertised foods and beverages were exaggerated in all but one advertisement. The main findings demonstrate 1) advertised food and beverage products are enlarged, and 2) advertised portion sizes exceed those deemed appropriate in national nutrition guidelines. Stricter advertising policies with revised definitions are needed to improve the food environments surrounding schools.

Keywords Portion size, Children, Food advertising, Neighbourhood, Google Street View, Outdoor advertising, New Zealand

Background

New, larger-sized portions for a number of foods and beverages have been launched by the food industry since the late 1970s [4–6]. Between 2012 and 2016, cross-sectional surveys collecting data on fast foods sold at chain restaurants in New Zealand (NZ) demonstrated a 4.8% increase in the serving size of products; with greater than 10% increases in chicken, dessert and pizza [7]. Studies altering the front-of-pack portion size depictions on food packaging have found that exposure to larger image sizes significantly increases the amount of food poured and consumed by children [8, 9]. However, no prior research has examined how advertised portion sizes compare with national dietary recommendations.

The Advertising Standards Authority (ASA) Children and Young People's Advertising Code [10] states that advertised portion sizes should not exceed those deemed appropriate by the national nutrition guidelines, while a review of the ASA complaints system concluded that the regulatory framework is ineffective and not accountable in reducing advertisement exposure to children [11]. The Ministry of Health Nutrition Guidelines have limited reference to what an acceptable amount of high fat, sugar and salt (HFSS) foods to consume are beyond recommending children limit HFSS foods to less than one serving a week [12]. Furthermore, the Auckland Transport Advertising Policy specifies advertisements

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for HFSS products will not be permitted within 300 m of the schools [13]. In 2020, 382 (45.3%) advertisements for unhealthy foods were found on Auckland Transport-owned bus shelters within 300 m of school gates and demonstrated a breach in local advertising policy [14]. In Australia 75% of outdoor advertising promoting unhealthy foods and drinks were found within a 500 m boundary of Perth schools, a 3 km travel route of Sydney schools and 62% within a 750 m boundary of Melbourne schools [15–17]. As current advertising policies are largely voluntary, ambiguously worded and poorly enforced [11], independent research measuring the compliance of advertisements with current policy is needed to assess the effectiveness of existing policies.

Portion and serving sizes are terms which are often used interchangeably [18]. Serving sizes are standard quantities of food or drink, such as usual servings used in dietary guidance to indicate how much to eat to meet energy and nutrient requirements or those dictated on the nutrition information panels of food packaging [12]. However, the total number of servings can be consumed in several smaller or larger portions. Portion Size Estimation Aids (PSEAs) offer a practical tool that helps people to accurately estimate volumes of food and beverage servings [19–21]. PSEAs often employ a standardised fiducial marker, fixed camera set-up, reference object and serving count to quantify the estimated portion size (see Appendix A and B). The paucity of research to date assessing portion sizes in outdoor food advertising or the effect this has on dietary consumption in children may be attributable to the difficulty of accurately estimating food volumes from a singular image. The aim of this study is to develop an understanding of how portion sizes in food and beverage advertising to children in NZ compare to national dietary guidelines.

Methods

Portion size Estimation in Advertising Reckoner (PEAR) Tool

The development of the PEAR Tool was carried out from August to September 2022. The design and development work on the spreadsheet application was conducted by an external software developer in collaboration with the researchers. The base code for the PEAR Tool was written using Microsoft 365 Excel, v2207 on Windows and v16.64 on Mac, and Microsoft 365 Excel Visual Basic Applications (VBA) v7.1. In order to meet the specifications set by the research team, the PEAR Tool was built in VBA programming language, and standard functionality was used with no special add-ins. VBA functions were developed to size and compute scaled marker points overlaying the images and develop a report to apply the information to a database of food and beverage products. A comprehensive overview of the PEAR Tool can be found in Appendix C. Additionally, a short, online instructional video on how to use the PEAR Tool can be viewed by typing "*Portion size Estimation in Advertising Reckoner (PEAR) Tool Guide Demonstration*" in the search box on YouTube [22]. A copy of the food and beverage items included in the Portion Size Database can be found in Appendix D.

Bus stop advertisements

This cross-sectional observational study utilised images of food and beverage advertisements on bus shelters within a 500 m boundary of schools (n = 190) from the Auckland region captured using Google Street View (GSV) (21a and 21b).

The capture date of street view images included in this study ranged from February 2012 to October 2019.

Each advertisement image for food and beverages was manually categorised and coded based on the World Health Organisation Regional Office for Europe Nutrient Profile Model [23] as either core or non-core. Further information on the 'Bus Stops Near Schools Advertising Junk Food and Sugary Drinks' study design, sampling strategy and data collection is available elsewhere [14].

Of the 842 bus stop advertisements identified, only images categorised as food and/or beverage were eligible for inclusion. Images with data coded as unclear or no image were excluded.

Coding and data analysis

Images were coded using manual content analysis performed in Microsoft Excel by a single researcher over one week in August, 2022. Advertisements containing two or more foods or beverages were copied to create separate data points for each advertised item. Each image file was then categorised as 'core', recommended to be marketed to children, or 'non-core', not recommended to be marketed to children (see Table 1), in accordance with the previous research strategy by Huang et al. [14].

A count for how many of the same food or beverage items depicted in a single advertisement was recorded in Microsoft Excel. For example, an image depicting two Whopper Jr. burgers is recorded as a portion count of 2. The analysis of food and beverage advertisements by distance from the school boundary is illustrated in Figs. 5 and 6. Figure 5 shows that the proportion of non-core food portion sizes decreases as the distance from the school boundary increases. In contrast, Fig. 6 demonstrates that the probability of advertisements containing more than two food items increases with distance from the school boundary, although this probability remains relatively constant up to approximately 300 meters.

Table 1 Categorisation of Food and Beverages in Advertisements

Advertisement category	Examples
Food core	Yoghurt, bread, fruit and vegetables (see Fig. 1)
Food noncore	Chocolate, burger, ice cream (see Fig. 2)
Beverage core	Milk, water (see Fig. 3)
Beverage noncore	Flavoured milk, coffee, energy drinks, juice (see Fig. 4)

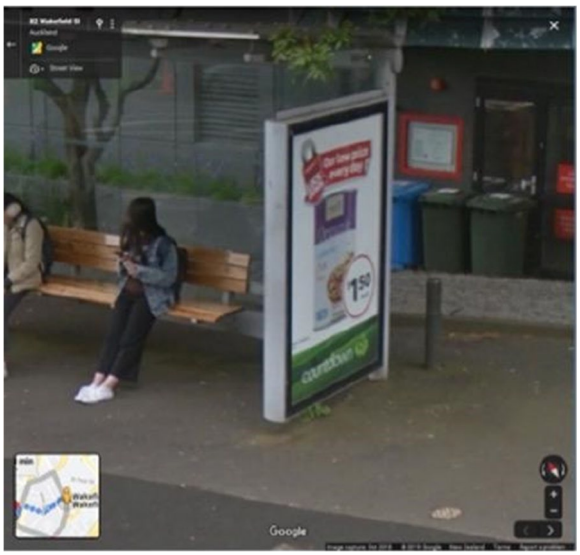

Fig. 1 Proportion of total portion size by distance from school boundary

Fig. 3 Proportion of total portion size by distance from school boundary

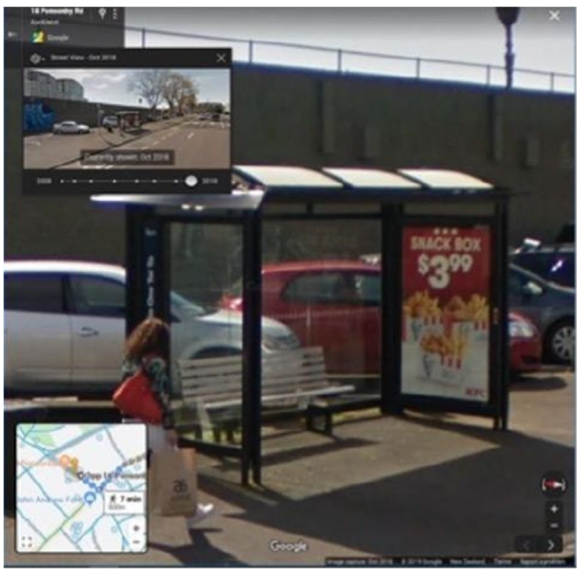

Fig. 2 Proportion of total portion size by distance from school boundary

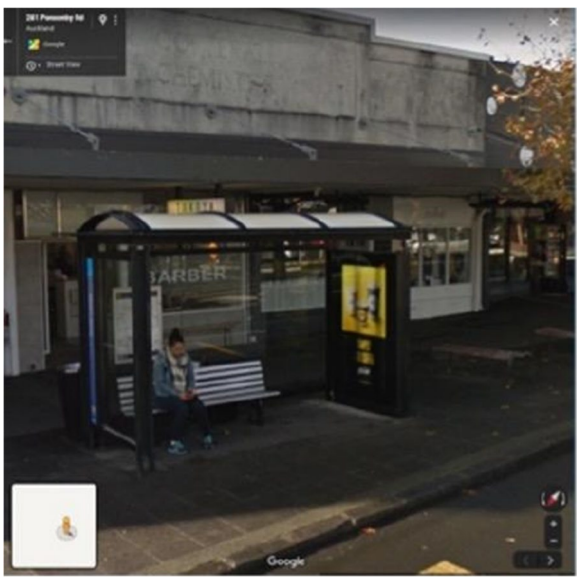

Fig. 4 Proportion of total portion size by distance from school boundary

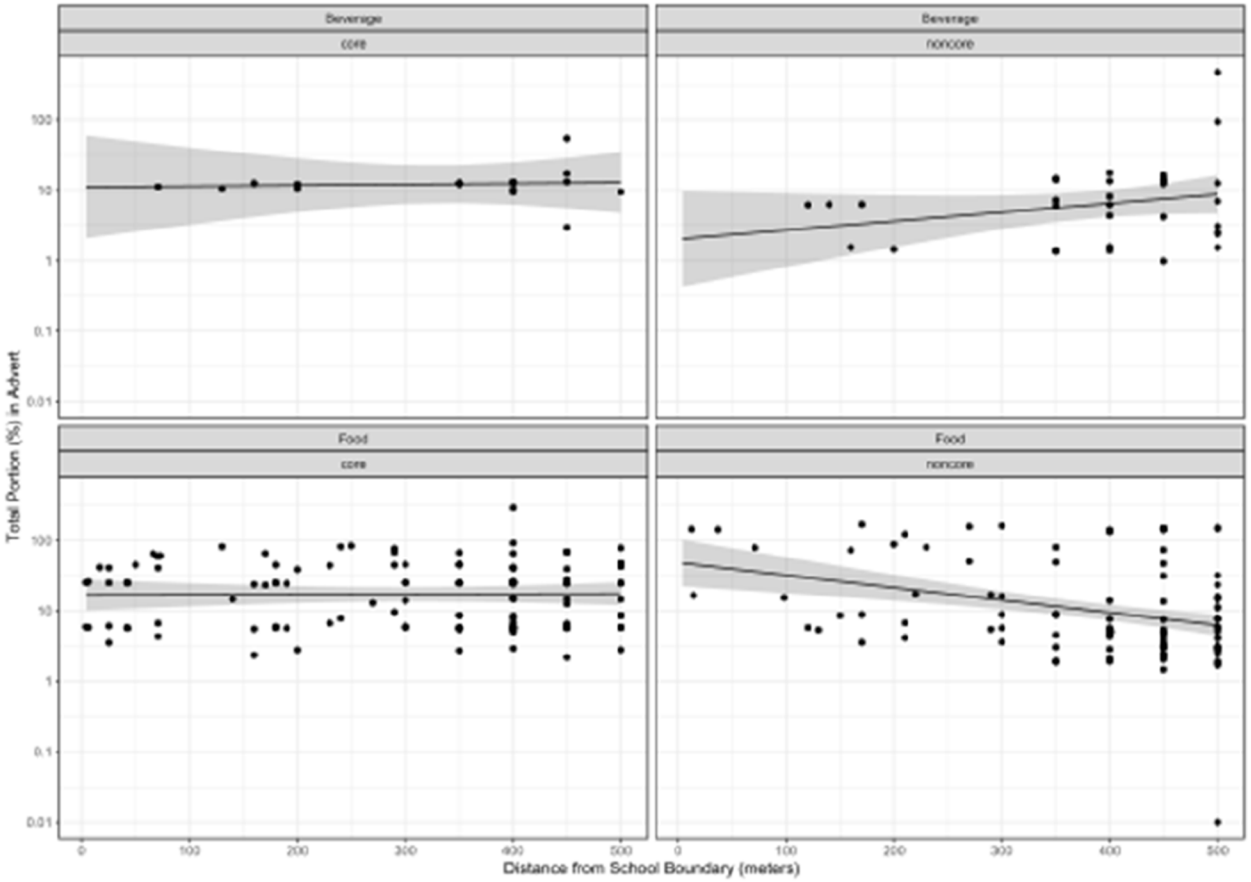

Fig. 5 Proportion of total portion size by distance from school boundary

The eligible bus stop images were then imported into the PEAR Tool as per the methods outlined in Appendix C.

As bus shelters were a common object with standardised dimensions, the reference dimensions, measured in centimetres, were used as a fiducial marker.

Each food and beverage item was collected and measured to determine the height and width of the item, as measured in centimetres. The packaged servings of food and beverages were then recorded using millilitres or grams and then compared to the number of children's guideline portions in the product serving for a range of child age brackets. As nutrient requirements vary widely between different age brackets of children under 18 years-of-age [12], an effort was made to have an option to enter different portion sizes for different age groups. Due to a paucity of recommended portion sizes for unhealthy foods and beverages, the criteria was expanded to include Australian nutrition guidelines for children and NZ nutrition guidelines for adults which resulted in six age group brackets being identified.

Two markers are overlayed over the advertisement image, one for the fiducial marker dimension and the other for the food or beverage item. The system then estimates the actual size of the food or beverage advert (in centimetres) using coded formulas to calculate the scale of the depicted fiducial marker relative to the actual fiducial marker dimensions and then applies this calculated scale to the actual food or beverage dimensions.

The number of recommended portions in the packaged servings is then multiplied by the calculated scale of the advertisement to determining the portions after image size manipulation. Second the portions after count is determined by multiplying the number of recommended portions in the packaged serving by how many of the same food or beverage item is depicted in the advertisement. Finally, the portions after image size manipulation and portions after count are multiplied to calculate the total number of portions depicted in the advertisement.

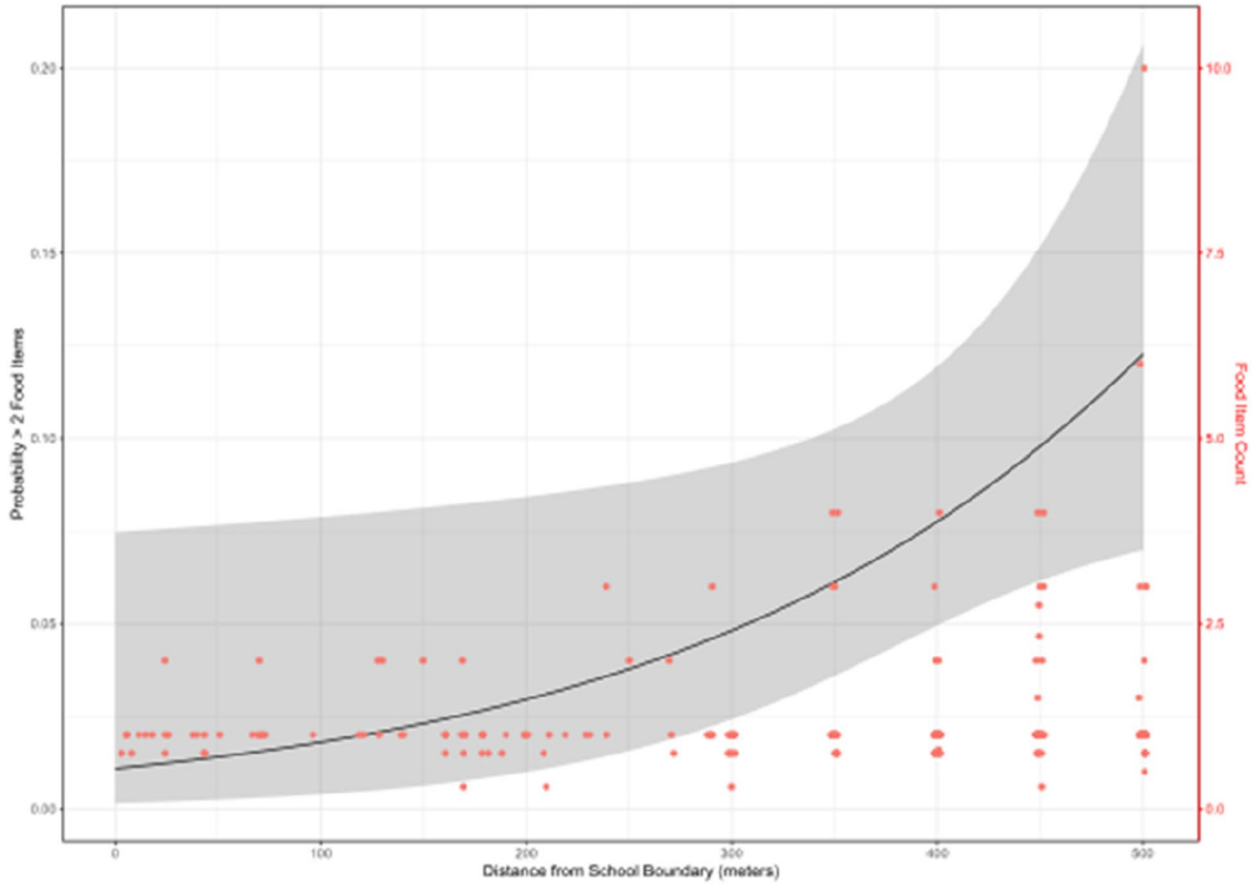

Fig. 6 Probability of food item count >2 by distance from school boundary

Statistical analysis

Data were analysed using IBM SPSS for Mac version 29 [24] and the statistical package R version 4.2.1 [25]. Descriptive statistics were used to assess the number and proportion of food and/or beverage advertisements.

Descriptive statistics were conducted to determine the mean and standard deviation of the portion size after adjusting for the manipulation to the image size, item count and total portion size depicted in advertisements across each food and beverage category. For this analysis, the portion size calculated across the six age groups, for each of the portion size variables, were averaged. This was due to the portion size for each food or beverage not being available for all age groups, subject to the available guideline recommendations.

The significance of variables was assessed using the Type II Wald chi-square test. To ensure the assumptions of homogeneity of variances and normality of residuals were met, as well as to check the dispersion parameter, the R package DHARMa was utilised [26]. For the analysis, the logarithmically transformed values of"Total portion in advert"were used to satisfy the assumptions of homogeneity of variances and normality of residuals.

Results

Of the 842 bus shelter advertisements within a 500 m walking distance of schools in the Auckland region, 211 had advertisements for food and/or beverages that could be identified. Among these, 10 (4.74%) did not include a food or beverage item, 10 (4.74%) promoted infant formula, 13 (6.16%) featured discontinued products, and 6 (2.84%) were categorized as miscellaneous. All 39 of these advertisements were excluded from analysis.

Of the 172 advertisements remaining, 13 (7.6%) of advertisements were for core beverages, 22 (12.8%) were for non-core beverages, 77 (44.8%) for core food, 58 (33.7%) for non-core food and 2 (1.1%) for non-core food and beverages. The greatest proportion of schools with advertisements within a 500 m boundary were contributing schools for students Year 0–6 ($n=65$, 37.8%), followed by full primary schools for students Year 0–8 ($n=34$, 19.8%), and then secondary schools for students Year 9–13 ($n=25$, 14.5%). 41.3% ($n=71$) were located

Table 2 Descriptive Table of Advertisement Results

		Advert	Item
		N (%)	N (%)
Food or beverage category	Beverage core	13 (7.6)	16 (6.0)
	Beverage noncore	22 (12.8)	32 (12.1)
	Food and beverage noncore	2 (1.1)	N/A***
	Food core	77 (44.8)	116 (43.8)
	Food noncore	58 (33.7)	101 (38.1)
School Type	Activity centre	2 (1.1)	2 (0.8)
	Composite	14 (8.1)	20 (7.5)
	Contributing	65 (37.8)	100 (37.7)
	Full Primary	34 (19.8)	56 (21.1)
	Intermediate	18 (10.5)	27 (10.2)
	Secondary (7–15)	7 (4.1)	12 (4.5)
	Secondary (9–15)	25 (14.5)	35 (13.3)
	Special School	7 (4.1)	13 (4.9)
Decile†	N/A*	3 (1.7)	3 (1.1)
	Low (1–3)	54 (31.4)	86 (32.5)
	Medium (4–7)	44 (25.6)	60 (22.6)
	High (8–10)	71 (41.3)	116 (43.8)
Distance from school (m)	< 100	18 (10.5)	26 (9.8)
	101–200	23 (13.4)	33 (12.5)
	201–300	20 (11.6)	32 (12.1)
	301–400	48 (27.9)	72 (27.2)
	401–500	63 (36.6)	102 (38.4)
Walk Score	1	3 (1.7)	6 (2.3)
	2	23 (13.4)	33 (12.5)
	3	53 (30.9)	85 (32.0)
	4	68 (39.5)	114 (43.0)
	5	25 (14.5)	27 (10.2)
Transit Score	N/A**	5 (2.4)	9 (3.4)
	1	0 (0.0)	0 (0.00)
	2	64 (37.5)	92 (34.7)
	3	71 (41.3)	126 (47.6)
	4	12 (7.2)	18 (6.8)
	5	20 (11.6)	20 (7.5)

† *School decile was used as a proxy for the socioeconomic status*

* *Private schools without a decile rating were coded 'N/A'*

** *Schools without a Transit Score® were coded 'N/A'*

*** *As each item in an advert were transformed into a single data point no image contained a food and beverage*

within a 500 m boundary of the high decile schools, and 31.4% located around low decile schools ($n = 54$).

It was considered important to identify the proportion of individual foods and beverages within the advertisements, as several different food or beverage items could be advertised within a single advert. A total of 265 foods or beverages were identified within the advertisements. 133 (50.2%) of all foods or beverages in advertisements were coded non-core. However, the most frequent category of foods or beverages in advertisements were for core food items (n = 116, 43.8%). Table 2 presents descriptive results of the advertisement as a whole as well as the individual food and beverages items within advertisements. The scale of distortion applied to these advertised shows that all but one of the items is exaggerated in size, with items ranging from a minimum of 0.9 (n = 1, 0.4%), to a maximum 11.7 times the original item size.

Table 3 Descriptive Table of Food and Beverage Items

	N (%)
Biscuit	1 (0.4)
Bread	2 (0.8)
Burger	11 (4.2)
Cereal	30 (11.3)
Chickpeas	4 (1.5)
Chocolate	25 (9.4)
Coffee	11 (4.2)
Condiment	26 (9.8)
Cream	2 (0.8)
Egg	3 (1.1)
Energy drink	3 (1.1)
Fizzy/soft drink	3 (1.1)
Flavoured milk	8 (3.0)
Fruit	2 (0.8)
Hot chips	11 (4.2)
Hot dog	1 (0.4)
Ice cream	3 (1.1)
Instant noodle	1 (0.4)
Juice	6 (2.3)
Milk	13 (4.9)
Potato chip	3 (1.1)
Processed chicken	17 (6.4)
Rice	3 (1.1)
Sandwich	4 (1.5)
Sports drink	2 (0.8)
Supplement	3 (1.1)
Vegetable	8 (3.0)
Yoghurt	59 (22.3)

As seen in Table 3, among the 265 advertised food and beverage items, most core foods advertised were yoghurt ($n = 59$, 22.3%) and breakfast cereals ($n = 30$, 11.3%). Plain milk was the primary core beverage advertised ($n = 13$, 4.9%). Examples of non-core foods advertised included condiments such as mayonnaise and tomato sauce ($n = 26$, 9.8%), chocolate bars ($n = 25$, 9.4%), and burgers ($n = 11$, 4.2%). The most frequent non-core beverages were coffee ($n = 11$, 4.2%); followed by flavoured milk ($n = 8$, 3.0%), energy drinks ($n = 3$, 1.1%) and soft drinks ($n = 3$, 1.1%).

Table 4 Proportion of Items in Advertisements Which Included a Count

	Number of adverisments	Portion count of food or beverage in advertisement	
Food or beverage categorisation	**N (%)**	**Mean (SD)**	***P* value**
Beverage core	1 (1.3)	1.1 (0.5)	0.010
Beverage noncore	9 (11.7)	1.4 (1.0)	
Food core	41 (53.2)	1.1 (0.5)	
Food noncore	26 (33.8)	1.3 (1.1)	
Total	77 (29.1)*	1.2 (0.9)	

Of the advertised food and beverages, 77 (29.1%) images were coded to have a count with more than one of the same item (Table 4), i.e. For Beverage noncore there were 9 images in which more than one of the products were advertised of those 9 images there was a mean portion count of 1.4 per advertisementThe mean count, for the number of the same items in an advert, was 1.2 (SD = 0.9).

Portions by advertisement categories

The mean number of portion sizes for a food or beverage in advertisements, after adjusting for the manipulation of the image size and item count, was 28.4 (SD = 47.8) times the recommendations (see Table 5).

Discussion

Quantifying the portion sizes in advertisements has allowed a comparison to be made against national dietary recommendations for children and identified breaches in current advertising policies. This allows us to build upon current knowledge describing what types and where advertisements are found in children's neighbourhoods and begin to understand the nature of the content to which children are exposed.

Advertised foods and beverages were exaggerated in all but one advertisement. This scale may have been underestimated; as the largest unit size for each item was selected when there were no distinguishable features among the available units to choose from to demonstrate that even when the largest unit size is selected, the degree of distortion is still high. As individuals are likely to regard an item as one portion, even when the size of a food item increases [27], marketing messages whereby appropriate amounts of food products are larger than reality are passively accepted into an individual's beliefs [28]. Furthermore, as per previous research, the depiction of product volumes may be outweighed by the effect of larger product image sizes on the amount of food served and consumed by an individual [8, 9]. When candies were served in their original form or cut in two, the total amount consumed remained equal but cutting the candy significantly lowered energy intake [29]. Results from McGale et al. [9], show that 63% of children perceived the product packaging to display an appropriate portion size; despite the depicted servings containing three times the recommended servings. To aid the promotion of realistic portion size, advertisements may benefit from a requirement to include something of known size for reference, such as a person's hand, cutlery or utensils.

In NZ children's environmenst promote portion sizes larger than those set out in dietary recommendations. The results from this study may be subject to under and over-estimation when comparing distinct food and beverage items. For example, comparisons were made between items such as a jar of mayonnaise, which is unlikely to be consumed in one sitting, to items that come in a predetermined amount, such as a burger or an orange. Our results are much larger than the findings from a study conducted in The USA, where the average depicted serving size on cereal packaging was 65.26%

Table 5 Mean Number of Recommended Portion Sizes in an Advertised Food or Beverage

Mean (SD)						
Food or beverage categorisation	**Portion after image manipulation[1]**	**P value**	**Portion after count[2]**	***P* value**	**Portion total[3]**	***P* value**
Beverage core	11.8 (3.4)	< 0.001	5.4 (3.3)	< 0.001	14.1 (11.1)	< 0.001
Beverage noncore	22.7 (84.0)		7.9 (24.2)		24.4 (83.7)	
Food core	35.5 (44.1)		8.6 (14.1)		28.5 (33.5)	
Food noncore	34.4 (59.2)		5.9 (8.9)		31.8 (50.2)	
Total	32.1 (55.2)		7.3 (13.7)		28.4 (47.8)	

[1] *Number of recommended portions in the packaged servings multiplied by the scale of the advertisement*

[2] *Number of recommended portions in the packaged servings multiplied by how many of the same food/beverage items are in the advertisement*

[3] *Portions after image size manipulation multiplied by the portions after item count*

greater than the average suggested serving size on the nutrition panel . This discrepancy may be accounted for by the depiction of a single food item and the product packaging as the primary advertising medium. Portion sizes in this study for tomato sauce, mayonnaise, soft drinks, energy drinks and sports drinks were evaluated using guidelines for adults [30, 31]. Thus, there is no ambiguity that the advertised portions of advertisements relative to the recommendations for adults would exceed the recommended portions for a child. Exposure to enlarged images on food packaging has been shown to have a positive association with children's purchasing and consumption of the advertised product [8, 9, 32].

This study is important for informing effective policy-making as it reinforces the need for researchers to understand both the nature and extent of unhealthy food advertising. Furthermore, demonstrating a breach in the compliance of NZ children's exposure to advertisements can be used to support policymakers to ensure depicted portion sizes better match the recommended portion sizes set out in national guidelines to positively influence nutrition behaviours and health in children.

This study is the first to analyse the nature of portion sizes in advertising and has highlighted opportunities to strengthen policies to promote healthy food environments in places commonly frequented by children. Previous research has demonstrated that self-regulated advertising has done little to reduce children's exposure to food and beverage advertisements [33–35]. Non-compliance with the current advertising codes and ineffective reviewing of advertisements by the ASA may be in part due to the lack of quantifiable portion size recommendations for occasional food and beverages in the Ministry of Health Nutrition Guidelines [12]. Current policy definitions and criteria need to be strengthened for a clearer assessment of how the principles are to be interpreted and applied. Policies can be further strengthened by integrating clear and convincing consequences for policy breaches beyond removing inappropriate advertisements. South Korea has implemented a minimum $10,000 fine for displaying broadcast, radio or internet advertisements for unhealthy food and beverages [36]. Removing unhealthy food and drink advertising targeted to children in public spaces provides an opportunity to use these spaces and occupy these spaces with more enriching elements such as artwork on public transport structures. There are future research opportunities to explore the nature of advertising in more locations, such as parks and playgrounds or other regions in NZ, which may aid in the overall aim to create healthier environments for children to live, learn and play. There is also a future research opportunity to apply the PEAR Tool to alternative advertising mediums captured in previous research such as billboards, posters or in-store adverts [1–3]. When combined with literature linking portion distortion on food packaging to consumption our finding suggests that exaggerated portion sizes in advertising may contribute to unhealthy dietary habits population-wide, and the development of nutrition-related diseases [8, 9]. When exposed to manipulations of image size on front-of-pack cereal advertising, larger image sizes have been found to influence self-served consumption [8]. Tal et al. found the depictions were 65.26% greater than the nutrition information panel serving sizes and resulted in a 17.8% increase in cereal served. This acceptance of image sizes depicting an appropriate portion size has the potential to transfer to larger image size manipulations, such as those in outdoor advertising.

The novelty of this study is the primary strength of this research, as it aids understanding how portion sizes are depicted in outdoor advertising. This is the first step in evaluating the portion sizes of outdoor advertisements. As a pilot study, conclusions on the effectiveness of the PEAR Tool for evaluating portion sizes in advertising cannot be drawn. However, it is hoped that the data provided has offered a feasible approach to future research on larger samples and more diverse advertising mediums.

GSV has proved to be a useful time and cost-effective tool [2, 3, 14, 37] as it reduces the need to travel in person to collect data in large geographically dispersed samples, it also offers a logistically convenient method to enable multi-city and international comparisons. GSV utilises freely available data without the need for costly software or equipment, such as wearable cameras. GSV images in our study date back to 2012, with one advertising company replacing all advertising structures on bus shelters resulting in the same dimensions being applied to all advertising images. A lack of updated data may also overlook changes to the portion sizes or types of food and beverages being advertised over the last decade. Furthermore, advertised products are subject to temporal patterns and vary seasonally. For example, adverts over easter could be expected to advertise more confectionery. This poses a barrier to evaluating change brought about by policy, especially in areas where GSV data are infrequently updated.

The exposure of children to food advertisements is likely to be underestimated following the exclusion of several products which have been discontinued or a lack of appropriate nutritional guidelines to perform portion size comparisons. Limitations are also associated with the exclusions caused by the poor image

quality, size and presence of buses or people partially blocking advertisements [37]. It is anticipated that the accuracy of the data derived from GSV will improve as technology advances and more image quality capabilities are added to the service. Due to time constraints, only advertisements on bus stops were included in this research which is likely to under-represent the frequency and nature of advertising children are actually exposed to in other advertising mediums. A final limitation of the current study is a lack of participants and exposure data following the use of screenshot images.

Conclusions

The PEAR Tool is the first of its kind to estimate portion sizes in advertising images captured using GSV and on bus stops near schools. The application of this tool has demonstrated that advertised food and beverage items are largely exaggerated, and depicted portion sizes exceed those set out in national dietary guidelines for children. The need for stricter enforcement and revised definitions in national and local advertising policies for children was highlighted. Future research should assess whether exaggerated portion sizes in public advertising influence children's dietary behaviours.

Abbreviations

GSV	Google Street View
NZ	New Zealand
ASA	Advertising Standards Authority
AIC	Akaike information criterion
PEAR	Portion size Estimation in Advertising Reckoner
VBA	Visual Basic Application
SD	Standard Deviation
HFSS	High Fat Sugar and Salt
PSEAs	Portion Size Estimation Aids

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-23452-2.

Supplementary Material 1.

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Authors' contributions

Conceptualization, J.P and V.E.; methodology, J.P. and V.E; software, J.P. and B.V.D.W.; formal analysis, B.V.D.W. and J.P; writing—original draft preparation, J.P.; writing—review and editing, V.E. and R.R.; supervision, V.E. and R.R. All authors have read and agreed to the published version of the manuscript.

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Data availability

The data presented in this study are available on request from the corresponding author. The data are not publicly available due to potential commercial sensitivity, but may but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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