ABSTRACT

Background: There are few objective data on how nutrition labels are used in real-world shopping situations, or how they affect dietary choices and patterns.

Design: The Starlight study was a four-week randomised, controlled trial of the effects of three different types of nutrition labels on consumer food purchases: Traffic Light Labels, Health Star Rating labels, or Nutrition Information Panels (control). Smartphone technology allowed participants to scan barcodes of packaged foods and receive randomly allocated labels on their phone screen, and to record their food purchases. The study app therefore provided objectively recorded data on label viewing behaviour and food purchases over a four-week period. A post-hoc analysis of trial data was undertaken to assess frequency of label use, label use by food group, and association between label use and the healthiness of packaged food products purchased.

Results: Over the four-week intervention, study participants (n=1,255) viewed nutrition labels for and/or purchased 66,915 barcoded packaged products. Labels were viewed for 23% of all purchased products, with decreasing frequency over time. Shoppers were most likely to view labels for convenience foods, cereals, snack foods, bread and bakery products, and oils. They were least likely to view labels for sugar and honey products, eggs, fish, fruit and vegetables, and meat. Products for which participants viewed the label and subsequently purchased the product during the same shopping episode were significantly healthier than products where labels were viewed but the product was not subsequently purchased: mean difference in nutrient profile score -0.90 (95% CI -1.54 to -0.26).

Conclusions: In a secondary analysis of a nutrition labelling intervention trial, there was a significant association between label use and the healthiness of products purchased. Nutrition label use may therefore lead to healthier food purchases.

KEYWORDS

Nutrition, labelling, diet, behaviour, nutrient profile

BACKGROUND

Nutrition labels provide point-of-purchase information on the nutritional content of pre-packaged foods. Labelling information is commonly found on the back of food packages (e.g. nutrient lists) but may also be present on the front-of-pack (e.g. symbols). Nutrition labels may be either interpretive in nature i.e. where colours or symbols are used to improve consumer understanding of the label information, or non-interpretive where quantitative nutrient data are provided without any interpretation.

A systematic review of 120 studies found that self-reported prevalence of nutrition label use was typically greater than 50%.[1] However, in-store research suggests that actual label use is typically much less, with just 27% of UK shoppers found to have looked at nutrition information on the label during observational research undertaken in supermarket aisles.[2]

Reviews of research on consumer response to nutrition labels highlight that there is little information on how such labels are used in real-life shopping situations, or how they affect dietary choices and patterns.[3] Eye-tracking studies have been used to gain insight into how shoppers use labels in the real world but, due to the intrusive nature of the tracking devices, studies are typically laboratory-based and short-term.[4,5] Therefore, little information exists on the use of nutrition labels in the real world over longer periods.

The New Zealand Starlight study was a four-week randomised, controlled trial of the effects of interpretive versus non-interpretive nutrition labels on consumer food purchases.[6] Because it was not possible to apply nutrition labels to food packages in randomly allocated supermarkets, we approximated a real-world labelling intervention by using a customised smartphone application (app) to deliver randomly allocated interpretive nutrition labels directly to consumers. Smartphone technology allowed participants to scan barcodes of any packaged food or non-alcoholic beverage (hereinafter referred to as “foods”) in any grocery store and receive allocated labels on their phone screen, and to record their food purchases. Although study participants viewed nutrition labels via the app rather than on-pack, the study provided unique, objectively recorded data on label information viewing behaviour and food purchases over a four-week period.

This paper reports the results of a post-hoc exploratory analysis of recorded label information viewing behaviour and associated packaged food purchases of study participants over the four-week intervention period. Specific research questions were: (1) How frequently were labels viewed? (2) Did label use vary by food group? (3) Was there an association between label use and the healthiness of food products?

METHODS

The Starlight trial evaluated the effects of different nutrition label formats on consumer food purchases.[6] Between October 2014 and November 2015, 1,357 household shoppers across New Zealand who owned smartphones (iOS or Android) and were aged 18 years or older were enrolled in the study. Full details of recruitment methods have been published previously.[7] Participants were randomly assigned (1:1:1) to receive either Traffic Light Labels (TLL),[8] Health Star Rating labels (HSR),[9] or a non-interpretive, control label (Nutrition Information Panel (NIP)) via their smartphone.

A customised study smartphone application (app) enabled conduct of a fully automated smartphone-delivered intervention trial. App functionality has been described in detail elsewhere,[10] and included eligibility screening, collection of informed consent, questionnaire administration, randomization, intervention delivery (nutrition labels), and outcome data collection (food purchases). The labelling intervention and food purchase data collection both used smartphone camera technology, where the phone camera was used to scan the barcode of a packaged food and link it with its corresponding nutrient composition in a food composition database. In intervention delivery mode, nutrition labels were displayed for scanned products if matched successfully with an existing product in the database (the match rate was approximately 70%). In data collection mode, scanned products were recorded in an electronic food purchase list for outcome assessment. All recorded data were transmitted via Wi-Fi or 3G/4G to the trial database which was hosted on a secure remote server. Study participants also submitted photographs and hard copies of their grocery till receipts, which were used to supplement scanned purchase data. However only scanned data (with barcodes) could be linked to the brand-specific food composition database, thus all food purchase data reported in the main study analysis[6] and used for the current analysis were scanned via the app.

The primary outcome of the Starlight trial was the average healthiness of all packaged food purchases over the four-week study intervention period, measured using Food Standards Australia New Zealand Nutrient Profiling Scoring Calculator (NPSC).[11] NPSC scores are calculated by allocating baseline points for levels of risk-associated nutrients in a food (energy, saturated fat, total sugars and sodium); V points based on content of fruits, vegetables, nuts and legumes; protein points (P points); and, in some cases, fibre points (F points). A final score is derived using the formula: baseline points – (V points) – (P points) – (F points). Lower scores indicate a better nutrient profile.

The study protocol was approved by the University of Auckland Human Participants Ethics Committee (reference number 011390), and was published in 2014.[12] The trial was registered on the Australian New Zealand Clinical Trials Registry (ACTRN12614000644662). All participants provided informed consent. The main trial results were published in 2017.[6]

Since the main trial analysis found no difference in label use or healthiness of food purchases by label intervention group,[6] data from all three label intervention groups were combined for this analysis. Trial participants who scanned at least one product label and/or purchased at least one packaged food or non-alcoholic beverage over the four-week study intervention period were included. Demographic characteristics of eligible participants were summarised using descriptive statistics. Continuous variables were described as means (standard deviation (SD)) and medians (interquartile range (IQR)). Categorical variables were described as frequencies and percentages.

For each shopping episode defined by date (of a product scan) recorded in the study app database, unique products with label views were matched to products purchased on the same day (if any). If a label was scanned more than once or if more than one of the same product was purchased in the same shopping episode, duplicate label views or purchases were excluded. The frequency of label viewing and product purchases were summarised by food group, and mean NPSC scores were calculated and compared using paired t-tests. A generalised linear mixed model was used to estimate the probability of label use by food group (irrespective of whether the product was subsequently purchased or not), adjusting for study week and repeated shopping episodes (correlated data) for each participant. Odds ratios (OR) and 95% confidence intervals (CI) were estimated. Given the ethnic inequalities in burden of diet-related disease in New Zealand,[13,14] subgroup analyses by ethnicity (Maori or Pacific shoppers versus other shoppers) were also conducted to test consistency of findings between ethnic groups. Statistical analyses were performed in SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). All statistical tests were two-sided at 5% significance level. Due to the exploratory nature of the analysis, missing data were not imputed and no adjustment was made for multiple testing.

RESULTS

Of the full sample of randomised trial participants (n=1,357), 1,255 met the inclusion criteria for the current analysis (92.5%). Participants included in this analysis had a mean age of 33 (SD 9) years, 88% were female, and 67% were tertiary educated. There were no significant differences between these participants and the full trial sample for any measured baseline characteristic.[6]

Over the four-week study intervention period, participants viewed labels for and/or purchased a total of 66,915 barcoded packaged products (excluding duplicate products scanned/purchased during the same shopping episode). A total of 56,670 products were purchased over four weeks, of which labels were viewed for 12,944 (23%) during the same shopping episode. Labels were viewed for 23,189 products overall, of which 56% (n=12,944) were purchased during the same shopping episode (**Table 1**).

Shoppers of Maori and Pacific ethnicity viewed the labels of products they had purchased slightly more often than other shoppers (labels viewed for 25% of purchased products, versus 22%, $p<.0001$), but were somewhat less likely to purchase products following label viewing (53% of viewed products were purchased, versus 57% of non-viewed, $p<.0001$). However, findings should be considered with caution given the relatively small number of Maori and Pacific shoppers (n=390, 23% sample).

Table 1. Numbers of products purchased or for which a label was viewed

	Product purchased		
	No	Yes	Total

Label viewed			
No	-	43,726	43,726
Yes	10,245	12,944	23,189
Total	10,245	56,670	66,915

Table footnote: - = not applicable as the study app database only captured scanned products for which a label was viewed or the product was purchased

Frequency of label viewing

Over the four-week intervention period, labels were viewed a mean of 18 (SD 20) times. Label viewing frequency decreased over time from a mean of eight (SD 8) views per week in week 1 to four (SD 7) views in week 4. The distribution of label use was left skewed however, and median label views were 12 over the four-week period (interquartile range [IQR] 5-24), with a similar reduction in frequency of label viewing over time from a median of five views per week (IQR 2-11) in week 1 to just one view (IQR 0-5) in week 4.

Label use by food group

Frequency analysis of the total 23,189 products for which labels were viewed showed that the food groups people viewed labels most often for were: dairy (17.3% total views), bread and bakery (16.3%), packaged fruit and vegetables (13.1%), cereals (11.9%) and sauces and spreads (8.2%) (**Table 2**).

Table 2. Number and proportion of packaged food and non-alcoholic beverage products for which label information was viewed

Packaged food group	**Number of products for which label information was viewed (n=23,189)**	**%**
Dairy	4,004	17.3
Bread and bakery	3,784	16.3
Fruit and vegetables	3,034	13.1
Cereals	2,751	11.9
Sauces and spreads	1,896	8.2
Non-alcoholic beverages	1,553	6.7
Snack foods	1,514	6.5
Meat and meat products	1,032	4.5
Confectionery	971	4.2
Oils	734	3.2
Convenience foods*	544	2.4
Fish and seafood	521	2.3
Eggs	415	1.8
Sugar, honey and related products	331	1.4
Special foods±	105	0.5

**Convenience foods include meal kits, other frozen foods, pizza, pre-prepared salads and sandwiches, ready meals, and soups. They differ from snack foods in being meal-based options*

±Special foods include diet products, baby foods, vitamins, and sports supplements

Purchases by food group were similar to label viewing patterns in terms of ranked order and proportional contributions to total purchases. Food groups purchased most often (irrespective of label viewing behaviour) were dairy (17.2% total purchases), bread and bakery (15.5% purchases), packaged fruit and vegetables (13.8%), cereals (11.3%) and sauces and spreads (8.1%).

The probability of label use by shoppers according to food group was examined with confectionery as the referent group because we hypothesised that people are less likely to use labels for ‘treat’ foods like confectionery. The hypothesis was supported by the data which showed that shoppers were least likely to check nutrition label information for confectionery. Compared with the reference, shoppers were significantly more likely to view labels for products (irrespective of whether they purchased them or not) in the following five groups: convenience foods (OR 1.25, 95% CI 1.05 to 1.49, p=0.014), cereals (OR 1.23, 95% CI 1.09 to 1.38, p=0.001), snack foods (OR 1.22, 95% CI 1.08 to 1.37, p=0.001), bread and bakery products (OR 1.21, 95% CI 1.08 to 1.37, p=0.002), and oils (OR 1.19, 95% CI 1.03 to 1.37, p=0.019) (**Figure 1**).

Figure 1. Probability of nutrition label use by shoppers according to food group during a 4-week intervention trial

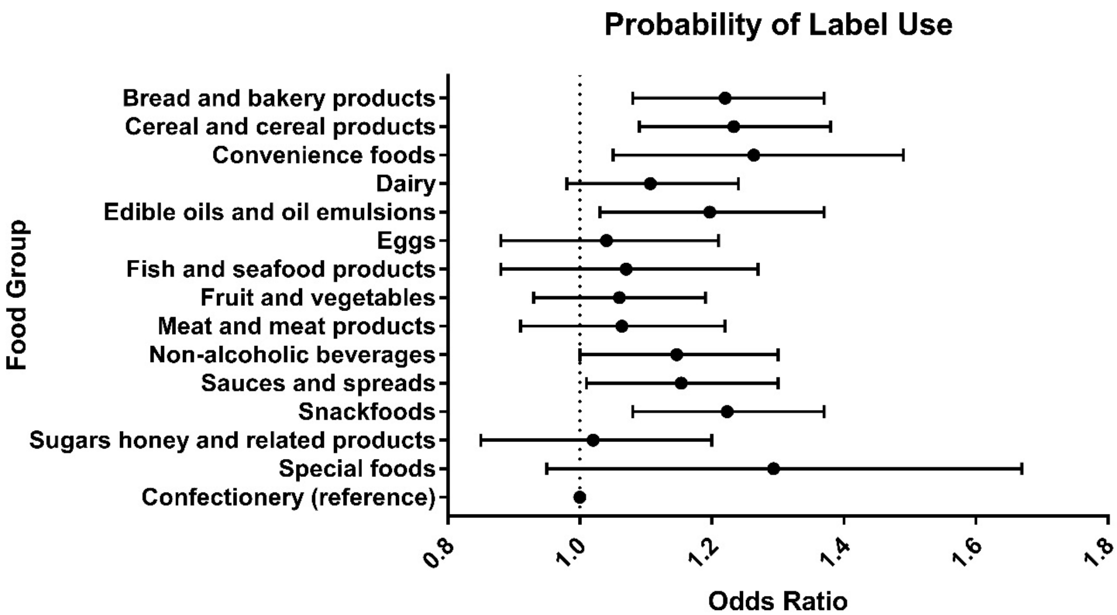

Figure footnote: Probability of label use by shoppers according to food group (irrespective of whether a product was purchased or not) was tested using a generalised linear mixed model. Circles represent odds ratio of label use compared with the reference group, confectionery, and horizontal lines represent 95% CIs.

Association of nutrition label use with nutrient profile (healthiness) of foods

NPSC scores for packaged foods available for sale in New Zealand supermarkets range from approximately -17 (most healthy) to +53 (least healthy).[15] The mean NPSC score for all products purchased in our analysis was 6.75 (SD 3.51) (**Table 2**). Products for which participants viewed labels had a significantly healthier (lower) mean NPSC score than purchased products overall (mean difference -0.35 (95% CI -1.61 to -0.09), 5.2%) (**Table 2**). Furthermore, products for which participants viewed the label and subsequently purchased the same product during the same shopping episode were significantly healthier than products where labels were viewed, but the product was not subsequently purchased (mean difference -0.90 (95% CI -1.54 to -0.26), 12.8%). Although association of label use with nutrient profile varied somewhat by ethnicity (Table 2), differences were not statistically significant.

Table 2. Association of nutrition label use with product nutrient profile

	All Products (Viewed or Purchased)			**Products for which Label was Viewed**		
NPSC score*	Nutrition label viewed, mean (SD)	All product purchases, mean (SD)	Difference, mean (95% CI)	Label viewed and product purchased, mean (SD)	Label viewed and product not purchased, mean (SD)	Difference, mean (95% CI)

All shoppers	6.43 (4.88)	6.75 (3.51)	-0.35 (-0.61, -0.09)[#]	6.18 (5.88)	7.02 (7.24)	-0.90 (-1.54, -0.26)[#]
Maori or Pacific shoppers	7.17 (5.09)	7.18 (3.31)	-0.10 (-0.69, 0.49)	6.99 (6.30)	7.12 (7.05)	-0.47 (-1.81, 0.88)
Other shoppers	6.21 (4.79)	6.62 (3.56)	-0.42 (-0.71, -0.13)[#]	5.95 (5.74)	6.99 (7.31)	-1.03 (-1.76, -0.30)[#]

*Table Footnote: *NPSC = Nutrient Profiling Scoring Calculator. Lower score = healthier product.*

[#] P <0.01

DISCUSSION

This post-hoc analysis of a randomised, controlled nutrition labelling intervention trial showed that label information was viewed for approximately one fifth of all purchased packaged products. Shoppers were most likely to view labelling information for convenience foods, cereals, snack foods, breads, and oils. Furthermore, products for which participants viewed the label information and subsequently bought the same product during the same shopping episode were significantly healthier than products where label was viewed but the product was not then purchased.

Systematic reviews highlight that much research has been undertaken on consumer understanding and self-reported use of labels, but little on how they are actually used and influence food choices.[1,3] In recent years, positive evaluations of the Guiding Stars and NuVal labelling programmes have been published,[16,17] but the results of evaluations of other front-of-pack labelling systems have been less encouraging.[6,18,19] However, previous studies were either limited to a small number of specific food categories or they combined all food category data together. This analysis therefore extends the field by examining and reporting on label use by food group and by investigating the association between label use and the healthiness of products subsequently purchased by shoppers.

To our knowledge, this is the only published analysis of objectively measured nutrition label information use in real-world settings over a medium-term period (four weeks). Strengths include the large number of study participants who contributed data, and objective measures of both nutrition label use and food purchases. The labelling feature on the app could be used for all barcoded, packaged foods in any grocery store across the entire country, thus approximating the availability of packaged food labels in the real world if implemented widely.

Some limitations should be considered however. This was a post-hoc, exploratory analysis of data collected during a RCT. The RCT study population included high proportions of individuals who self-rated their diet at baseline as healthy, had good self-rated knowledge of nutrition, higher education, and reported interest in healthy eating. The population may not therefore be representative of a general population with less healthy diets, nor of individuals with health conditions that respond to dietary change. A further potential limitation was the medium of intervention delivery (smartphone app). The aim of the Starlight trial was to simulate the effects of labels on real world consumer purchases. However, the app may have acted as a barrier between consumers and label reading because of the burden involved in scanning, viewing and comparing products using the app compared with use of on-pack information. It is therefore possible that consumers used the app to check labels less frequently than they would have used on-pack labels, particularly in the case of the control group since the control label (Nutrition Information Panel) was already present on-pack. Conversely it is possible that the app enabled consumers to check labels more frequently than if labels were on-pack, particularly given that front-of-pack labelling schemes are typically voluntary and often present only on a limited number of packaged foods.

Implications for research and policy

There is significant potential to collect continuous, objectively measured, data on nutrition label use via smartphone apps. Whilst the current analysis used app data from an RCT on label viewing and food purchasing behaviour, there are apps with similar labelling features and functionality (e.g. FoodSwitch)[20] which offer exciting potential to undertake large-scale continuous analysis of label viewing behaviour by app users in the general population.

Labels were viewed for a moderate proportion of food purchases (between one fifth and one quarter) made by study participants over a four-week period. Although frequency of label use may have been different in this RCT context than in the general population, and declined over time (e.g. because motivation to use the app decreased, or because participants learned the nutrition information of commonly purchased items after scanning them once), the finding nevertheless suggests that nutrition labels are used for a reasonable proportion of food purchases. There are many factors that influence decision to purchase foods including price, taste and convenience;[21] nevertheless our research suggests that label viewing may also influence healthier food purchases, with products where shoppers viewed the label and subsequently purchased the same product being significantly healthier than products where labels were viewed but the product was not subsequently purchased (the mean difference in NPSC score of 0.90 was equivalent to an overall difference in nutrient profile of about 13%).

Our work also provides clear guidance on the food groups that shoppers are most likely to use nutrition labels for. In common with previous research (generally self-reported or undertaken in controlled settings)[2-4] shoppers in our study were most likely to use labels for foods groups where nutrition composition is heterogeneous and frequently ambiguous (e.g. convenience foods, breakfast cereals, snack foods, and bread), and least likely to use them for food groups where nutrition composition is homogeneous and products are recognised as generally more easily classified as either ‘unhealthy’ (e.g. confectionery and sugar) or ‘healthy’ (e.g. fish, fruit and vegetables, and eggs). To enhance consumer understanding of the composition of packaged foods and promote healthier food choices, specific attention should be paid to the most frequently viewed food groups when implementing nutrition labelling schemes, particularly voluntary labelling systems which may be displayed selectively by industry on only certain products.

Conclusion

This secondary analysis of a nutrition labelling intervention trial showed that labels were viewed for about one fifth of all food purchases made over a four-week period, but frequency of use decreased over time. Shoppers were most likely to view labels on packaged foods where nutrition composition is heterogeneous and ambiguous. There was a significant positive association between label use and healthiness of products purchased, which suggests that nutrition labels may influence healthier food purchases by those consumers who choose to use them.

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CONFLICT OF INTEREST STATEMENTS

Cliona Ni Mhurchu is a member of the New Zealand Health Star Rating Advisory Group. The New Zealand Health Star Rating Advisory Group had no role in in study design, data collection and analysis, decision to publish, or preparation of the manuscript. The remaining authors have no conflicts of interest to declare.

AUTHOR CONTRIBUTIONS

CNM formulated the idea for the analysis and had leadership responsibility for the Starlight trial planning and execution; YJ performed the statistical analyses of the study data; CNM wrote the paper and had primary responsibility for final content. All authors provided critical review and commentary on the draft manuscript, and approved the final manuscript.

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