



Children's exposure to alcohol marketing within supermarkets: An objective analysis using GPS technology and wearable cameras



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ABSTRACT

Background and aim: Exposure to alcohol marketing within alcohol retailers has been associated with higher rates of childhood drinking, brand recognition, and marketing recall. This study aimed to objectively measure children's everyday exposure to alcohol marketing within supermarkets.

Method: Children aged 11–13 ($n = 167$) each wore a wearable camera and GPS device for four consecutive days. Micro-spatial analyses were used to examine exposures within supermarkets.

Results: In alcohol retailing supermarkets ($n = 30$), children encountered alcohol marketing on 85% of their visits ($n = 78$). Alcohol marketing was frequently near everyday goods (bread and milk) or entrance/exit.

Conclusion: Alcohol sales in supermarkets should be banned in order to protect children from alcohol marketing.

1. Introduction

Early onset drinking is linked with a range of adverse physiological, physical and social outcomes (Babor et al., 2010). Globally, almost half (46%) of children and young adults aged 15–19 report drinking alcohol in their lifetime (World Health Organization, 2014), with an average monthly occurrence of heavy episode drinking (HED) of 12% in this group (World Health Organization, 2014). In New Zealand (NZ), over half (57%) of children (as defined by the United Nations Convention on the Rights of the Child, <18 y (Unicef, 2014)) aged 15–17 had consumed alcohol in the past 12 months, with a 7.8% (95%CI 5.0–12.4) with an Alcohol Use Disorders Identification Test score 8 points or over (Ministry of Health, 2016). Exposure to alcohol marketing is positively related to consumption, particularly in children (Babor et al., 2010). Multiple systematic reviews of longitudinal studies have concluded that exposure to alcohol marketing increases the likelihood children will begin drinking and increases consumption in those children already drinking (Anderson et al., 2009; Smith and Foxcroft, 2009; Jernigan et al., 2016).

Supermarkets account for 30% of all beer and 60% of all wine sales in NZ, despite only making up 3% of alcohol retailers (McEwan et al., 2010). In contrast to other jurisdictions, NZ supermarkets are only allowed to sell beer, wine and mead and thus the sale of spirits or spirit-based drinks are not permitted for sale. In the supermarket

environment, sales promotions are one of the most prominent marketing tactics employed, particularly for alcohol (Pettigrew et al., 2015). The primary function of sales promotions is to stimulate demand through product displays, contests, price discounts and free tastings (Pettigrew et al., 2015). Supermarkets permitted to sell alcohol use large refrigerated areas with stacks of beer and signs that promote the prices and brands of the alcohol. US evidence suggests that children's exposure to alcohol marketing in alcohol retailers predicts their ability to list beer brands, match brands with slogans and name products in masked beer advertisements (Collins et al., 2003). Similar evidence in Australia showed children exposed to on-site marketing at alcohol retailers were more likely to start drinking earlier (OR 1.49, 95%CI 1.04–2.14) (Jones and Magee, 2011). A longitudinal study of 12–14 year old students from the US found that non-drinkers at baseline exposed to sales promotions at alcohol retailers were 42% more likely to use alcohol when they were aged 14–15 years (Ellickson et al., 2005). Another cross-sectional US study demonstrated that children exposed to on-site advertising at alcohol retailers at least once per week were 50% more likely to have consumed alcohol than children less frequently exposed (Hurtz et al., 2007).

One mechanism by which on-site alcohol marketing influences child non-drinkers to consume alcohol is by its conflation with everyday consumer goods sold at supermarkets, or the normalization of

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alcohol (Ellickson et al., 2005). The conflation is exacerbated by the alcohol industry adopting promotional tactics similar to those used to market general products to portray alcohol as an ordinary commodity (Pettigrew et al., 2015). Alcohol marketing in supermarkets may normalise alcohol as one of the thousands of consumer products children observe on a daily basis, increasing positive drinking expectancies and alcohol consumption in children. Children's conflation of alcohol with everyday consumer goods sold at supermarkets may help explain why the association between alcohol retailers and childhood drinking has been stronger in younger children (Ellickson et al., 2005; Hurtz et al., 2007), despite evidence that they rarely attempt to or actually, acquire alcohol from formal sources such as supermarkets (Rowland et al., 2014).

Alcohol is permitted for sale in supermarkets, smaller grocery stores, dedicated liquor stores and on-licence premises (such as bars and pubs) in NZ (*The Sale and Supply of Liquor Act, 2012*), unlike Australia and some US States which do not permit alcohol sales in supermarkets (Jones, 2010; Delaware State Government, 2017; Alaska State Government, 2017). In 2012, NZ implemented the Sale and Supply of Alcohol Act (SSAA) (replacing the 1989 Sale of Liquor Act) which specified that “the sale, supply, and consumption of alcohol should be undertaken safely and responsibly; and the harm caused by the excessive or inappropriate consumption of alcohol should be minimised.” (*The Sale and Supply of Liquor Act, 2012*, p19). While primarily concerned with limiting the proliferation of alcohol retailers, sections 112–114 of the SSAA sought to limit the exposure of shoppers in supermarkets and grocery stores to displays and promotions of alcohol, and advertisements for alcohol (*The Sale and Supply of Liquor Act, 2012*). These sections require supermarkets to have a single, designated alcohol sales area that is not on the most direct path from the entrance to the checkout. The SSAA provisions provided supermarket owners with grace periods between 3 and 18 months to bring their stores into compliance with the different sections of the SSAA (*The Sale and Supply of Liquor Act, 2012*).

Determining the precise spatial location of the exposure, particularly within supermarkets, provides a set of challenges for exposure studies. Global Positioning Satellite (GPS) technology can provide information on the precise location of the exposure of interest as well as person's movement patterns. However, GPS data used in isolation tends to have a large amount of measurement error when participants are indoors and is therefore unreliable. Consequently, Geographic Information System (GIS) data models have largely treated geographical features such as buildings as indivisible entities without internal partitions or subunits (Lee and Kwan, 2005). In response, there is increasing interest in the development of research methodology for analysing smaller geographical units, particularly indoor spaces (Lee et al., 2017). One approach has been micro-spatial analysis that uses GIS data (e.g. information of building blueprints or supermarket floorplans) to break down smaller geographical units such as homes or buildings into small spatial units (Lee and Kwan, 2005). Micro-spatial analysis enables a greater understanding of people's movements and behaviour within indoor structures. Recently, micro-spatial analyses have examined building population distributions (Lwin and Murayama, 2009), route analysis in university buildings (Lee et al., 2017), and emergency management and response in buildings (Lee and Kwan, 2014). Therefore, micro-spatial analyses offer a promising methodology for investigating the relationship between smaller spatial units and health related behaviours.

Measuring exposure to alcohol marketing at alcohol retailers has often relied on self-report methods, which are prone to measurement error. Wearable cameras are a novel tool to potentially overcome the bias inherent in previous exposure measurements. Wearable cameras have been deployed to study a range of health behaviours (Doherty et al., 2013; Kerr et al., 2013; Oliver et al., 2013; Barr et al., 2015). The images collected from wearable cameras have been used as an objective measure of children's exposure to food marketing (Signal et al., 2017).

This current research used wearable cameras to objectively measure children's exposure to alcohol marketing within supermarkets.

The aim of this research was to objectively measure NZ children's everyday exposure to alcohol marketing within supermarkets using image and GPS data. Specifically, it sought to: 1) examine children's alcohol marketing exposures during visits to supermarkets; 2) conduct micro-spatial analyses to examine children's alcohol marketing exposures within supermarkets i) with low and high rates of exposure to alcohol marketing per supermarket visit, and ii) before and after the implementation of the 2012 Sale and Supply of Alcohol Act (SSAA).

2. Method

2.1. Study design: Kids'Cam

The current analysis of alcohol marketing is nested in a larger cross-sectional observational study of the world in which children live and their interaction with it, called Kids'Cam. Kids'Cam participants were randomly selected children aged 11–13 years ($n = 168$) from 16 randomly selected schools in the Wellington region of New Zealand. Each child was instructed to wear a wearable camera (Autographer <http://www.autographer.com>) and GPS unit (Qstarz BT-Q1300ST Sports Recorder) every waking hour over one four-day period (Thursday to Sunday) between July 2014 and June 2015. The camera captured a 136° image approximately every seven seconds, and the GPS unit captured latitude and longitude every five seconds. Information on the Kids'Cam study design, sampling strategy and sample characteristics has been published elsewhere (Signal et al., 2017).

2.2. Data processing

2.2.1. Content analysis of alcohol marketing in images

Content analysis was used to code image data for alcohol marketing exposures. This current study used the World Health Organization definition of marketing: “Any form of commercial communication or message that is designed to, or has the effect of, increasing the recognition, appeal and/or consumption of particular products and services. It comprises anything that acts to advertise or otherwise promote a product or service” (World Health Organization, 2012, p.9). As such, all forms of commercial communication including labelling, signs and product displays were classified as marketing. Customised software developed by Dublin City University for Kids'Cam enabled tags to be assigned to image data, more information on the software is detailed elsewhere (Signal et al., 2017). Image data were coded for two types of alcohol marketing exposures. An alcohol marketing exposure was coded when the participant was inside the supermarket premises and was exposed to any form of alcohol marketing where > 50% of the brand or promotion was visible (Gee et al., 2013). Colours and shapes of the product counted towards the 50% criteria and are identifiable features of the product's marketing (Gee et al., 2013). A particular exposure was only coded once in a sequence of images of the same marketing item (that is, until the brand was no longer seen for a minimum of three consecutive images). In total approximately 700,000 images (approximately 1400 observation hours) captured in non-school time were coded through content analysis.

2.2.2. Imputing missing GPS data

To compensate for missing GPS data (e.g., when the unit ran out of battery or lost signal), a mixed imputation method was developed and implemented. The imputation method used a Python script to automatically impute points based on spatial and temporal parameters. Next, image data was used to validate the imputation process and impute additional points that were outside the scope of the automated process. In total, 23% of the final dataset GPS points were imputed through this method. More information on the imputation methods used can be requested from the corresponding author.

After imputation, however, some GPS data for supermarket visits were still missing. Data were manually imputed for these locations based on identifiable information in the images. Once an identifiable feature of a supermarket was observed, such as the supermarket name or nearby businesses, *Google Maps* was used to obtain the latitude and longitude coordinates of the premise where the alcohol marketing exposure occurred.

2.3. Identifying visits to supermarkets selling alcohol

2.3.1. Geocoding supermarkets and identifying participant visits and exposures

The registry of alcohol retailers in NZ in February 2015 was obtained from the Ministry of Justice (MoJ) and Wellington retailers were geocoded using R 3.2.4 (R Institute, Vienna, ggmap Institute, Vienna, ggmap). The geocoding process was validated using *Google Earth* for a sample of 30 alcohol retailers. Alcohol retailers classified as 'supermarket' or 'grocery store' by the MoJ registry in Wellington were included in the dataset ($n = 86$, 10% of all retailers). All image data coded as 'supermarket' or 'convenience store' were then linked with GPS data and spatially joined with alcohol retailers in ArcGIS 10.4 (ESRI, Redlands, CA). Individual visits were defined by the first image when the participant entered the supermarket to the last image in which the participant was inside the supermarket. The specific supermarket visited was validated manually using the image data and *Google Maps* to determine that the visit had been assigned to the correct supermarket. Marketing exposures were mapped using linked GPS data and then spatially joined to geocoded supermarkets.

2.4. Micro-analysis of exposures

2.4.1. Selecting supermarkets for micro-spatial analyses

To investigate the reasons for children's exposure to alcohol marketing at some supermarkets and not others we first selected two supermarkets for comparison, one with no exposures and one with a high number of exposures. We chose the supermarket with the most visits with no exposures (Supermarket A; four visits, zero exposures) and a supermarket with a similar number of visits with a high number of exposures (Supermarket B; six visits, with exposure on 100% of visits). Both supermarkets were from the same chain brand and located in the same territorial authority (Wellington City). To investigate the impact of the 2012 SSAA, we chose the supermarket with the most visits, and noticeable changes to its layout and promotion of alcohol as a result of the SSAA, that is, store alterations made midway through data collection (Supermarket C; 16 visits, with exposure on 100% of visits). Due to the flexible timeline for implementation of the SSAA, this was the only supermarket that had enough data to confirm changes had been made during the study period to comply with the act and was purposely selected as a case study of the SSAA's effectiveness.

2.4.2. Mapping the micro-spatial supermarket environment

Image data were used to reconstruct the floor plans of the supermarkets, which were used later to trace participants' movements within the store. In one case, participants did not go far enough into the store to reveal its entire floor plan. In this case, the supermarket was visited by a researcher, and the floor plan was recorded manually. Systematic recording involved noting the placement of aisles and the types of products sold. The height of shelving was also recorded to account for the three-dimensional nature of the floor plan. The raw data were then entered into *SketchUp* (Trimble Inc, Sunnyvale, CA). The floor plan was exported from *SketchUp* as a .jpeg and imported into ArcGIS 10.4.

2.4.3. Mapping children's movement within the micro-spatial supermarket environment

A child's journey through the supermarket was recorded as a line segment in ArcGIS 10.4 over the floor plan. Once all visits to the

supermarket were entered, varying line density was used to show differences in the intensity of time spent in each area within the supermarket. The location of alcohol marketing observed by children was added as point data. The number of times individual alcohol marketing was observed, the participant number, and the viewpoint location of the child were all recorded.

2.5. Ethical approval

The University of Otago Human Ethics Committee (Health) (13/220) granted ethical approval to study any aspect of the world children live in and their interaction with it. Written consent was obtained from the participating schools, children and their parents.

2.6. Statistical analysis

The proportion of visits with at least one exposure to alcohol marketing was calculated (with 95% confidence intervals) using data from all children who visited a supermarket. Exposure rates for supermarkets were calculated by dividing the total number of marketing exposures at a supermarket by the total number of visits to that location. Exposure rates for each piece of alcohol marketing captured and used in the analysis of pre- and post-legislation conditions were calculated in Stata v14 (StataCorp, College Station, TX) using Poisson regression. Individual marketing exposure rates are presented as mean rates per visit (with 95%CI, Poisson regression). Comparisons between pre- and post-legislation conditions were calculated using Poisson regression and are presented as rate ratios (with 95%CI). All analysis accounted for the complex sampling strategy.

3. Results

For the current study, all but one of the 168 study participants had observation time for non-school time ($n = 167$). Sociodemographic information for participating children is presented in Table 1. Most children were 12 years old (76%: mean = 12.6 years, SD = 0.5) with approximately equal numbers of girls and boys (52.7% female). The lower part of Table 1 shows the location and school decile rating for participating schools. The school decile rating is a socioeconomic measure determined by the Ministry of Education (Ministry of Education, 2014). There were approximately equal numbers of schools recruited across the Wellington region and in the lowest and highest decile ratings. Fewer medium decile schools were recruited resulting in

Table 1
Sociodemographic and other characteristics of participants and schools.

Sociodemographic variable	Group	N (%)
Child participants (total n = 167)		
Ethnicity	NZ European	66 (40)
	Māori	60 (36)
	Pacific	41 (25)
School deprivation decile	Low (1–3)	62 (37)
	Medium (4–7)	54 (32)
	High (8–10)	51 (31)
Age (years) ^a	11	13 (8)
	12	122 (76)
	13	25 (16)
	14	1 (1)
Gender	Female	88 (53)
	Male	79 (47)
School details (n = 16)	Wellington	6 (38)
	Porirua	6 (38)
Location	Hutt Valley	4 (25)
	Low (1–3)	7 (44)
School deprivation decile	Medium (4–7)	3 (19)
	High (8–10)	6 (38)

^a Missing 5 values for age.

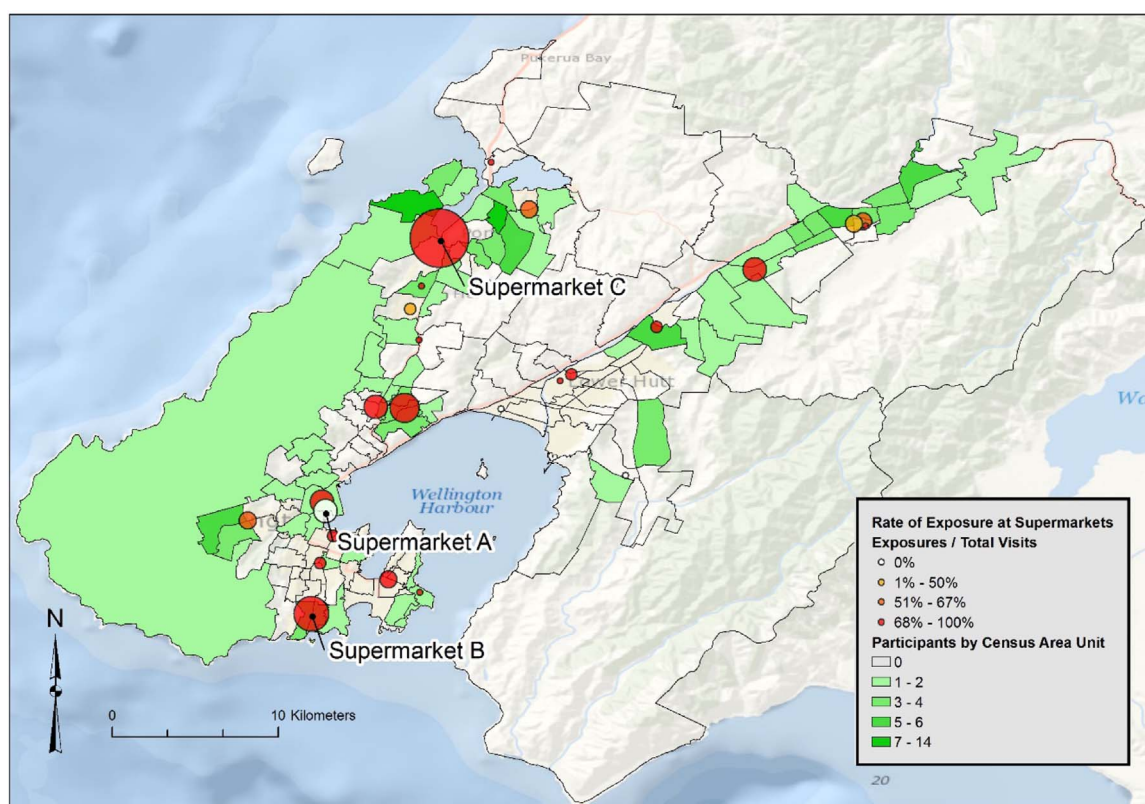


Fig. 1. Rate of exposure to alcohol marketing at Wellington regional supermarkets, showing the location of supermarkets used in micro-analysis. (For interpretation of the references to color in this figure, the reader is referred to the web version of this article.)

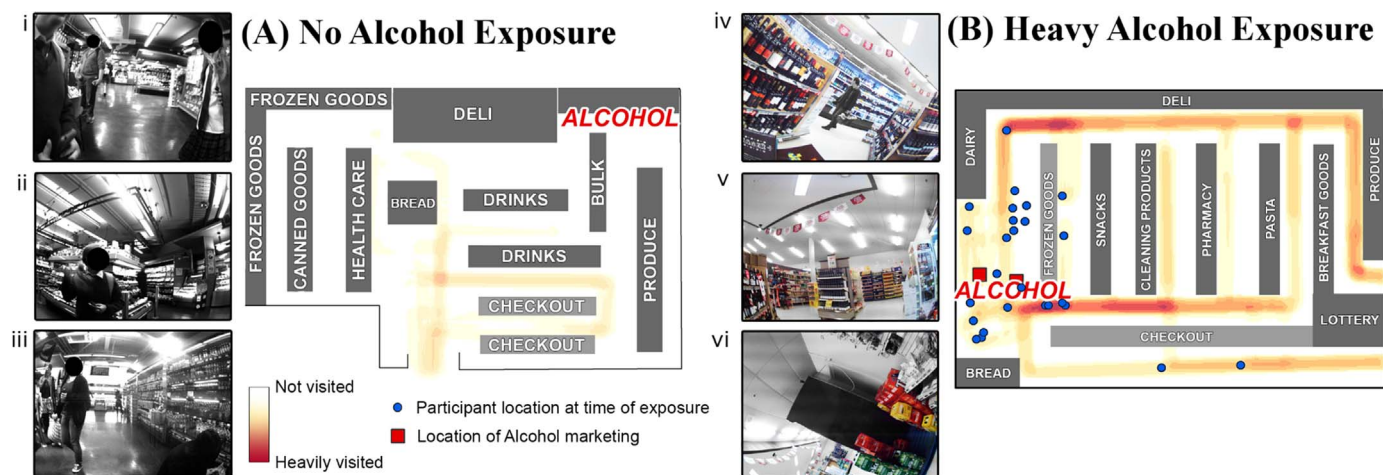


Fig. 2. Micro-spatial analysis of supermarket with 0% alcohol marketing exposure rate (supermarket A, four visits, 0 exposures) and a supermarket with an exposure rate of 100% (supermarket B, six visits, exposure on every visit).

more children being recruited from the participating medium decile schools than high and low decile participating schools.

3.1. Marketing exposures at supermarkets

Of the study sample, 56 children (34% of total sample) made at least one visit to a supermarket. Of the 56 children making trips to supermarkets, 51 (91% of children making visits) were exposed to alcohol marketing. The 56 children who visited a supermarket made a total of 78 visits to 30 different alcohol-retailing supermarkets. On 68 of the 78 visits (87%, 95%CI 78.3–93.3) children were exposed to alcohol marketing. Children were supervised by an adult when exposed

on 52 of the 68 exposures at supermarkets (76%, 95%CI 65.3–85.4). The number of visits to each supermarket is represented in Fig. 1 by the size of the points. The geographic distribution of children's visits and exposures was relatively consistent across the study area and reflected the spatial distribution of children's residences. Children made the most visits to Wellington City supermarkets ($n = 38$) and were exposed to alcohol marketing on almost all (with alcohol exposures on 84% of visits; 95%CI 70.0–93.3) of these visits, followed by Porirua City ($n = 22$ visits: with alcohol exposures on 95% of visits; 95%CI 79.6–99.8) and Hutt City ($n = 18$ visits: with alcohol exposures on 72% of visits; 95%CI 48.7–89.0). The three supermarkets in which the children had nil marketing exposures (0% exposure rate) are represented in white.

In contrast, children had a marketing exposure on every visit (100% exposure rate) in 63.3% of supermarkets visited (95%CI 45.2–79.0), and are represented in red.

3.2. Marketing exposures at supermarkets: micro-spatial analysis

3.2.1. Comparison of high versus low exposure supermarkets

Two supermarkets were purposively chosen to explore the reasons for different rates of exposure to alcohol marketing in one supermarket than another. Supermarket A had four visits and no exposures, whereas Supermarket B had six visits and had an exposure on every trip. Children spent much less time in Supermarket A than Supermarket B, as represented by the boldness of the red hot spots in Fig. 2. Further, children in Supermarket A never ventured past the aisles closest to the entry/exit. Children in Supermarket B travelled extensively throughout the supermarket, covering all but one aisle (cleaning products) on their visits. Children were often standing in the dairy sections or near the checkout when exposed to alcohol marketing in Supermarket B. Having the alcohol section in the far corner of the supermarket and away from the checkout reduced exposure in Supermarket A. In Supermarket B the alcohol area was close to the express checkouts and en route to other commonly visited areas (bread & stationery) which made exposure to alcohol marketing more likely.

3.2.2. Legislative effects of the 2012 Sale and Supply of Alcohol Act (SSAA)

Changes to the location and promotion of alcohol occurred at Supermarket C in the middle of the study period, as a consequence of the enactment of the 2012 SSAA in NZ. A total of 11 visits were made to Supermarket C before, and five after, the changes were made. Fig. 3 shows the two major changes: (i) the removal of the entire liquor store and its associated marketing (Henry's Liquor) from the entrance of the supermarket, and (ii) the establishment of a dedicated alcohol area for the promotion and sale of alcohol.

The marketing exposure rate and total number of exposures per visit and exposures by marketing type pre- and post-legislation implementation are presented in Table 2. In both pre- and post-legislative implementation, children had a marketing exposure on every visit to the supermarket (100% exposure rate). The mean rate of marketing exposures per visit increased after the introduction of the legislation from 4.8 (95%CI 3.2–7.2) to 5.0 (95%CI 3.1–7.9) per visit (rate ratio 1.03, 95%CI 0.60–1.82). These results show the legislation made no significant impact on the frequency of children's exposure to alcohol marketing in this case study. Prior to legislative changes, the alcohol marketing associated with the in-supermarket liquor store was the most prevalent exposure (100% exposure rate; mean 2.9 (95%CI

1.9–4.3) exposures per visit). The second most prevalent exposure was to a promotional banner stationed on the wall above the alcohol area (81% exposure rate; mean, 1.1 (95%CI 0.6–2.2) exposures per visit) that could be seen from as far as the back left corner of the store. After the legislative change, the promotional banner became the predominant marketing exposure (100% exposure rate; mean, 3.6 (95%CI 2.7–5.0) exposures per visit). The banner's proximity to the checkout and height at which it was stationed resulted in many children being exposed as they moved through the supermarket. In fact, the children were rarely standing in the alcohol area when exposed to alcohol marketing; rather they were in nearby areas of interest. This result highlights the weaknesses of a single designated alcohol area, as children do not need to enter the area to be exposed to its associated marketing. There were no statistically significant differences in the frequency of exposure to the primary alcohol area, aisle displays, liquor store marketing or total exposure between pre- and post- legislation conditions. Children were three times more likely to be exposed to the promotion banner after legislative implementation (rate ratio 3.20, 95%CI 1.66–6.19).

4. Discussion

To our knowledge, this is the first study to objectively investigate children's exposure to alcohol marketing at supermarkets using wearable camera technology and GPS devices. Children in this study were exposed to alcohol marketing on almost all (84.6%, 95%CI 75.3–91.4) of their visits to supermarkets that sold alcohol. In over half of the supermarkets (63.3%, 95%CI 45.2–79.0), children were exposed to alcohol marketing on every visit. Children were unsupervised on 24% of their visits to supermarkets when they were exposed to alcohol marketing. A result that suggests children are not simply following their guardians through the alcohol area. In supermarkets where children were not exposed to alcohol marketing ($n = 3$), alcohol areas were located in the back of the store and away from the checkout area. Further, nil exposure was reliant on children spending less time within supermarkets and/or only visiting the aisles closest to the entrance/exit of the supermarket. In a case study within this research, changes to the promotional environment for alcohol Supermarket C enforced by the 2012 SSAA did not alter the rate of children's exposure to alcohol advertising in the supermarket selected for analysis.

The use of wearable cameras enabled unprecedented access to children's worlds, recording their interactions with supermarket environments and alcohol marketing in real time. As such, the image data overcame weaknesses in other studies that rely on self-report data, which are subject to recall bias (Pettigrew et al., 2015), particularly as much marketing works on a sub-conscious level. Moreover, wearable

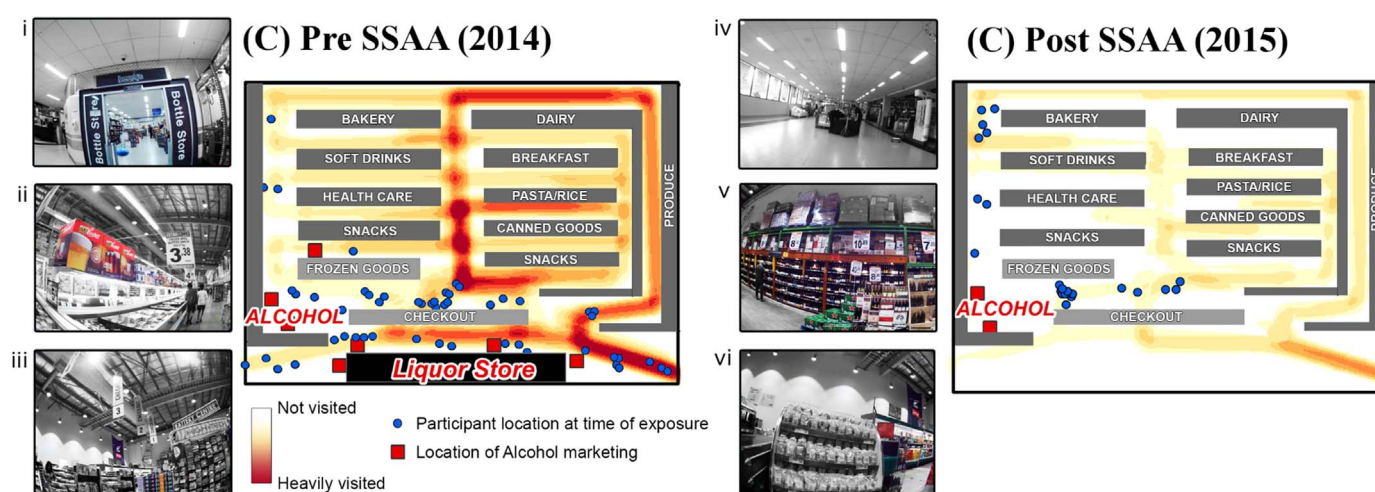


Fig. 3. Micro-spatial analysis of visits to supermarket C pre- and post- legislation implementation of the 2012 Sale and Supply of Alcohol Act.

Table 2

Micro-spatial analysis of alcohol marketing exposures at supermarkets pre- and post- 2012 Sale and Supply of Alcohol Act (SSAA) legislation implementation, mean rate (per visit, with 95%CI, from Poisson regression) of exposure to alcohol marketing.

Exposure variables	Supermarket C Pre SSAA Legislation (2014)	Supermarket C Post SSAA Legislation (2015)	Rate ratio (95%CI)
Visits	11	5	
Number of visits exposed to alcohol marketing	11	5	
<u>Marketing exposures</u> (mean rate per visit, 95%CI)			
Liquor Store exterior signage	2.9 (1.9–4.3)	0 (0–0)	0
Beer Brand Flag	1.1 (0.6–2.2)	3.6 (2.7–5.0)	3.20 (1.66–6.19)
Alcohol Area	0.6 (0.3–1.3)	1.3 (0.5–3.5)	2.15 (0.72–6.46)
Aisle displays	0.2 (0.04–0.8)	0 (0–0)	0
Total marketing exposures	4.8 (3.2–7.2)	5.0 (3.1–7.9)	1.03 (0.60–1.82)

cameras were also able to provide information used to impute missing GPS data and to map out the 3D nature of the indoor environment of the supermarket. The micro-spatial analysis used a combination of image data and GIS, providing a novel way of determining both reasons for children's exposure to alcohol marketing at supermarkets and the effectiveness (or lack thereof) of legislative change.

While the research provides objective evidence for children's exposure to alcohol marketing within supermarkets, it has some limitations. The study was limited to supermarkets in cities in the Wellington region, and therefore the results may not be widely generalizable. This is pertinent as, in NZ, local licensing trusts are permitted monopoly rights to the off-licence supply of alcohol that enables them to change the promotional environment within supermarkets. For example, supermarket sales of alcohol are not permitted in Waitakere (West Auckland) due to licensing trusts having exclusive rights to sell alcohol in the region (Auckland City Council, 2017). The study results are limited by the conservative coding criteria used in the content analysis. Some exposures were not coded if the images contained less than 50% of the alcohol brand or promotional material. It is likely we underestimated the total exposure to alcohol marketing under these criteria. Finally, the sample used in this study was relatively small and the inferential statistics conducted produced results with large confidence intervals. Consequently, the observed results may be underpowered to detect any significant differences between the pre- and post-legislative conditions. However, no exposure is acceptable if children are to be protected from the pervasive effects of alcohol marketing and the associated adverse health outcomes (Anderson et al., 2009; Smith and Foxcroft, 2009; Jernigan et al., 2016).

In future, research should explore incorporating an alcohol outcome measure (preferably consumption) in a longitudinal study design to add weight to existing evidence of the association between on-site alcohol marketing and drinking behaviour or expectancies. Longitudinal studies have specifically examined the link between exposure to on-site alcohol marketing, like that in this current research, and childhood drinking (Jones and Magee, 2011; Ellickson et al., 2005), but have been subject to the measurement bias from self-report data. Within a longitudinal design, it would be useful to have a larger geographic sample to compare areas in New Zealand where licensing trusts have monopoly rights and alcohol is not sold in supermarkets to examine the effects of reduced exposure on consumption. Finally, a larger sample may lend itself to examining possible differences by sociodemographic characteristics as well as provide more power to the statistical analysis.

The high exposure of children to alcohol marketing within supermarkets, combined with evidence that exposure to alcohol marketing at alcohol retailers is associated with alcohol use (Jones and Magee, 2011; Ellickson et al., 2005; Hurtz et al., 2007) and increased knowledge of alcohol brands and slogans (Collins et al., 2003) highlights a need for further regulation of alcohol marketing within supermarkets. In our case study, the 2012 SSAA did not protect children from exposure to

alcohol marketing. Alcohol sales and associated marketing are already banned in supermarkets in Australia (Jones and Magee, 2011), and in many states in the US (Delaware State Government, 2017; Alaska State Government, 2017; Pennsylvania Liquor Control Board, 2017). In response, Australian supermarket chains own off-licence alcohol retailers that are built into or located very close to the supermarket store. This phenomenon was observed in Supermarket C before the legislative changes with an external liquor store (Henry's Liquor) built into the supermarket. It should be noted that the children in this study were never exposed to alcohol at dedicated liquor retailers. A finding suggests that parents may avoid such retailers when supervising children. In New Zealand, supermarkets were not permitted to sell alcohol until the liberalisation of the alcohol laws with the Sale of Liquor Act 1989 (New Zealand Law Commission, 2010). Improving the supermarket promotional environment by repealing the section of the 2012 SSAA that permits supermarket alcohol sales would both significantly reduce children's total exposure to alcohol marketing, and reduce the prevalence of other supermarket-based alcohol-related infractions that are or have been, regularly in media headlines, such as underage sales (Groenestein, 2016), loss-leading alcohol sales (Newton, 2010) and cross-promotional activities (Wardle and Chang, 2015). However, such an approach has challenges, none as prominent as those posed by the alcohol industry whose legal challenges have hindered public health goals and the objectives of the SSAA. Yet a recent high court decision against the alcohol industry does provide optimism for the future as long as significant legislative change can be implemented (Broughton, 2015). In addition to effective legislation, a shift in public priorities away from convenience, typical of supermarket sales, towards reducing harm to young people and society is required.

5. Conclusion

In this study, children were exposed to alcohol marketing on nearly every occasion they visited an alcohol-retailing supermarket in the Wellington region. In a case study within this research, the current 2012 SSAA was ineffective at preventing children's exposure to alcohol marketing at supermarkets. Policy action is required to create healthier environments for our children, which may also have positive health outcomes for the adult population. Banning alcohol sales in supermarkets appears to be the only way to prevent such exposure. It is also feasible given that, in NZ, alcohol sales in supermarkets were prohibited in the past and restrictions have been successfully implemented in a number of other countries. Micro-spatial analysis using image data from wearable cameras was a unique methodological approach that provided an objective account of children's actual exposure to alcohol marketing. This methodological approach could help inform similar studies investigating similar scales of analysis such as supermarkets, convenience stores and public spaces, informing research on a range of public health issues that previously were unquantifiable or relied on less robust measurements.

Declaration of interests

There are no conflicts of interest to declare.

Author contributions

LS MS, MB, JS, ALP, CNM conceived and developed the Kids'Cam study and LS, MS MB and TC collected the data. ALP and TC conceived of the current study. TC drafted the tables, map and manuscript. TC led spatial and content analyses, in collaboration with ALP. TC conducted statistical analyses, in collaboration with JS. All authors edited and approved the manuscript.

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References

- Alaska State Government. Title 04. Alcoholic beverages [cited 2017 May 4]. Available from: <http://www.legis.state.ak.us/basis/folioproxy.asp?Url=http://www.jnu01.legis.state.ak.us/cgi-bin/folioisadll/statxt14/query=alcohol/doc/t289?>
- Anderson, P., De Bruijn, A., Angus, K., Gordon, R., Hastings, G., 2009. Impact of alcohol advertising and media exposure on adolescent alcohol use: a systematic review of longitudinal studies. *Alcohol Alcohol* 44 (3), 229–243. <http://dx.doi.org/10.1093/alcalc/agn115>.
- Auckland City Council, 2017. Alcohol [cited 2017 27 March]. Available from: <http://www.aucklandcouncil.govt.nz/EN/licencesregulations/alcohol/alcoholpolicies/Pages/licensingtrustsinwestauckland.aspx>.
- Babor, T., Raul, C., Sally, C., Griffith, E., Norman, G., Kathryn, G., et al., 2010. *Alcohol: No Ordinary Commodity Research and Public Policy*. Oxford University Press, Oxford (UK).
- Barr, M., Signal, L., Jenkin, G., Smith, M., 2015. Capturing exposures: using automated cameras to document environmental determinants of obesity. *Health Promot. Int.* 30 (1), 56–63. <http://dx.doi.org/10.1093/heapro/dau089>.
- Broughton, C., 2015. High court ruling limits supermarkets' booze displays stuff.co.nz. stuff.co.nz [cited 2017 13 June]. Available from: <http://www.stuff.co.nz/national/health/73913133/high-court-ruling-limits-supermarkets-booze-displays>.
- Collins, R.L., Schell, T., Ellickson, P.L., Mccaffrey, D., 2003. Predictors of beer advertising awareness among eighth graders. *Addiction* 98 (9), 1297–1306.
- Delaware State Government. Title 4 Alcoholic liquors Chapter 7. Regulatory provisions [cited 2017 May 4]. Available from: <http://delcode.delaware.gov/title4/c007/>.
- Doherty, A.R., Kelly, P., Marshall, S., Oliver, M., Badland, H., et al., 2013. Using wearable cameras to categorise type and context of accelerometer-identified episodes of physical activity. *Int. J. Behav. Nutr. Phys. Act* 10 (22.10), 1186 <http://www.ijbnpa.org/content/10/1/22>.
- Ellickson, P.L., Collins, R.L., Hambarsoomian, K., Mccaffrey, D.F., 2005. Does alcohol advertising promote adolescent drinking? Results from a longitudinal assessment. *Addiction* 100 (2), 235–246. <http://dx.doi.org/10.1111/j.1360-0443.2005.00974.x>.
- Gee, S., Jackson, S.J., Sam, M.P., 2013. The Culture of Alcohol Promotion and Consumption at Major Sports Events in New Zealand. Health Promotion Agency, Wellington (NZ).
- Groenestein, C., 2016. No alcohol sales at either of Hawera's supermarkets for five days. Stuff.co.nz. [cited 2017 May 4]. Available from: <http://www.stuff.co.nz/business/85901222/no-alcohol-sales-at-either-of-haweras-supermarkets-for-five-days>.
- Hurtz, S.Q., Henriksen, L., Wang, Y., Feighery, E.C., Fortmann, S.P., 2007. The relationship between exposure to alcohol advertising in stores, owning alcohol promotional items, and adolescent alcohol use. *Alcohol Alcohol* 42 (2), 143–149. <http://dx.doi.org/10.1093/alcalc/agl119>.
- Jernigan, D., Noel, J., Landon, J., Thornton, N., Lobstein, T., 2016. Alcohol marketing and youth alcohol consumption: a systematic review of longitudinal studies published since 2008. *Addiction*. <http://dx.doi.org/10.1111/add.13591>.
- Jones, S.C., 2010. When does alcohol sponsorship of sport become sports sponsorship of alcohol? A case study of developments in sport in Australia. *Int. J. Sports Mark. Spons.* 11 (3), 250–261.
- Jones, S.C., Magee, C.A., 2011. Exposure to alcohol advertising and alcohol consumption among Australian adolescents. *Alcohol Alcohol* 46 (5), 630–637. <http://dx.doi.org/10.1093/alcalc/agr080>.
- Kerr, J., Marshall, S.J., Godbole, S., Chen, J., Legge, A., Doherty, A.R., et al., 2013. Using the SenseCam to improve classifications of sedentary behavior in free-living settings. *Am. J. Prev. Med.* 44 (3), 290–296. <http://dx.doi.org/10.1016/j.amepre.2012.11.004>.
- Lee, J., Kwan, M.P., 2005. A combinatorial data model for representing topological relations among 3D geographical features in micro-spatial environments. *Int. J. Geogr. Inf. Sci.* 19 (10), 1039–1056. <http://dx.doi.org/10.1080/13658810500399043>.
- Lee, J., Kwan, M.-P., 2014. Spatiotemporal routing analysis for emergency response in indoor space. *J. Korean Soc. Surv. Geod. Photogramm. Cartogr.* 32 (6), 637–650. <http://dx.doi.org/10.7848/ksgpc.2014.32.6.637>.
- Lee, K., Lee, J., Kwan, M.-P., 2017. Location-based service using ontology-based semantic queries: a study with a focus on indoor activities in a university context. *Comput. Environ. Urban Syst.* 62, 41–52. <http://dx.doi.org/10.1016/j.compenvurbsys.2016.10.009>.
- Lwin, K., Murayama, Y.A., 2009. GIS approach to estimation of building population for micro-spatial analysis. *Trans. Gis.* 13 (4), 401–414. <http://dx.doi.org/10.1111/j.1467-9671.2009.01171.x>.
- Mcewan, B., Campbell, M., Swain, D., 2010. New Zealand culture of intoxication: local and global influences. *N.Z. Sociol.* 25 (2), 15–37.
- Ministry of Education, 2014. School decile ratings Wellington. Ministry of Education 2014 [cited 2014 Jan 10]. Available from: <http://www.education.govt.nz/school/running-a-school/resourcing/operational-funding/school-decile-ratings>.
- Ministry of Health, 2016. Annual Update of Key Results 2015/16: New Zealand Health Survey. Ministry of Health, Wellington.
- New Zealand Law Commission, 2010. *Alcohol in Our Lives Curbing the Harm: A Report on the Review of the Regulatory Framework for the Sale and Supply of Liquor*. Wellington, N.Z.: Law Commission, Wellington, N.Z.
- Newton K., 2010. Supermarkets 'driving alcohol affordability'. Stuff.co.nz. [cited 2017 May 4]. Available from: <http://www.stuff.co.nz/national/4239830/Supermarkets-driving-alcohol-affordability>.
- Oliver, M., Doherty, A.R., Kelly, P., Badland, H.M., Mavoa, S., Shepherd, J., et al., 2013. Utility of passive photography to objectively audit built environment features of active transport journeys: an observational study. *Int. J. Health Geogr.* 12 (1), 1. <http://dx.doi.org/10.1186/1476-072X-12-20>.
- Pennsylvania Liquor Control Board. Title 47, Chapter 1. Liquor Code [cited 2017 May 4]. Available from: [https://govt.westlaw.com/pac/Browse/Home/Pennsylvania/UnofficialPurdonsPennsylvaniaStatutes?Guid=ND1A91B3BFF81436C9BB9A57A71893DCC&originationContext=documenttoc&transitionType=Default&contextData=\(sc.Default\)](https://govt.westlaw.com/pac/Browse/Home/Pennsylvania/UnofficialPurdonsPennsylvaniaStatutes?Guid=ND1A91B3BFF81436C9BB9A57A71893DCC&originationContext=documenttoc&transitionType=Default&contextData=(sc.Default)).
- Pettigrew, S., Biagioni, N., Jones, S.C., Daube, M., Kirby, G., Stafford, J., et al., 2015. Sales promotion strategies and youth drinking in Australia. *Social. Sci. Med.* 141, 115–122. <http://dx.doi.org/10.1016/j.socscimed.2015.07.035>.
- Rowland, B., Toumbourou, J.W., Satyen, L., Tooley, G., Hall, J., Livingston, M., et al., 2014. Associations between alcohol outlet densities and adolescent alcohol consumption: a study in Australian students. *Addict. Behav.* 39 (1), 282–288. <http://dx.doi.org/10.1016/j.addbeh.2013.10.001>.
- Signal, L.N., Smith, M.B., Barr, M., Stanley, J., Chambers, T.J., Zhou, J., et al., 2017. Kids'Cam: an objective methodology to study the world in which children live. *Am. J. Prev. Med.* <http://dx.doi.org/10.1016/j.amepre.2017.02.016>.
- Smith, L., Foxcroft, D., 2009. The effect of alcohol advertising, marketing and portrayal on drinking behaviour in young people: systematic review of prospective cohort studies. *BMC Public Health* 9 (1), 51. <http://dx.doi.org/10.1186/1471-2458-9-51>.
- The Sale and Supply of Liquor Act2012, 2012. New Zealand Government No 120, (18/12/2012).
- Unicef, 2014. The convention on the rights of the child. UNICEF [cited 2017 13 June]. Available from: <http://www.ohchr.org/EN/ProfessionalInterest/Pages/CRC.aspx>.
- Wardle, J.L., Chang, S., 2015. Cross-promotional alcohol discounting in Australia's grocery sector: a barrier to initiatives to curb excessive alcohol consumption? *Aust. N.Z. J. Public Health* 39 (2), 124–128. <http://dx.doi.org/10.1111/1753-6405.12291>.
- World Health Organization, 2012. *A Framework for Implementing the Set of Recommendations on the Marketing of Foods and Non-alcoholic Beverages to Children*. World Health Organization, Geneva (CHE).
- World Health Organization, 2014. *Global status Report on Alcohol and Health*. World Health Organization, Geneva (CHE).