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RESEARCH METHODS

Kids'Cam: An Objective Methodology to Study the World in Which Children Live

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Introduction: This paper reports on a new methodology to objectively study the world in which children live. The primary research study (Kids'Cam Food Marketing) illustrates the method; numerous ancillary studies include exploration of children's exposure to alcohol, smoking, "blue" space and gambling, and their use of "green" space, transport, and sun protection.

Methods: One hundred sixty-eight randomly selected children (aged 11–13 years) recruited from 16 randomly selected schools in Wellington, New Zealand used wearable cameras and GPS units for 4 days, recording imagery every 7 seconds and longitude/latitude locations every 5 seconds. Data were collected from July 2014 to June 2015. Analysis commenced in 2015 and is ongoing. Bespoke software was used to manually code images for variables of interest including setting, marketing media, and product category to produce variables for statistical analysis. GPS data were extracted and cleaned in ArcGIS, version 10.3 for exposure spatial analysis.

Results: Approximately 1.4 million images and 2.2 million GPS coordinates were generated (most were usable) from many settings including the difficult to measure aspects of exposures in the home, at school, and during leisure time. The method is ethical, legal, and acceptable to children and the wider community.

Conclusions: This methodology enabled objective analysis of the world in which children live. The main arm examined the frequency and nature of children's exposure to food and beverage marketing and provided data on difficult to measure settings. The methodology will likely generate robust evidence facilitating more effective policymaking to address numerous public health concerns.
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INTRODUCTION

This paper reports on a methodology developed to objectively study the world in which children live and their interaction with it. In doing so, it provides a means to address children's rights to health and development.[1] Wearable cameras, bespoke software for image coding, GPS units, and spatial analysis were used. The primary research study (Kids'Cam Food Marketing) is used here to illustrate the method. This main study examines the frequency and nature of children's exposure to food marketing, by sociodemographic factors (e.g., ethnicity, SES) and personal characteristics (e.g., BMI). Numerous ancillary studies use the Kids'Cam data, including studies of children's exposure to alcohol, smoking, "blue" space and gambling, and their use of "green" space, transport, and sun protection.

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According to the WHO Commission on Ending Childhood Obesity (ECHO), there is unequivocal evidence that unhealthy food marketing is related to childhood obesity.[2] Reducing children's exposure to, and the power of, marketing is one of ECHO's key recommendations.[2] Internationally, little is objectively known about children's actual exposure to food marketing, other than via TV.[3] It appears that no studies have quantified the presence of food marketing across multiple media in multiple settings. This research gap is largely due to the difficulty of collecting objective data.

The potential of wearable cameras for health research has been identified[4] and demonstrated in physical activity,[5–7] behavioral nutrition,[8,9] and food marketing[10] research. Wearable cameras collect data passively in real time, thus overcoming the recall bias and comprehension issues of survey research.[11] As researchers are not required to be present during data collection, wearable cameras are less invasive and less time and resource intensive than traditional observation methods.[4] Wearable cameras have the potential to provide more comprehensive access to participants' behavior and environment than other observation methods, for example, access to homes.[12] Social desirability bias is also limited, particularly if participants are blinded to the purpose of the study.[10] Challenges of wearable camera and GPS unit research include difficulty in getting large sample sizes, reliance on the user for battery charging and powering on/off, device interference, poor-quality images in low-light situations, the time-consuming nature of data analysis, and ethical concerns.[4] Further, research with preteens is limited to a feasibility study for Kids'Cam.[10] This paper reports on the Kids'Cam methodology as a means to study the world in which children live.

METHODS

Study Design

Kids'Cam was a cross-sectional observational study of 168 Year 8 children (aged 11−13 years) in the Wellington region of New Zealand. This age group was considered to be the youngest that could use the technology and deal with the study demands.[12] Participants wore an automated camera (Autographer, www.autographer.com/, US$280) and GPS unit (Qstarz BT-Q1300ST Sports Recorder, US$120) on lanyards around their neck. The camera captured a 136-degree image of the scene ahead approximately every 7 seconds, and the GPS unit captured latitude and longitude every 5 seconds. Structured qualitative interviews were conducted with 33 participants to explore their engagement with food marketing, as part of the main study.

Ethical Approval

Ethical approval was obtained from the University of Otago Human Ethics Committee (Health) (13/220) to study any aspect of the world children live in and their interaction with it. Children were blinded to the primary food marketing focus of the study. Ensuring informed consent, protecting children from harm, and anonymity of participants and third parties are key ethical issues that will be discussed. Ethical issues about research with wearable cameras are discussed further in Barr et al.,[10] Barr and colleagues,[12] and Kelly et al.[13]

Pilot Study

A pilot study was conducted with ten children in one school, including focus groups with the children to explore their experience after the research was completed, and interviews with the lead teacher and principal. Of the few reported problems, most arose from the GPS unit being on a separate armband (therefore, the device was instead worn on a lanyard for the full study). All agreed that the experience was positive. Children commented "it was fun" and "I felt so professional." Following the pilot, the study protocol and the children's instruction manual were revised based on feedback from the children, teacher, and principal and using the researchers' observations (available at diet.auckland.ac.nz/content/kidscam).

Quality Control

A study protocol was developed, piloted, and refined prior to the full study. Researchers were trained in the research procedures in a 1-day training session that included role play. Researchers collected data in pairs to cover the tasks required. Senior researchers (LS and MS) undertook initial data collection and then worked with others (MB, TC, GJ) until they were sufficiently skilled. A simple instruction manual for children was developed, piloted, and refined. Cameras and GPS units were checked for functionality after use. Calibrated scales (HD-316 Wedderburn Scales, Tanita Corporation, Tokyo, Japan) and a laser height measure (Precaster CA770 electronic laser measure) were used to calculate BMI.

Sampling and Recruitment

Sampling and recruitment were conducted in two stages, at school and then student level. All 93 schools in the Wellington region with Year 8 students were eligible for selection. Sampling of schools was stratified by school decile (socioeconomic measure) and student ethnicity (Māori, Pacific, and New Zealand European) based on aggregate school enrollment data from the Ministry of Education. Though this sampling method was appropriate for the primary study and provided high-quality data for subsequent studies, sampling for future research will depend on the study questions.

A total of 28 schools were randomly selected across the resulting nine strata, using probability-proportional-to-size sampling methods (schools with a larger proportion of the total number of Year 8 students in each stratum had a higher probability of invitation). A school may have been selected for recruitment of students from more than one ethnic group, and the sampling method allowed for a school to be selected multiple times for the same study stratum. Stratified sampling was used to better facilitate comparisons of marketing exposure by SES and ethnicity, as childhood obesity is strongly patterned by these factors, as are many public health exposures and outcomes.[14]

Sixteen schools consented to participate (57% of those invited). Children who were unable to collect data or deal with the demands of the study, owing to health or family circumstances, were excluded. A total of 168 Year 8 students participated based on a target of four children per selected school/ethnic group. Data analysis for projects using the Kids'Cam data will account for the complex sampling using sampling weights and appropriate management of stratification variables and clustering of children within schools and neighborhoods.[15]

Sample size was determined prior to the study based on achieving a particular estimation precision for the mean number of marketing exposures per day. Under the study team's estimates that children might have a mean of 60 exposures per day (SD=20 exposures), 28 children per decile/ethnicity stratum (six strata at planning stage) were expected to produce a margin of error (i.e., half-width of 95% CI) of ±7.5 exposures per day within a given stratum, giving a total of 168 participants. The sampling frame was expanded to nine strata after funding was awarded; thus, the budgeted sample size had fewer children per stratum and estimates from each stratum have a slightly wider margin of error. At least two children from each school, one girl and one boy, were randomly selected to participate in the qualitative interviews.

Data Collection

Selection. Selected schools were invited to participate. Reasons for declining included a busy term and senior staff on leave. The school principals informed their school communities about the study and invited feedback; if any objections were received, the research did not proceed (an objection was received in one school). Written consent was obtained from all participating schools, participating children, and their parents. The researchers met with the children at school, fitting around children's timetables.

Briefing. A briefing session was held with participating children to explain their role as researchers and provide them with the devices. Each child was given a GPS unit and two cameras. They were asked to change the first camera they used at lunchtime as the battery life was limited and to charge all devices each evening. Children were instructed to wear the camera and GPS unit for 4 days, Thursday to Sunday (thus capturing both school days and weekend days), from when they got up in the morning until going to bed. They were advised to remove the camera in situations where privacy could be expected (e.g., toilet or shower facilities), if they felt uncomfortable, or if requested. Children were also instructed to remove the equipment when swimming or playing vigorous sport. Participants were given information cards to provide to interested parties, which explained the study and gave the researchers' contact details if people had questions or concerns. Children rarely reported handing cards out and no calls were received. An instruction manual was provided and texts were sent to children or parents each day to remind them to change their camera and charge the devices.

Device retrieval. The devices were retrieved on the Monday following data collection, and the images and GPS data were downloaded to password-protected laptops without being viewed by the researchers. There was a 99% return rate.

Review. On the Tuesday or Wednesday after data collection, participants reviewed their own images on the laptops in private and deleted any images they did not wish the research team to see. It is not possible to quantify how often image deletions occurred, but some children reported deleting personal images (e.g., when taken accidently in the toilet). Height and weight was measured (to calculate BMI); children's feedback on the study was recorded. Children reported a high degree of comfort with the research, little attention from others, and no instances of distress in relation to wearing the cameras or GPS units. Qualitative interviews for Kids'Cam Food Marketing were undertaken. Children were asked about their awareness of, and engagement with, food marketing. They were also asked if they thought policy about food marketing should be changed and, if so, how. As a token of thanks, children received a certificate of participation for their role as a researcher and a $30 gift voucher for either books or sporting equipment. Participating schools received a $200 book voucher.

Timeframe. Data were collected over a 12-month period between July 2014 and June 2015 to allow for seasonal variations and to smooth out the research team workload. Analysis commenced in 2015 and is ongoing.

Data Management

The approved images were downloaded to a password-protected server, saved in cloud storage, and backed up to a password-protected external hard drive. Approximately 1.4 million images were recorded, 95% of which contained clear image data (Figure 1) that could be coded for the presence of food marketing, along with 2.2 million GPS coordinates. Some data loss may be due to battery failure, lost satellite communication, and powering off of camera/GPS unit. GPX data were extracted from GPS units using Qstarz-Qsports Version 3.75(T) software. Raw GPX files were converted into shapefiles (ArcMap, version 10.3). A data cleaning protocol was developed. GPS coordinates underwent a cleaning and imputation process that included correction of noise related to satellite communication obstruction (e.g., inside buildings). Image codes were linked to GPS data based on timestamps, allowing spatial analysis of coded exposures. Interviews were transcribed, coded in NVivo, and analyzed using thematic analysis.

Data access was restricted to members of the research team who signed a data release form that included strict protocols. Anonymity of participants and third parties in image data was protected by obscuring faces, or other identifying information (e.g., school name) captured in images. Anonymity of spatial data was ensured by publishing only jittered, aggregated point maps or removing identifiable basemap features.

Coding of Image Data

Manual coding of images was performed using a protocol that guided content analysis.[16] For the Kids'Cam Food Marketing study, this protocol was informed by previous research on food marketing to children and initial viewing of the images. Marketing was defined as "any form of commercial communication or message that is designed to, or has the effect of, increasing recognition, appeal and/or consumption of particular products and services."[17] A three-tiered framework was developed whereby each relevant image was coded with setting, marketing medium, and food product category (Table 1). Where multiple advertisements for a product were observed in an image with the same setting and marketing medium, the category was only coded once (e.g., multiple advertisements for Coke were coded as sugary drinks and juices 1). However, it was also possible to code each image with multiple three-tiered codes. For example, an image

Figure 1. Food marketing at school, in a corner store, at home, and in the street.

could be coded as street > sign > sugary drinks and juices 1 and shopfront > sign > fast food to account for multiple instances of marketing in the same image. Codes were only assigned to an image where ≥50% of a brand name or logo could be clearly seen by the coder. Food product category codes included convenience store and supermarket, as the diversity of marketing in these sites

Table 1. Summary of Coding Framework

Setting	Marketing medium	Food product category
School	Default	Default
Street	In-store marketing	Bakery 1,2+[a]
Home	Print media	Cereal (unhealthy) 1,2,3+
Bakery, indoor	Product packaging	Confectionary 1,2,3+
Community venue	Merchandise	Cookies cakes and pastries 1,2,3+
Convenience store, indoor	Mobile food vendor	Convenience store 1,2+
Fast food, indoor	Screen	Core 1,2,3+
Full-service restaurant	Sign	Diet drinks 1,2,3+
Fresh-food market	Vending machine, external	Fast food 1,2,3+
Other retail	Camera not worn	Ice cream 1,2,3+
Outdoor recreation space	Uncodable	Milk product (unhealthy) 1,2+
Private transport		Other
Public transport, vehicle		Processed meats
Public transport, facility		Snack foods 1,2,3+
Service station, on-site		Sugary drinks and juices 1,2,3+
Shop front		Supermarket 1,2+
Shopping mall		Blurry/blocked
Sport		Camera not worn
Supermarket, indoor		Check
Vending machine, inside		Uncertain
No setting		
Uncertain		

[a]The number of different product brands in a photo was coded.

was too substantial to code individually. Manual coding required approximately 1 hour to code 6 hours of recorded images. Reliability testing was conducted before coding commenced, with each coder achieving 90% concurrence with model answers on a test data set of 115 images. Other elements were also coded and used in ancillary studies.

Coding Software

To code the images, bespoke software was developed by the team at Dublin City University (JZ, CG, AS, AD) enabling the attachment of codes to each image. The front-end browser is shown in Figure 2 with the three-tiered framework on the left. The small images are the photographs taken every 7 seconds. The highlighted image is the photograph currently being coded. It shows a Coca-Cola can coded home(setting) > product packaging(marketing medium) > sugary drinks and juices 1(food product category). Partnership with computer scientists enables the development of such software, but is not essential to the method. Some ancillary studies utilized Excel spreadsheets to record coding.

Nutrient Profiling

All foods were classified as either core (healthy) or non-core (unhealthy) to be marketed to children based on the WHO Regional Office for Europe Nutrient Profiling Model.[18] Some modifications were made in line with previous research on TV and Internet food marketing to children.[19–22] For example, a fast-food category was added that included all commercially prepared food products sold at quick-service restaurants for ease of classification. All fast food was classified as non-core, as it is typically high in saturated fat and sodium and low in fiber.[23] Fats, oils, spreads, yeast extracts, sauces, baby food, infant formula, coffee, tea, slimming products, and dietary supplements were excluded from this analysis as they are not typically marketed to children.

RESULTS

The Kids'Cam methodology enabled automated, objective observation of children's lived experiences in a wide range of settings, including home, school, in transport, and the community. In doing so, it provided insights into aspects of the world of children that have previously been difficult to measure, such as the private world of the home, at school, and during leisure time. The method overcame the biases of survey research[11] and the invasiveness and potential bias of researcher observation. The method is ethical, legal, and acceptable to children and the wider community. Having permission to study the world in which children live reduced the risk of social desirability bias in relation to specific elements of interest. The method enabled a large sample size as the participants collected the data, significantly reducing time and resources. The Autographer cameras provided high-quality images, of which 95% could be coded. Pairing the camera data with GPS data allowed for spatial analyses of observed patterns of exposure. This research demonstrates the feasibility of manual image coding, although it is time consuming. Automated image recognition, using image tagging based on convolutional neural networks,[24] has considerable potential and is

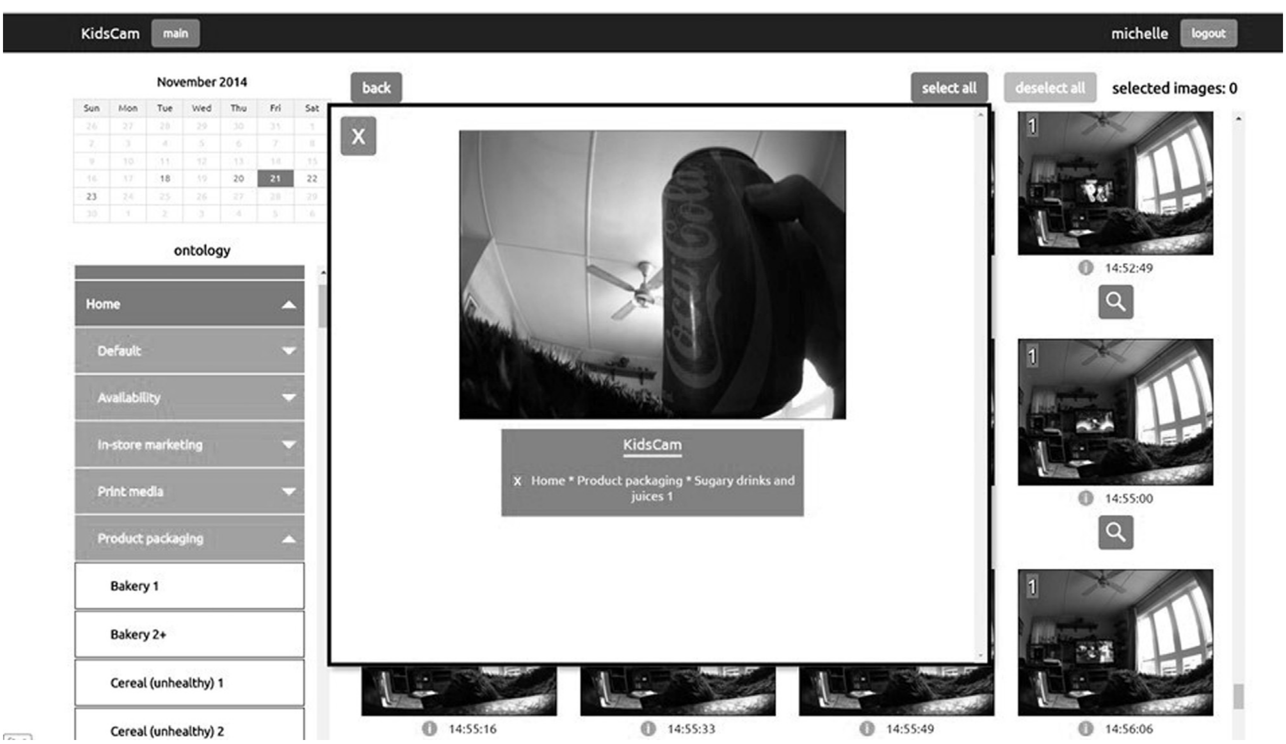

Figure 2. Example of coding using bespoke software.

currently being explored for application to this data set as a complement to manual coding.

This paper illustrates the Kids'Cam methodology with a report on the primary study to capture children's exposure to food marketing. It appears this is the first study to objectively measure such exposure from a child's perspective in real time and across varied settings and marketing media and throughout the day. Though inclusion of qualitative interviews was not essential, they provide insights into children's engagement with marketing and their perspectives about policy change, and demonstrate the use of other methods to enhance the Kids'Cam methodology.

DISCUSSION

The Kids'Cam methodology is a promising new approach for research into children's lives. The method provides a new means to ensure the rights of children are respected by revealing the world in which they live.[1] The Kids'Cam Food Marketing study provides robust evidence of children's exposure to food marketing across a full range of media in multiple settings throughout the day.

Limitations

Although this methodology provides the most robust data on children's actual exposure to food marketing to date, and many other aspects of their environment, it has limitations. First, the authors cannot be certain that the participating child was the person wearing the camera; however, the teachers, other students, and family members knew and therefore provided a quality check. The authors also have GPS data that identify their home location, which were cross-referenced with address data obtained at enrollment. Second, the images do not establish that a child is definitively visually exposed to the elements detected in the images. For example, a child may be looking the other way when marketing is detected by the camera. Nevertheless, the qualitative interviews suggest children are highly aware of marketing in their environments and give confidence that children registered a high proportion of the material evident in each image.

CONCLUSIONS

The role of unhealthy food marketing in childhood obesity is unequivocal and urgent action is required.[2] Such evidence will enable policymakers and public health advocates to better target policies to limit the exposure of children to unhealthy food marketing, a critical step to ending childhood obesity. The ancillary Kids'Cam studies indicate that this methodology is valuable in assessing other aspects of children's lives. The Kids'Cam methodology will likely generate robust evidence for effective policymaking to address a suite of public health concerns.

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