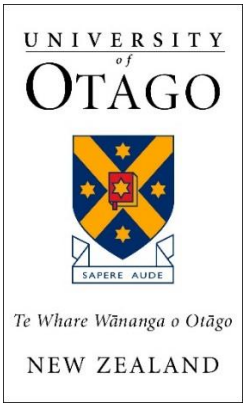

Kids'Cam Tonga 2017

Looking at Health in Tonga from a Child's Eye View

A 4th year MBChB project

By Timothy Galt, Sabrina Koh, Max Hardie Boys, Dhenisha Dahya, Devon Winders, Rita Kettoola, Emily Fiennes, Mikayla Barnett, Jordan Tewhaiti-Smith, Felicia Joe, Shaina Pinares Garcia, Silabhakta Livirya, Gobi Ou, Andy Robinson, Sarah Hulme-Moir, Logan Clarricoats, Viliami Puloka, Moira Smith, James Stanley & Louise Signal

Abstract

Importance

Tonga is a country with a high burden of non-communicable disease (NCD) risk factors. The Tongan government has in place a NCD strategy to try and reduce the burden of these risk factors and the subsequent disease. Kids'Cam uses automatic cameras in order to see what children are seeing in their environment. This methodology might be used to see what risk factors children in Tonga are exposed to, and where and when appropriate intervention might take place. This paper presents data from an initial analysis from a subset of students.

Setting

12 semi – randomly selected schools in Tongatapu, Tonga. Both rural and urban schools were selected.

Participants

6 children aged 11 to 13 from each school were selected to take part in the study.

Data Collection

Children were given an automatic camera, which took photographs every seven seconds. The children were asked to wear the camera during the waking hours from Friday morning through to Sunday evening. Images were then coded for relevant non communicable disease risk factors and protective factors. These included type of food and drink intake, the layout of and purchases from *fale koloa*, amount of time spent on screens, anti-smoking messages and adults smoking, and transport time and type of transport.

Results

Children appear to be consuming high levels of processed food while at school, while their diet is more balanced when at home. The consumption of drinks in Tonga amongst these children appears to be split evenly between water and drinks high in sugar. Although the *fale koloa* was visited frequently by children in Tonga, there were low levels of advertising stimulus. Purchases from the *fale koloa* were largely unhealthy products. Children are generally engaged in active transport when appropriate. Children are exposed to anti-smoking messages more than they see smoking. Children were engaged in moderate levels of screen time, and that half of this time was spent watching television, and half of this time was spent on other screen modalities.

Conclusions

This study is preliminary due to the limited subset of children analysed for each subsection. Diet appears to be the biggest risk factor of the risk factors studied for the children. Interventions to improve the diet of these children should be aimed at changing their diet while at school. Restricting children's access to the *fale koloa* may limit their access to unhealthy and processed foods. Interventions like those above could improve the non-communicable disease risk factor profile in Tonga, and reduce the burden of disease.

Executive Summary

Kids'Cam Tonga followed 72 children between the ages of 11 and 13 at random schools on Tongatapu. Images were collected from cameras worn around the participant's neck, which took photographs every seven seconds. This data was collected from a Friday morning to a Sunday afternoon. The images were then analysed for risk factors for non-communicable diseases that the children were exposed to.

Key Findings:

- Children saw more processed food on Friday while at school than they did at home
- Approximately half of drinks seen were water. Sugar sweetened beverages or different kinds (soda, fruit juice, fruit drink) made up the other half of drinks seen
- Children visited *fale koloa* often, and often purchased processed foods at these outlets.
- The children studied spent approximately 2 hours over the three days watching screens. That is approximately 40 minutes of screen time per day
- Children were largely engaged in active transport where they could be
- Children were exposed to more anti-smoking signs than images of adults smoking

Key Recommendations

- Interventions to improve diet should be targeted at children while they are at school, such as educating parents about health lunch choices for children, or having health food policies in schools
- Educate parents about having healthy drinking options around the home
- Increase the sugar sweetened beverage tax
- Adding incentives for owners of *fale koloa* to stock healthier items for children
- Trying to intervene in the transport sector is likely to result in perverse outcomes
- Kids'Cam methodology needs to be supported by survey data in the Tongan context.

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Introduction

Tonga is a country with high levels of risk factors for non-communicable disease. The STEPwise approach to surveillance (STEPS) report was commissioned by the World Health Organisation (WHO) Western Pacific district, and involved both an interview and measurements of height, weight and blood pressure. The STEPS report sampled 2928 Tongans between the ages of 25 and 64 years old (1). The 2014 STEPS survey suggested that 90.7% of adults older than 25 had a BMI greater than 25 kg/m^2, and 67.6% of adults older than 25 had a BMI greater than 30 kg/m^2. 23.7% of adults had low levels of physical activity, and 73.1% consumed less than 5 servings of fruit and vegetables a week (1). The Global School-Based Student Health survey suggests many of these risk factors are present in children as well. This surveyed 2200 13 to 15 year olds in Tonga, questioning them about a wide range of lifestyle factors such as alcohol, smoking and diet. 58.7 % of respondents had a BMI in the overweight range, and 21.1% had a BMI in the obese range. 25.1% of respondents were physically active for 60 minutes per day on five or more days, and 28.8% spent three or more hours per day in sedentary behaviours (2). It is likely that these surveys will underestimate the prevalence of some of these risk factors due to recall and social acceptability bias.

The Tongan Government is concerned about the risk of cardiovascular disease and diabetes that may result from the behaviours described by the surveys, and so has implemented a national strategy to prevent and control these non-communicable diseases. Strategies currently being implemented include increasing physical activity by increasing access to sports goods and encouraging physical activity within the school curriculum, increasing availability of healthy foods by creating tax incentives, reducing tobacco related harms by increasing enforcement of tobacco restriction policies, and increased screening for diabetes and other NCD risk factors (3).

Kids'Cam is a methodology developed to assess the environment children lived in and interacted with. It allows researchers to see what the children are seeing from their own point of view (4). From there, it is possible to see the influences in the children's world which promote healthy lifestyles and which promote unhealthy lifestyles. This could have a direct impact on their own healthy or unhealthy behaviours, and comment on likely future NCD risk. For example, marketing of unhealthy food to children may increase the likelihood of consuming unhealthy food (5). The Kids'Cam methodology can be applied the Tongan setting, in order to assess qualitatively what kinds of risk factors children in Tonga are seeing and what kinds of risk factors the children are exposed to themselves. In this way, aspects of the environment that the children interact with that may lead to higher risk can be identified and intervened in.

Food environment

One of the risk factors identified by the STEPS report is unhealthy eating habits of Tongan adults. There was low consumption of fruit and vegetables, with only 29% achieving the recommended 5 servings of fruit and vegetables per day (1). Over half of young people report not eating fruit or vegetables at least once per day according to a 2007 study. Tinned mutton or beef was the most common regularly consumed food amongst the participants (6)

Access to food sources is the greatest predictor of consumption in Tonga, it is a higher predictor than individual preference. Cheap, low quality food is therefore highly consumed, even though the population is aware of its nutritional value (7). People in Tonga have a preference for higher quality, traditional foods

than for imported foods of low nutritional value (8). Consumption of this food follows a socio-economic gradient, as people in lower economic positions have higher consumption of low quality food items (9).

High levels of food consumption appear to occur on religious occasions. Food is regarded as a social service, and this therefore encourages preparation and consumption of large quantities of food. In order to be a valued as a host, large quantities of food are prepared for food associated with the church, and large quantities of food consumed in order not to 'embarrass' the host (10). Although the church is a strong institution which encourages high levels of social cohesion, some cultural elements of service attached to religious observation appear to encourage consumption of large quantities of food.

Amongst Tongans, consumption of sugary drinks was positively associated with total fat mass (11).
Small convenience stores (called *fale koloa*) are common in Tongan villages and in Nukualofa, many of which are staffed by Chinese immigrants (12). The *fale koloa* have been identified as a source of unhealthy processed food, which may be targeted as part of a public health initiative to reduce NCD risk factors (13).

Attitudes to obesity

According to McCabe et al (2013) (10), Tongan adults and adolescents have a much different attitude to obesity than Western countries. Ideal and attractive body weight tends to be higher in among Tongans than in places such as Australia (14, 15) , although these attitudes may be changing (15). This attitude toward body size is influenced by adolescent's peers, parents, the media and religious institutions (16), and Tongans are more likely to receive positive messages about large body sizes from their communities than Tongans who are living in New Zealand (17).

Transport

The STEPS 2014 report found that men had significantly higher levels of transport related physical activity than women. Men spent 22 more MET minutes (a measure of physical activity) per day on transport related physical activity (1).

Smoking

According to the 2011 census, 24% of adults smoke daily. <0.1% of 10-14 reported smoking daily, however 12% of 15- 19 year olds reported smoking daily (18).

Diabetes

The age standardised prevalence of diabetes in Tonga was 15.1% in 2002, which was double the prevalence measure in 1973, and much of this was undiagnosed diabetes (19).The estimated prevalence of diabetes in Tonga in 2015 is 12.6%, which is one of the highest rates in the world, and this may be underestimating the true prevalence due to under diagnosis (20).

Dental Caries

Dental caries are a concern to the government of Tonga, which have implemented school based water fluoridation programs to try and improve the rate of dental caries amongst Tongan children (21). The rate of dental caries might be linked to the consumption of sugary drinks (22).

Physical Activity

The STEPS report found low levels of physical activity in the Tongan population (1). Regular physical activity outside of school was reported by only 20.7% of adolescence, and 58.2% reported watching more than 1 hour of television a day in 2007 (6). The Global School-Based Student Health Survey estimated the prevalence of watching more than 3 hours of television a day at 28.8% in 2010 (2). It is suggested that fat mass in ethnic Tongans is related to length of television watching in a dose dependent manner (11).

In the Global School-Based Student Health Survey, only 25% of adolescents were physically active for at least 60 minutes per day for five days in the past seven. Only 24% went to a physical education class on three or more days per week. However, 60% were taught about the benefits of physical activity in the previous school year (2). After school physical activity was inversely associated with total fat mass in Tongans in a dose dependent manner, that is, more physical activity was associated with less total fat mass (11).

General Methods

Kids'Cam Tonga is based on Kids'Cam New Zealand, a cross-sectional observational study of the world children live in. Participants were 169 randomly selected Year 8 children, aged 11-13y, from 16 randomly selected schools in the Wellington region of New Zealand (4). Each child wore a wearable camera (Autographer http://www.autographer.com) on a lanyard around their neck. The devices automatically took a wide-angle, 136° image approximately every seven seconds, from the child's perspective.

In the Tongan study, 72 children, selected in groups of 6 from 12 different schools in Tongatapu, the main island, were selected. The schools were randomly selected from a list of schools in Tongatapu, and the children within the school were randomly selected. The children were Year 6 children (11 to 13 years old) at the time of recruitment. An even distribution of rural and urban schools were selected. The children were instructed to wear the camera from Friday morning through to Sunday evening. The particular days which were recorded were strategically designed to capture a normal school day and the more religiously observed days over the weekend. Approximately even numbers of male and female students were selected. Ethical approval was obtained from University of Otago Human Health Committee (University of Otago 13/220) and Tonga National Health Ethics and Research Committee (290116) for this study. Ethical approval has been given for the study of any aspect of the world the child sees that is of an interest to public health.

The data was transferred onto computers. Images were screened and coded for various health risk factors and protective factors as described below. The images from each child were randomised into one of six sets which were designed to have representation from most schools and even numbers from each sex. A set would be allocated to the team coding each of the areas, so that the breadth of children would be covered. The images were viewed on a screen, with two images on the screen at a time. The images on the screen measured 12 cm by 9.5 cm.

Because the image coding and analysis all took place within five weeks of 2017, only a limited amount of subjects were viewed for each area of study. As such, interpretations of the data are based only on a small number of subjects and is therefore indicative rather than conclusive in nature.

Reliability Testing

Reliability testing was conducted on each of the coding schedules developed for each area. This was done by allocating a set of instances to another person to code. The original entries were then compared to the new entries. The total number of entries on the coding schedule was used as the baseline score. The entries in the new schedule were then matched to the entries in the original schedules. Where there were errors in matching, this was counted in toward the error score. A matching score was then calculated using the following formula

$$Matching\ Score\ = 1 - \frac{Error\ Score}{Baseline\ Score}$$

This formula corrects for the number of categories where entries aren't made for every photograph. Because there are a large number of categories that are not relevant for every photograph, counting negatives would exaggerate the level of coherence between different raters.

Section Reports

This report is divided into subsections, detailing one specific area of study where risk factors for NCD's were searched for. Each subsection used a different method to extract results from the Kids'Cam images. The methods and results from each subsection are presented below.

General Observations

The children observed were largely very active, spending large amounts of time outdoors. The children appear to have large amounts of unstructured time, even during the Friday while at school, where they are able to move about the local area largely unrestricted. The children appear to be very social, very often accompanied by other children. A large amount of time is spent outdoors, and during this time the children are very active. The children are often not directly facing adults, even if they are in the room. This means that the Kids'Cam camera does not capture images of adults nearly as frequently as they capture other children.

Food

Aim

While the traditional Tongan diet is generally considered healthy, in recent years, processed, energy dense, packaged foods have infiltrated the traditional Tongan food environment. This has contributed to the manifestation of an obesogenic environment. This project provided us with an insight into the diet of Tongan youths.

This study explored the frequency of food consumption, type of food consumed and whether the food was consumed in a shared environment, in Tongan school children. This allowed us to build a foundation to understanding the food environment which Tongan school children are exposed to.

Methods

Using the above-described randomisation process, 12 children from the top of the randomisation list were selected for photo analysis.

A coding schedule was designed using Microsoft Excel software. The initial coding schedule included detailed analysis of the content of various foods. However after trialling, this was not a feasible schedule, due to our insufficient knowledge on different areas of nutrition and the traditional Tongan diet and the time constraints. The final coding schedule included date, time, whether the food was shared, location and the type of food eaten. The food was classified using a dictionary of food groups (Appendix: Food) specifically designed to cater for the foods typically present in a Tongan environment. In the case where food was unidentifiable, it was coded as 'Unknown'. This coding schedule was applied to photographs taken by each of the 12 children.

Analysis of the results was primarily qualitative where common trends observed in the photographs were noted. Summary statistics were calculated using Microsoft Excel. The principle investigator provided

individual BMI cut-off data (determined using Cole's Extended International (IOTF) body mass index for thinness, overweight and obesity) for the individual participants we used (23).

Data collection error arose in 5 of the children included in our study. The source of this error was due to an in-camera error resulting in incorrect date-labelling of the photographs. However, these children collected data over the standard 3 day period. Thus, it was assumed that Friday was when the child wore a school uniform, Sunday was when the child went to church and the remaining day was Saturday.

The reliability of the coding schedule was assessed using 2 hours of images selected from each child.

Results

Participants

Table 1: Participant Demographics of children selected for coding for their food environment

Participant Demographics		
	N	%
Gender		
Male	6	50.0%
Female	6	40.0%
Age		
Median	11.3	
Range	10.3-14.5	
Weight Classification (Cole, 2012)		
Healthy	5	50.0%
Overweight	3	25.0%
Obese	2	16.7%
Morbid Obesity	1	8.3%

The median age of the participants was 11.3 years (Table 1). Children were from 12 different schools from around Tonga. The sample consisted of an equal number of females and males. 50% of the participants were classified as 'healthy'. 25% were 'overweight', all of whom were male, and 25% were obese/morbidly obese, all of whom were female.

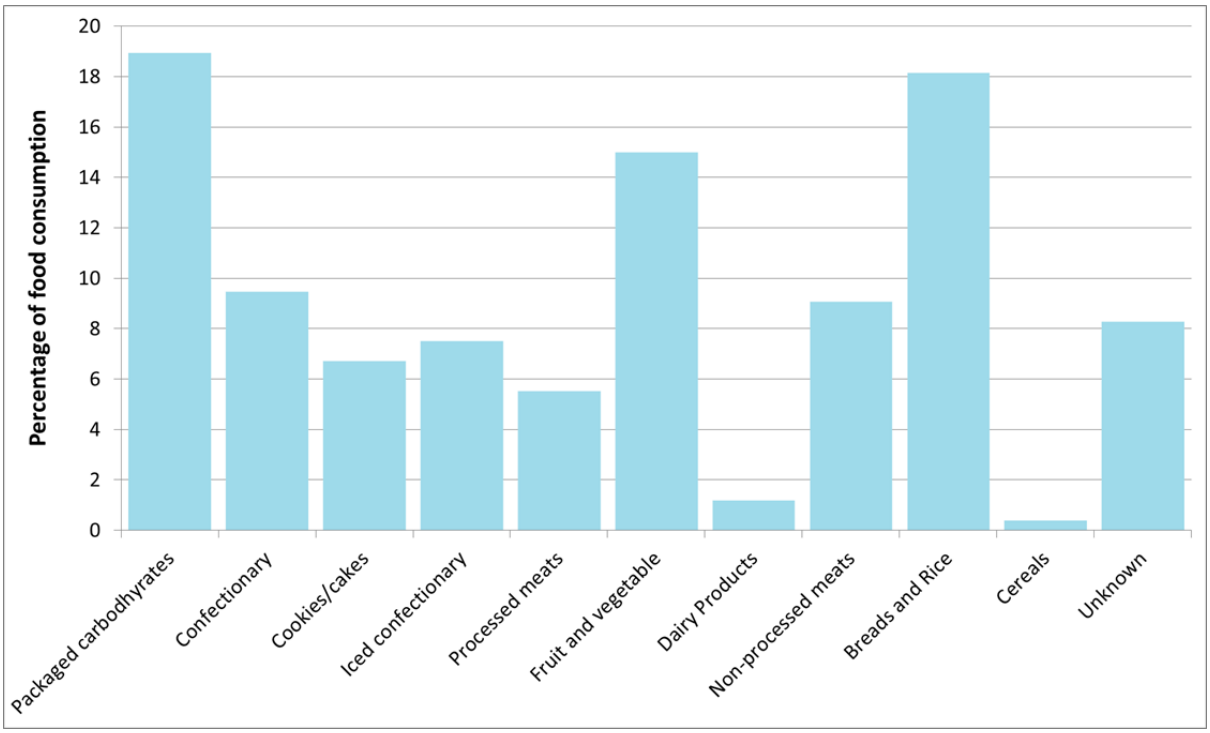


Figure 1: Total proportion of foods images by category

Figure 1 presents the total percentage of types of foods seen in images across the three days divided by category. Fruit and vegetable consumption accounted for 15% of the total food consumed. None of the participants consumed the recommended 5 servings of fruit and vegetables per day. The most commonly consumed fruit and vegetables consumed primarily consisted of starchy, root vegetables such as taro and tapioca. There was minimal consumption of green, leafy vegetables. Fruit consumption did not contribute to a large proportion of this category and included coconut, watermelon, oranges, apples and bananas. Consumption of fruit and vegetables was greatest during the weekends.

Packaged carbohydrates were the most frequently consumed category (Fig. 1), accounting for 19% of the total food consumed. This included dry noodles, chips, crackers and popcorn. Consumption of these products peaked on Friday. Within this category, the consumption of dry packaged noodles was the most frequent and was typically shared amongst a group of friends. Cabin-bread and crisps were also highly consumed.
Non-processed meats contributed to 9% of the total diet (Fig.1). This was greater than the consumption of non-processed meats which comprised 5% of the total food consumed.

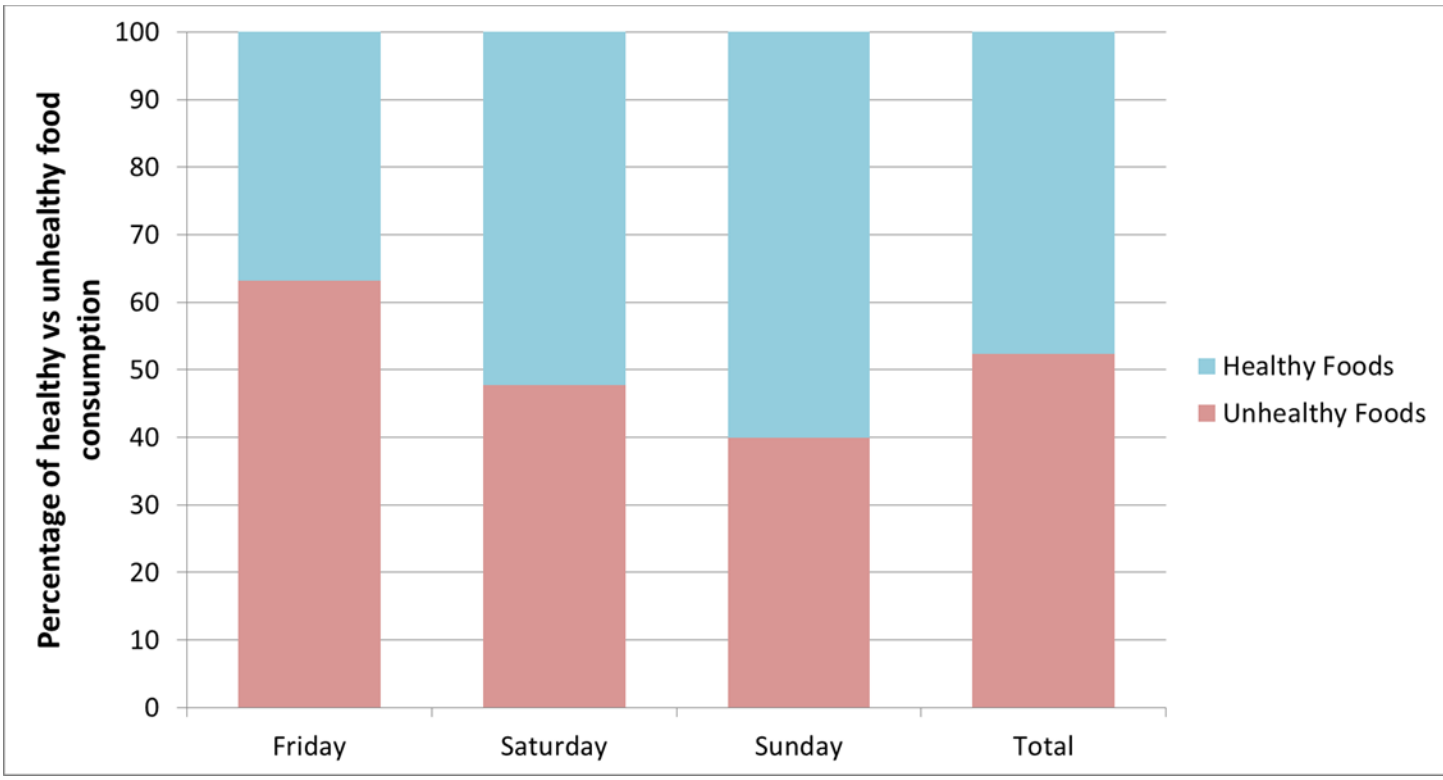


Figure 2: Proportion of healthy versus unhealthy foods consumed across Friday, Saturday, and Sunday and in total across the three days

Figure 2. presents the percentage of healthy versus unhealthy consumption by day. For the purpose of this analysis, unprocessed meats, bread and rice and dairy products were classified as healthy foods. Confectionary, cookies, cakes and pastries, iced confectionary, packaged carbohydrates and processed meats were classified as unhealthy foods. An increased consumption of unhealthy foods was observed on Friday in comparison to the weekend. Greater consumption of healthy foods compared with unhealthy foods was observed in the weekend with 52% of the total diet accounted for by healthy foods on Saturday, and 60% on Sunday. Unhealthy foods contributed to 51% of the total diet, and according to the food pyramid, unhealthy foods should not be making up such a substantial proportion of the diet.

Matching Score

Matching score for the coding schedule was 0.63. This indicates a moderate degree of inter rater reliability. Missing food during validation of photos was the source of most errors.

Discussion of Food Results

The infiltration of the traditional healthy Tongan by imported, packaged, processed foods has resulted in the formation of an obesogenic environment.

From the elevated consumption of healthy foods on Friday compared with Saturdays and Sundays, we can infer that the Tongan school environment has a large role in fuelling the obesogenic environment currently seen in Tonga. Cacavas et al (24) emphasises the sharing of resources between Tongan children to buy food from school and shops in near proximity to school. This pattern was replicated in our study, where children typically shared their consumption of unhealthy packaged foods with friends, thus perhaps there is a social aspect to eating unhealthy foods. Our findings are also consistent with those

presented by Smith et al. who observed elevated levels of unhealthy food consumption in Tonga in comparison to 34 other countries.

With children spending the majority of their time at school on the Friday, schools are a prominent target for intervention. If policies can be implemented at the level of the school, improvements in diet of Tongan children will likely be observed, due to the increased accessibility of nutritious foods, and decreased accessibility of unhealthy foods (24). Given that children spend a lot of their time at school, this is a critical place for healthy food choices to be enforced to them. One barrier to implementing healthy food policies in many schools, is the easy access to unhealthy foods from stalls surrounding the school border and the close proximity of dairies. One child attended a school where a healthy breakfast was provided to all students, and we noted a subsequent decrease in snack consumption in this child. From these observations and the recommendations proposed by Carcavas et al., we suggest the stronger enforcement of restriction of access to unhealthy food outlets. To further reinforce the importance of healthy eating, it could also be beneficial for the Tongan government to introduce a free healthy school breakfast and lunch to all students, which hopefully will satiate their appetite, expose them to essential nutrients, and reduce the frequency of unhealthy snack food consumption.

Limitations

Because of the limited time frame for conducting this study, only a small subset of the students were analysed. It would enhance the recommendations if all the children in the study were analysed using this method.

The use of neck cameras restricted our ability to thoroughly observe the food consumptions. Food could only be observed if held within the field of the view of the camera, thus the angle of images was often inappropriate to identify the food. Thus, our food categories were broad to reflect our inability to provide detailed food analysis.

Time constraint was another barrier in our study as it lead to limitations in sample size, and depth of analysis.

While bread and rice have been classified as healthy foods, we did not have the capacity to differentiate between healthy grains and refined grains. The issue with this is that children primarily ate refined white bread which is not healthy, yet we have classified this as a healthy food due to the limitations of our coding schedule.

While the results from our analysis of the food environment surrounding Tongan schoolchildren is limited, our findings lay a good foundation for future detailed studies. This study paves the way for future studies which should consider reviewing the nutritional content of different foods and subsequently, a more robust food classification system. It is likely that the cultural context has an impact on the type and amount of food consumed and this may be an area for future research.

Recommendations for Interventions

This research suggests that the Tongan Government should focus on reducing accessibility to imported processed foods such as noodles, chips and confectionary. These foods appear to be replacing staple foods and substituting the place of meals, subsequently creating an inverted food pyramid where the unhealthy foods are accounting for a larger proportion of the diet than healthy foods.

Reducing sale points of these foods such as at dairies and stalls surrounding the school border could be a possible intervention to reduce accessibility of these unhealthy foods to children. Also, restricting the sale of food items around certain of the day (before and after school) and restricting the sale to school children could also be tried. But this requires stricter enforcement of current policies.

Furthermore, education of healthy food choices and the implications on health is critical for schoolchildren, thus the government should consider introducing free healthy school breakfasts and lunches to ensure that children are eating balanced diets, containing the necessary nutrients.

Drinks

Aims

The purpose of our portion of this study was to determine the drinking habits of the children in Tonga. Through looking at the data collected, we gathered information on the type, frequency and availability of different beverages to the children in the project. The access to sugary drinks for the people of Tonga is something that the government there has been concerned about due to their tendency to increase the likelihood of the development of type II diabetes mellitus and obesity (25) - two non- communicable conditions which place a high burden on the healthcare system. There is also concern for the high prevalence of dental caries in Tonga (21). As a result of this concern the government introduced a taxation on soft drinks which contained sugar or sweeteners in 2013 (26) in order to try and reduce their consumption.

Methods

We analysed the photographs taken by a random sample of 12 participants out of the overall 72 in the sample group, the characteristics of which can be seen in the table below (Table1).
These images were examined by two members of the overall group who each coded half of the participants using the coding schedule attached in Appendix: Drinks This coding schedule was modified from the one used by the Kids'Cam team to analyse the information on drink exposure and consumption from the Wellington project (4) to better suit the Tongan environment. All images were viewed by coders on computers in an isolated room in the medical school to ensure participant privacy was preserved. The images could be enlarged if needed for clarification on drink type or on location of consumption / availability. If a drink could not be identified within ten seconds it was coded as unidentified.
In order to ensure validity and replicability of the results, validity testing was undertaken where the coding schedule was given to other members of the group who were not part of the drinks team and their coding compared to that of the coding members. In this validation testing the alien coders examined 40 time points where drink availability had been identified.

In order to gather information which would be most useful in a public health setting a more detailed analysis was completed on the Fridays when the children were at school, where beverages were coded whenever they were encountered and then subsequently coded when available, consumed or bought. On days when the children were not at school general beverage encounters were not coded for and only drinking episodes or the purchasing of drinks were recorded, the reasoning behind this being that it would be harder to implement meaningful change in areas where there was less government/policy influences.
The data gathered was entered into a spreadsheet from which analysis was conducted. The data was gathered from the photos over a 2 week period during which 89 discrete data points were identified.

Results

Table 2: Demographics of children selected for coding for drinks

Variable	Level	Percentage sample
Gender	Male	58%
	Female	42%
Location	Urban	50%
	Rural	50%

Figure 3 shows the proportion of different types of drinks consumed by the children. It shows that water, making up 53.4% of the instances recorded, made up the highest proportion of consumed beverage. Table 4 shows that of the water that the children were drinking the most common source was bottled water (61.7%). Fruit drink, fruit juice, soda-sugar and drink powder only make up small numbers individually but when combined they make up 42% of drinks consumed by the participants Figure 5. The remainder was made up by consumption of standard milk.

Table 3 Number of instances of each drink type over three days

Drink Type	Number of Instances
Water	47
Fruit drink	11
Fruit juice	4
Soda - sugar	21
Milk - standard	4
Drink Powder	1

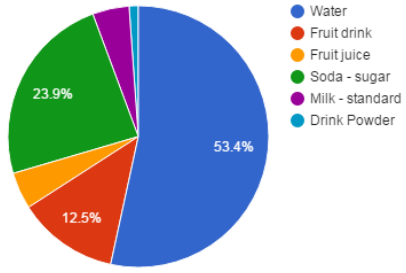


Figure 3: Percentage of instances of each drink type

Table 4:Source of water supply

Drink Type	Number of Instances
Water - bottled	29
Water - tap	15
Water - glass	3

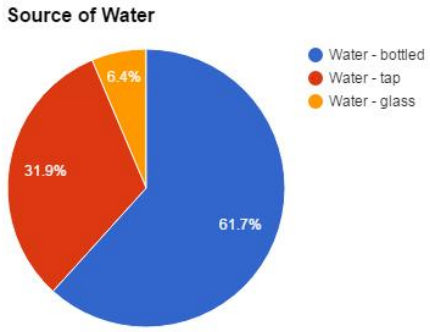


Figure 4:Source of water supply

Table 5: Number of instances of water, sugary drink and milk over three days

Drink Type	Number of Instances
Water	47
Sugary Drink	37
Milk - standard	4

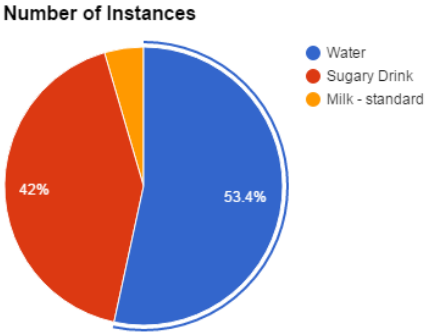


Figure 5: Percentage of water, sugary drinks and milk consumed

Of the drinks that were bought, the most common type was soda - sugar (40%), followed by fruit drink and bottled water at 20% each. The remainder was milk (13%) and undetermined (7%). The majority of drinks were bought on Saturdays, then Fridays, then Sundays.

The most common source of water was bottled water (62% of water consumed). Although, it was also noted that from the children that were observed, all schools appeared to have a water cylinder from which the children could drink if they so desired.

On our closer observation of the drink exposures to children on Fridays it was observed that the drink environment they were exposed to in schools was actually relatively healthy with the majority of their exposures at school being water. The major risks for their exposure to unhealthy options seemed to be on their journeys to and from school during which almost all children whose images were observed visited *fale koloa*. During these visits they were exposed to almost exclusively unhealthy drink options with no water visible for purchase in the images.

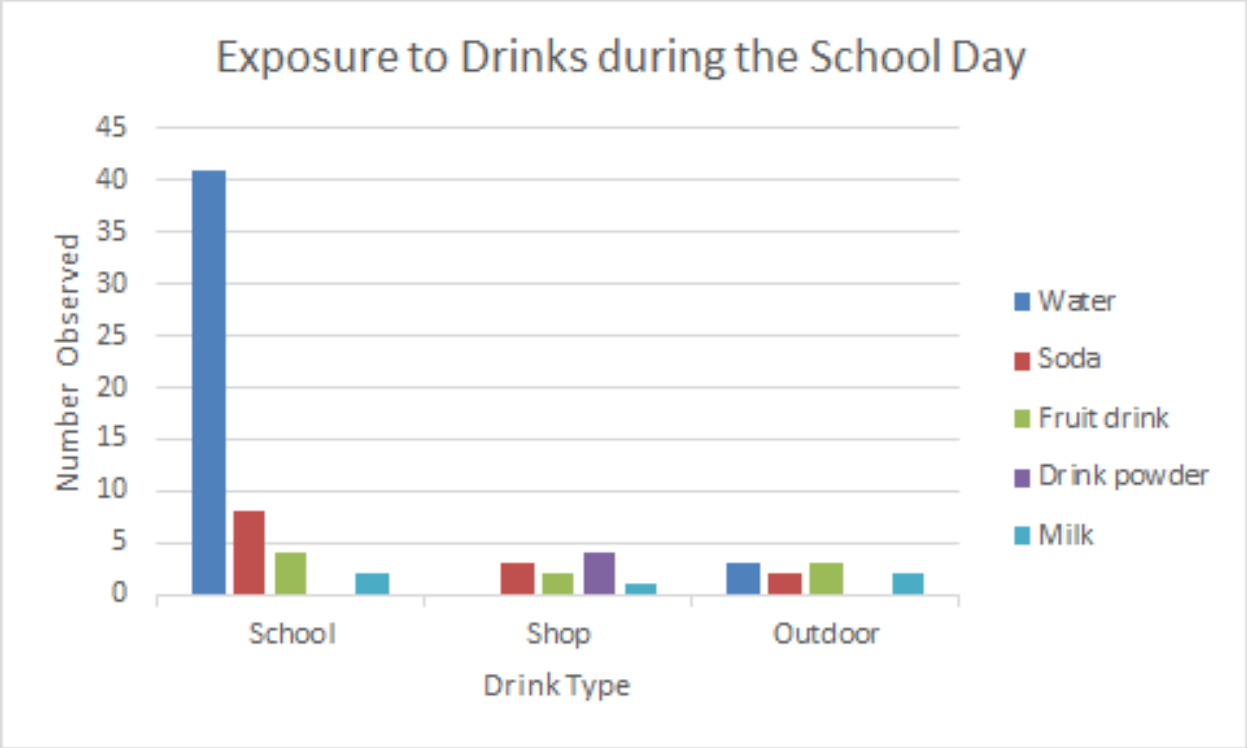


Figure 6:The overall exposure to beverages, consumed, available and observed during a school day

The graph above shows overall exposures to beverages, consumed, available and observed, in the participants during a school day, which is defined as the period of time from leaving home in the morning on a Friday, to their arrival home in the evening on Friday.

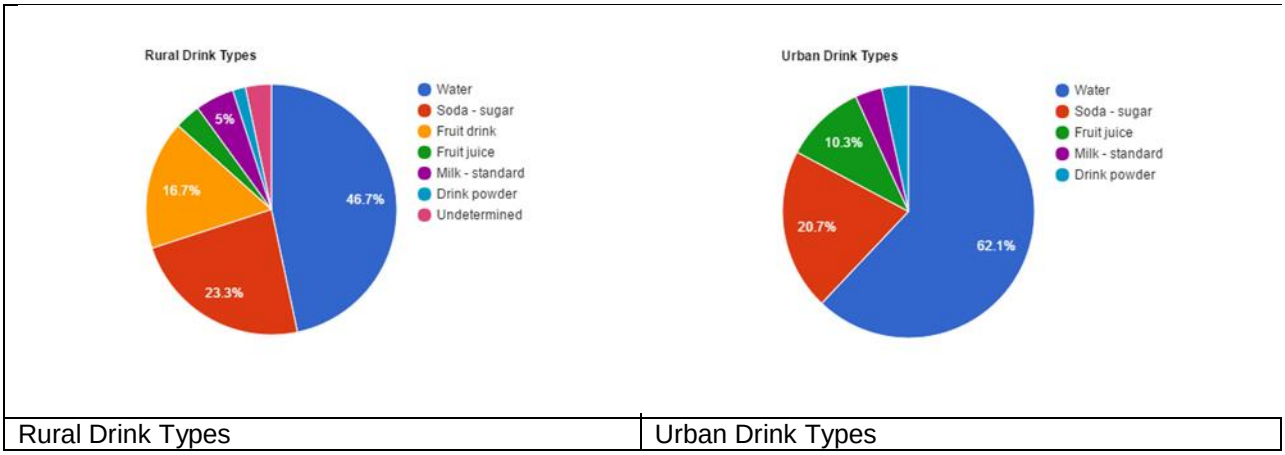
When comparing males and females, it was noted that females consumed more water overall. The instances recorded of females and males drinking water were 59% and 46% respectively. The consumption soda drinks was equal at about 20%, however, the consumption of fruit drinks by males and females was 23% compared to 7% respectively.

There was also a comparison made between urban vs rural participants. The most common drinks consumed in both areas were water, soda-sugar and fruit juice. However, there were some differences in the number of instances recorded as shown in Table 6. Of interest, in urban areas 62% of instances recorded were of water compared to 47% in rural areas.

Table 6: Comparison of the number of instances of each drink type in rural vs urban areas

Drink Type	Rural	Urban
Water - bottled	16	12
Water - tap	9	6
Water - glass	3	0

Fruit drink	10	0
Fruit juice	2	3
Soda - sugar	14	6
Milk - standard	3	1
Undetermined	2	1
Drink powder	1	0



Rural Drink Types	Urban Drink Types

Figure 7:Comparison of the percentage of each drink type in rural vs urban areas

The study also looked into where the children were consuming these drinks. It was found that around the home was where most of the instances that soda and fruit drinks were consumed, closely followed by outside other which is mainly representative of consumption of drinks which were purchased by children at *fale koloa* to and from school.

The matching score after the validity testing for the drinking coding schedule was 0.815. This indicates there was high inter rater reliability in the coding schedule. Most errors (21/37 errors) were in the consumed category - which is not surprising given that this was arguably the most subjective category for which to code.

Recommendations for Interventions

Overall from our data suggests that the drink consumption of the children of Tonga was just over half water, which is less than ideal for health. This is probably because it was the most accessible drink to them with many bottles being present both in schools and the home, water cylinders in the school grounds and taps at home. This theory of access is strengthened by our finding that of those drinks that the children bought for themselves, 60% were sugary drinks. This indicates that sweet beverages are still

the drink of preference of children if they are able to purchase them for themselves. Therefore, there may be reduced purchase and consumption of such drinks if the sugary drink tax was further increased.

From our analysis of how the children's location influenced the types of drinks that they were consuming it appeared that children were most susceptible to unhealthy beverages at home or to and from home - to combat this parents would need to be educated to raise awareness of the problem of consuming to many sugary drinks. Parents should also be encouraged to not have sugary sodas or fruit drinks available in the house.

Another public health measure which may improve health for children in Tonga would be the fluoridation of water in the water cylinders outside of schools if this is not already in place. These are regularly accessed by the children when at school and so this may have a protective influence on their oral health.

Dairies/Fale koloa

Aims

This research aimed to explore the nature of the *fale koloa* in the context of a Tongan child i.e. to explore the type of products available, where these products were placed and what was advertised. This research also explored when a Tonga child accessed *fale koloa* in terms of their journey. Therefore, the objectives of the research were:

- To investigate a Tongan child's access to *fale koloa* by exploring the length of time spent at *fale koloa* i.e. accessibility to *fale koloa*.
- Observe the general layout and product placement of the food and beverages available in these *fale koloa* which Tongan children access and;
- To investigate whether these visits to the *fale koloa* were the primary reason for their journeys i.e. the context of visiting the *fale koloa*.

Data Collection

The data was collected by scrolling through the appropriate set of images until a *fale koloa* was identified. Images were then closely examined and coded according to the annotation schedule (see Appendix: *Fale koloa*). To ensure accurate collection of data, researchers were assigned a 5 minute break half hourly to mitigate any measurement error. Only images from the Friday and Saturday data were analysed and coded, as Tongan law restricts commercial trade on Sundays. Coding of participants stopped when qualitative saturation was reached i.e. at 12 participants. Definitions for each section can be found in Appendix: *Fale koloa*.

The coding schedule was verified using three images of *fale koloa*, using three different children (one child per *fale koloa*).

Results

Access

Frequency of visits:

Across all 12 participants, the children visited a *fale koloa* a total of 74 times over the two days analysed (Friday and Saturday). This equates to a mean of 6-7 (1sf) visits per child over the two days. There was a large range of values between individual children with one child accessing a *fale koloa* a total of 16 times over the two days, while two other children only visited a single time.

Average time spent:

The mean average time spent overall at a *fale koloa* was 3 minutes and 31 seconds per visit.
As there were a few outliers in terms of the length of time spent at the *fale koloa*, we chose to focus on the median average (however both mean and median are presented in Figure 8 below). The median average for the length of time spent at the *fale koloa* was 2 minutes and 24 seconds. Outliers present in the data were from children spending an extended amount of time at the fale koloa due to reasons not related to directly purchasing products e.g. visiting a friend or relative who worked/lived at the *fale koloa.*

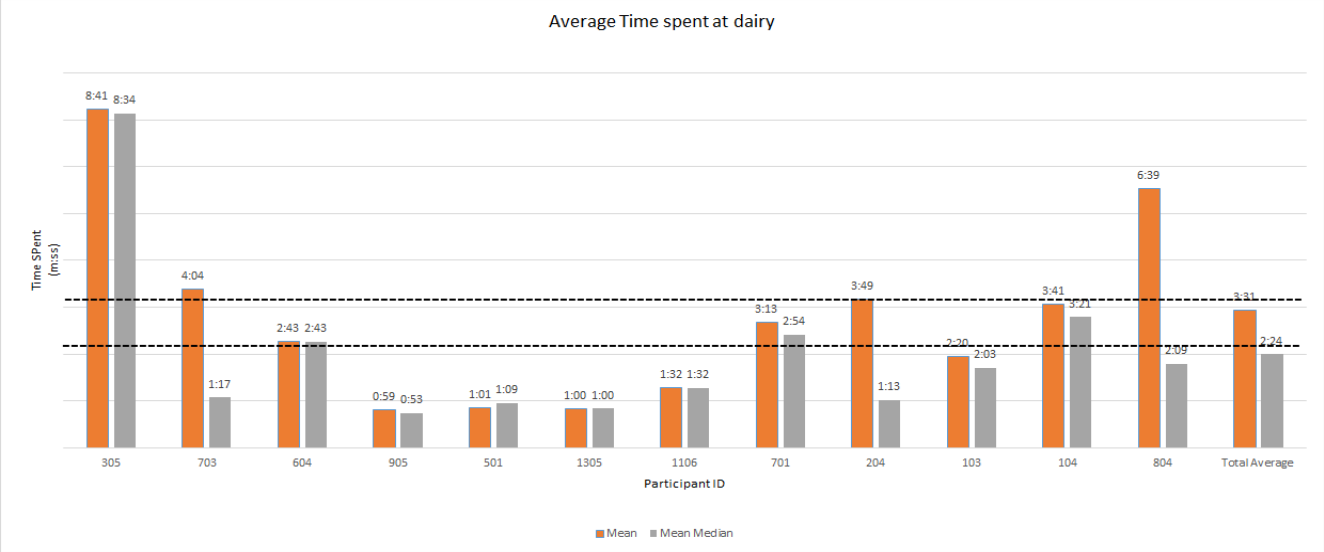


Figure 8: Average time spent at the dairy by each selected participant

Context of Journey:

Table 7:Context of journey to the fale koloa

	Frequency
Destination	59

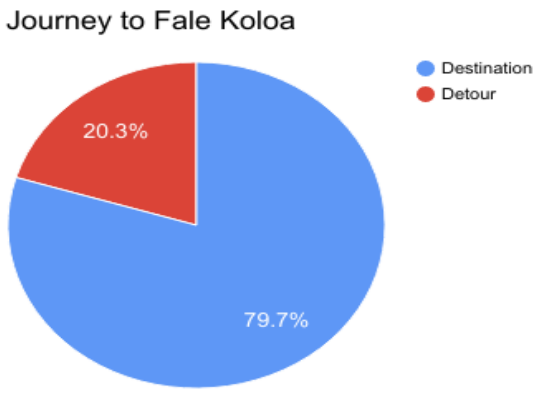


Figure 9:Context of the journey to the fale koloa

Detour	15

The journey to/from the *fale koloa* was most often (80% of visits) for the sole purpose of visiting the *fale koloa* (i.e. the *fale koloa* was the primary destination on a total of 59 occasions).
However, occasionally, children would detour and stop at the *fale koloa* on the way to another destination. There were a total of 15 occasions where the children detoured from their journey to stop at the *fale koloa*. On 8 of these occasions, children detoured on their way to or from school. The remaining detours consisted of deviating from their journey to church or while travelling to a different *fale koloa*, house, park or sports field.

Social context

Table 8: Social context of the fale koloa

	Frequency
Alone	27
Not alone	47

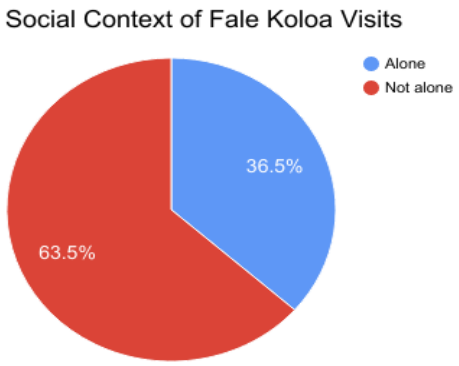


Figure 10: Social context of the fale koloa

Visits to the *fale koloa* were largely a social affair for these children as the majority of the time they were not alone. Of the 47 journeys where they were accompanied by someone else, the children were with peers of a similar age on 36 occasions (77%) and with at least one adult on 18 occasions (38%). On some of these journeys the child was accompanied by both peers and adults, hence why the values add to greater than 47.

Availability

Product placement

Products were most typically stored on a shelf along the back wall (64 occasions (86%)) of the *fale koloa*. The general design of a typical *fale koloa* saw most products being placed behind or underneath the front counter where they were inaccessible to customers. The placement of products on the front bench of a *fale koloa* only occurred on a few occasions. Of the 74 total visits, products were visible on the front bench of the *fale koloa* on only 16 occasions. These included lollies, fruit, chocolate, stationery, bread.
Most *fale koloa* visits (43 occasions or 58% of visits) saw products being hung from the roof or doorway of the *fale koloa*. These products varied but often included sunglasses, hats, hairclips, toys, containers, balloons, underwear, beanies and newspapers. On three occasions, there were potato chips being hung.
A fridge/freezer was seen within a *fale koloa* on 30 occasions (41%) as a means of storing frozen or chilled products for sale.

It is important to note that in general, confectionery, sugary drinks and other snacks that may appeal to children were most often located lower down on *fale koloa* shelving and at eye-level. Other general

household products, health and beauty products and the likes of fatty meats and condiments tended to be higher up on the *fale koloa* shelving.

Products available

Participants were exposed to the range of products within the *fale koloa*, which are represented in the Figure 11 below. The frequency of exposure was calculated by averaging the number of times each child was exposed i.e. the total number of exposures divided by 12 participants. As shown in the graph, sugary drinks had the largest frequency of exposure at 4.7 compared to that of water which had the lowest recorded frequency of 1.8. Other prominent frequencies of exposure were that of imported sweet and savoury snacks (e.g.confectionery products and noodle cakes) and fatty meats (e.g. canned corned beef).
Fruit and vegetables were seen to be exposed to children at a lower frequency (3.5), however, this category of food also included canned fruit/vegetables.

Other products were also recorded by researchers JT and MB, however not reported on. This included other food e.g. condiments and sauces, eggs and peanuts.

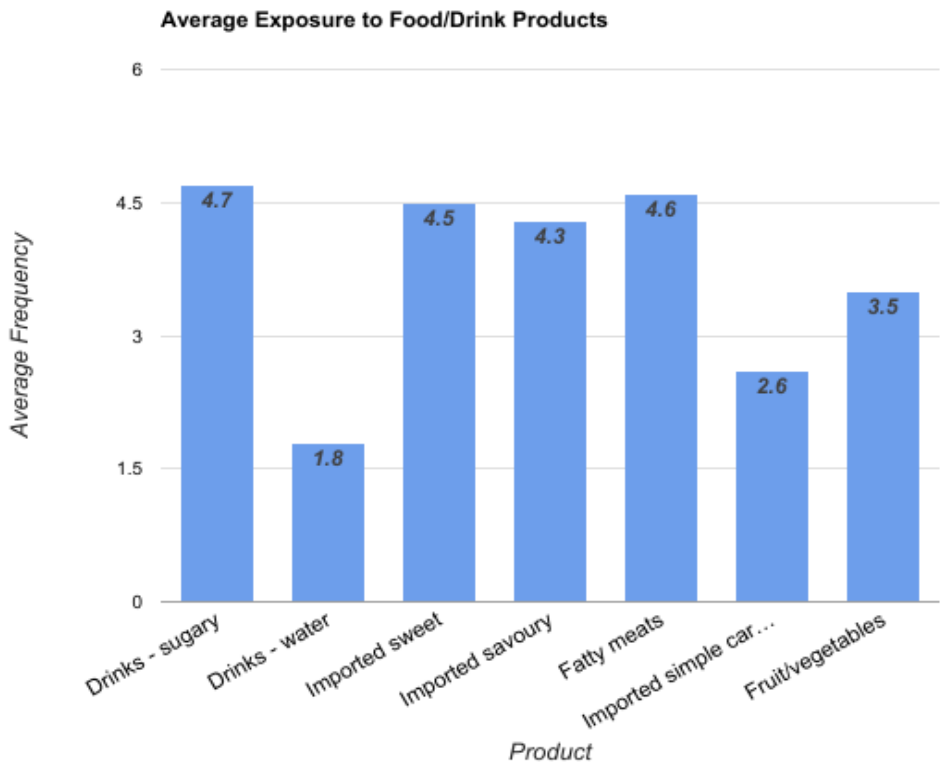


Figure 11: Average exposure to each type of product at the fale koloa per child

Marketing

Images from 40 of the total 74 visits (54%) contained visible advertising (excluding product packaging). The majority (25 occasions) of these sightings were of advertisements for telecommunications networks

available in Tonga i.e. Digicel and TCC. In addition to this, the next most prevalent advertising was for food/drink products (16 occasions) i.e. Milo, Coca Cola Zero, Powerade, ice-cream, mackerel and crisps. 4 of the 12 participants (67%) were not seen to be exposed to any external advertising at the *fale koloa*.

Purchases

On 34 of the total 74 visits (46%), the children were seen to purchase an item during their visit to the *fale koloa*. As some children bought multiple items during a single visit, the total number of items purchased on those 34 visits was 38. Only one of the 12 children did not appear to buy anything on any of their trips to the *fale koloa*, despite visiting on 4 occasions over the analysed period.
Due to the time difference between consecutive pictures, which often varied in length, it is highly likely that we have missed purchases that were made between frames. As a result, our data is potentially under-representing the true number of purchases that these children make when visiting the *fale koloa*.

The majority of items that were purchased (21 items (55%)) were categorised as unhealthy (see table below). All but one of the 11 children who made a purchase, bought at least one unhealthy item. However, the one item this child did purchase was unidentifiable so it is possible that it was, in fact, unhealthy.

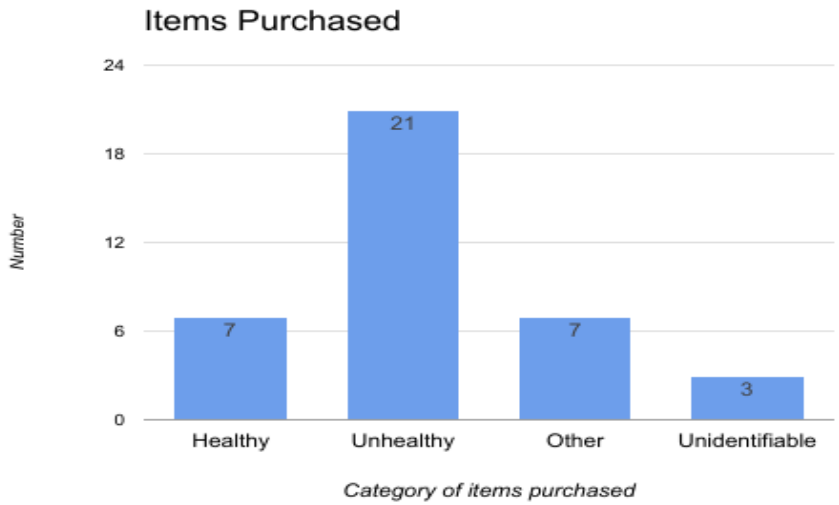


Figure 12:Items purchased by category at the fale koloa

Table 9: Categories of items at the fale koloa

Category	**Items included**
Healthy	Leafy veg, apples, bread
Unhealthy	Confectionery (i.e. lollies and chocolate), jelly cups, sugary drinks, potato chips, iced confectionery (e.g. ice-blocks)
Other	Razors, straws, mop, fake nails, oil

Unidentifiable	N/A

The matching score for the dairy coding schedule was 0.65. This indicates a moderate degree of inter rater reliability.

Recommendations for Interventions

Due to the short time frame of the study, we could not adequately examine the behaviours of children accessing dairies in the mornings or on their way to and from school. We recommend further research in this area in order to provide more solid answers and aid in policy development.

However, this research recommended that there needs to be more knowledge and education for children/their families about unhealthy food choices and behaviours and their impact on non-communicable disease development. Therefore, schools may be able to play a role in education about healthy eating and start programmes to provide healthy meals during school-time.

Restricting access to the *fale koloa* could reduce the number of unhealthy food purchases by Tongan school children. Government policy could be introduced to prevent *fale koloa* being open just before school begins and just after school ends. The sale of items to children in school uniform could also be prohibited. This might prevent children making unhealthy food purchases.

This research also recognises that, as seen in our results, the *fale koloa* does not enable families to easily make the healthy choice and therefore may be driving an unhealthy diet. A policy change may be needed to provide the *fale koloa* with an incentive to change their stock to provide healthier products and/or limit the sale of confectionery/sugary drinks and other unhealthy snack foods. at peak sale times or to children in general. Further to providing pathways to make the healthier choice, a front of pack food star rating on product packaging (or a similar concept) may be introduced so that Tongan families are able to assess the quality of food products they are considering for purchase at the *fale koloa*.

Screen-time

Methods

We analysed photos from 11 children who were chosen via randomisation. For this part of the project we used terms and definitions from a Master's thesis authored by Belinda Lowe (27), based on similar research with New Zealand school-children (4) to determine definitions and categories of screen-time and how to record and analyse what was seen in the photos.

We defined 'screen-time' as being any image seen in the photographs which included a 'screen' (see Appendix: Screen-time, Table 1). This assumed that the child wearing the camera was engaging with the screen as their main activity. When recording screen-time we noted the type of activity the child was carrying out (see Appendix: Screen-time, Table 2). We recorded times when a 'background' screen was present in two or more consecutive images, as 'background' screen-time could still influence viewers.

‘Screen-time’ was recorded starting from the timestamp of the photo in which a particular screen first appeared to the timestamp of the photo following the last seen image of the same screen. Images which showed a screen and showing any kind of activity with the screen but which did not show the screen in the photos immediately before and after were not recorded, as the data of zero apparent ‘screen-time’ could not be included in the analysis. However, this occurred very infrequently. Following this rule, the recorded screen-times are referred to as ‘screen-time sessions’. In the case where a child left the screen, for example, walking out of the room to retrieve a snack, and went back to engaging with the screen, the total time was recorded from the first interaction with the screen to the photo immediately after the subject’s last interaction with the screen. A ‘last interaction’ was recorded as the last image in which the screen was present which was followed by the subject child engaging in another activity (such as playing an instrument) or leaving the room to engage in another activity. This was also the recording method used when the child was sharing a tablet or mobile device with one or more other children, and they were passing the device around (i.e: taking turns) while playing an on-screen game.

Other coding criteria which we adhered to when recording screen-time include an ‘Eighteen-image Rule’, a rule for ‘Partially blocked images’ and a ‘50% Certainty Rule’ which have been used in similar past Kids’ Cam research (see Appendix: Screen-time).

The coding schedule was validated using two children over one day each.

Results

We have analysed data from 11 children involved in Kids’ Cam and have recorded the mean screen time over 3 days to be 2:03:46. However, the screen-time amongst the children varied widely with one having no screen-time while others having a screen-time spanning more than four hours as seen in Figure 13 below. This can be largely attributed to the lack of access the various children had. Some children had access to all forms of screen-time such as mobile devices, tablet, computer and television whereas some only had access to the television. This impacted on their screen-time usage.

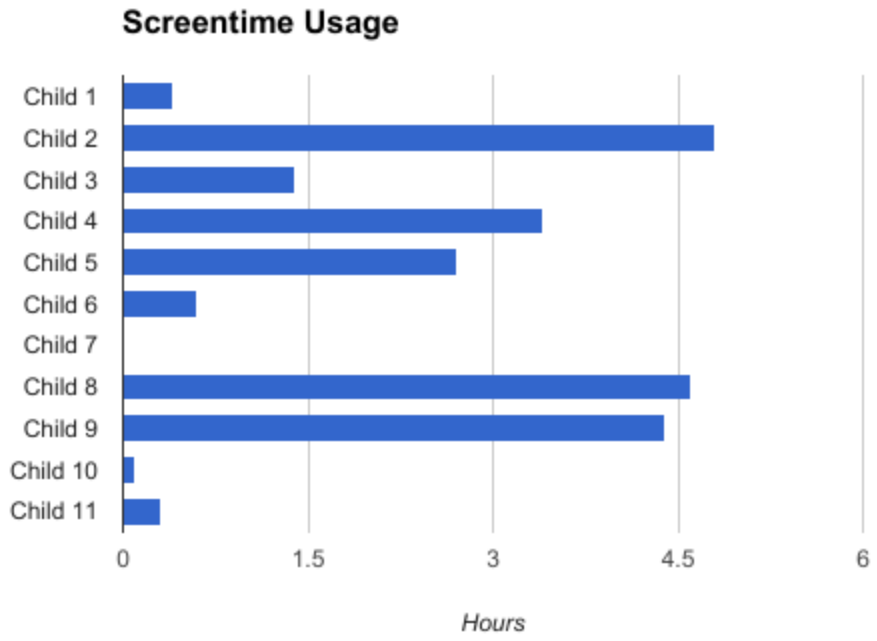


Figure 13:Screen-time usage by child over three days

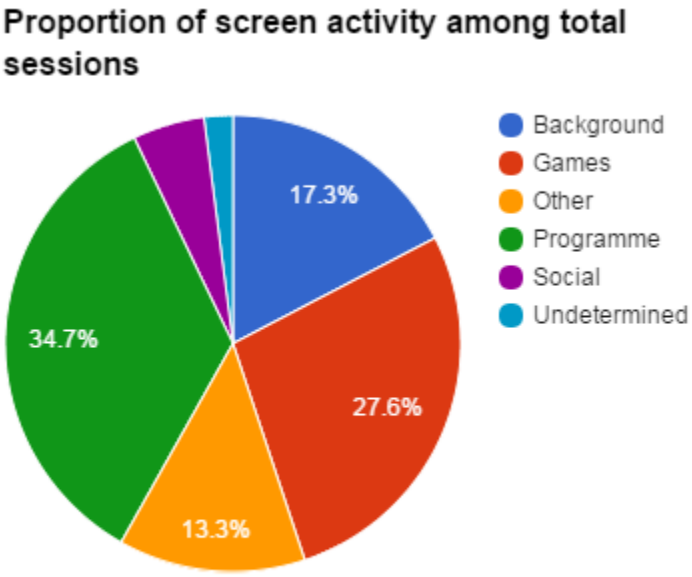


Figure 14: Proportion of screen activities amongst all screen time

As shown in Figure 14, 35% of the children's screen-time involved watching programmes. The children watched a wide variety of programme, with most of it involving cartoons. In terms of games, the children

seemed to play racing games the most. In addition, the children would also use their screens whilst engaging doing other activities. For example, the activities involved mainly social activities where the children would be in a group playing card games while having a screen in the background. The screen in this case was mostly the television. 13% of the time was spent on offline activities such as Microsoft Word or Excel. Only 5% of the time was spent on social media such as Facebook. Facebook was the most common form of social media the children used. Some of the time was undetermined as we could not see what was on the screen.

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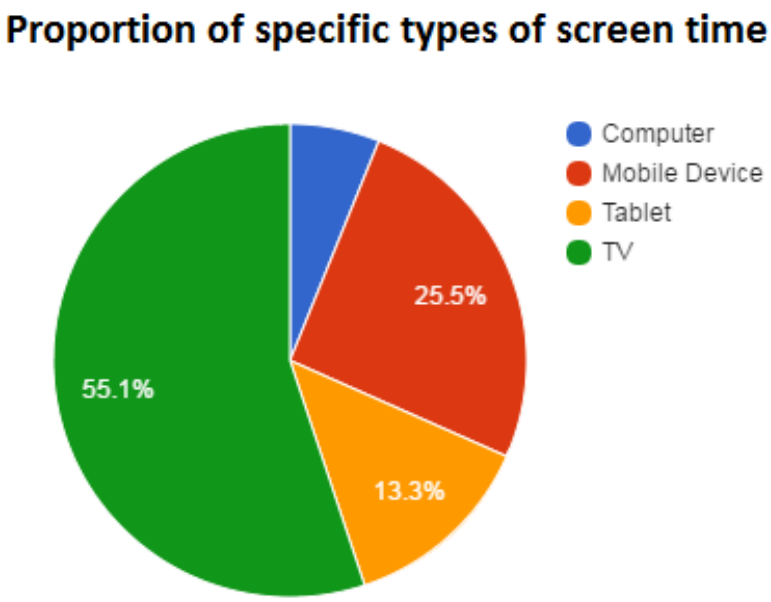

Figure 15: Proportion of specific screen use out of total sessions

The children spent 55% of their time using the television as their main source of screen-time. This was most houses having a television in the living room. However, there were some children whose houses did not have a television. One child in particular who did not have a television in his house had no screen time recorded. The second most popular source was a mobile device. Some of the children had their own phones however most of them were using their parent's or other adult's phones. This was evident as their parent would hand over their phone to them. Not many of the children had tablets or a computer, hence the proportion of specific screen use for those two were low. However, there was one child who did have access to a computer and spent around four hours of screen-time over the three days using the computer alone. This can be attributed to the limited degree of self-awareness of the children, and is due to the fact that most children can keep performing an enjoyable task for many hours with few if any breaks (28). This shows that access to sources of screen-time is important for determining a child's total screen-time.

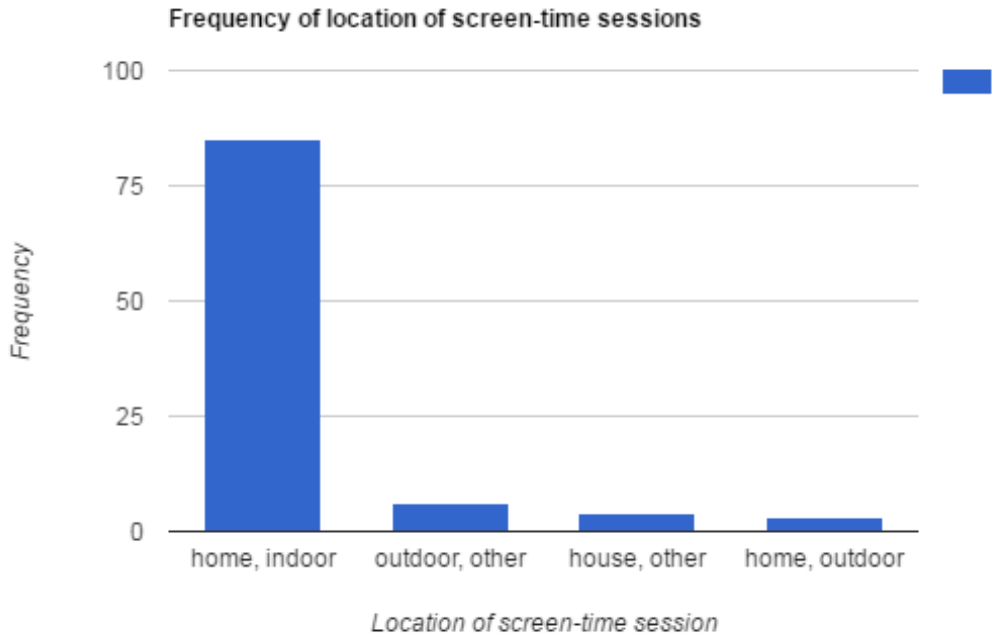

Figure 16: Frequency of location of screen-time usage

As seen in Figure 16, the majority of screen-time was observed at home. This was due to access to the television at home. The contribution of screen time from other homes were due to the child mainly watching television there too. At home outdoors, they spent their time using their mobile devices or tablets.

Recommendations for Interventions:

On average, the children spent 16.67% of their daily lives engaging with any form of screen. This involved mainly watching programmes as highlighted above. When the children did watch television though, they would spend most of their time just in that one position without taking any screen breaks.
Compared to the Kids'Cam study in Wellington, NZ, where children had a mean screen-time of 44minute 52seconds over only a Thursday after-school period, the children studied in Tonga had a much lower total mean screen-time (27).

Benefits of new and traditional media include exposure to new ideas and information, and a way of accessing a range of support networks, via social media. Social media can be used to enhance wellness, and healthy nutrition habits. At the same time, it has been found that exposure to adolescents through media to alcohol drinking and tobacco use has been linked to earlier initiation of these health behaviours (29). Television viewing, the most common activity amongst the screen-time activities recorded, is a risk factor for obesity among children aged 4 to 9 years of age if the viewing session is over 1.5 hours (29). However, these children are older (11 to 13years old). Exposure to blue screen light via screen-time before bed affects melatonin levels and can delay sleep, causing poor performance at school (29).

Extensive viewing of a screen can lead to dry eyes, eye discomfort, fatigue and other symptoms associated with eyestrain, and can be due to various factors such as poor lighting or a glare (28).
Given the frequency and length of television screen-time we would also recommend the use of television advertisements to encourage children in Tonga to have a healthy and active non-sedentary lifestyle (30).
Maintaining or reducing the screen-time might encourage the children to be more physically active, which would be a protective factor for cardiovascular disease.

The matching score for the screen time coding schedule was 0.68. This indicates a moderate degree of inter rater reliability.

Transport

Aim

This section of the study focused on transport from and to school for the children living in Tonga. Our research questions focused on the method of transport, the time taken each trip, differences in gender and rural/urban areas, and reasons for stoppage.

Methods

We assessed 46 participants from the sample population of 72 and because the students wore their cameras over the course of three days (Friday and the weekends), we analysed the photos on Friday which was the only school day. Only the trips that contained photos that showed the entire journey were coded, otherwise they were labelled as unknown.

The coding schedule used is a modified version of the Kids Cam schedule used in Wellington (4).

To calculate the time of the trip to school, the start time was recorded as soon as the child leaves the house. If the child was idle outside the house, the start time was as soon as they started moving. The stop time was recorded as soon as there was evidence that they stepped within school gates. Majority of the time there was sufficient evidence that the child had entered the gates.
To calculate the return trip from school, the same procedure was carried out except the start time was when the child clearly steps out of the school gates and the stop time was when they arrived indoors.

The coding was subsequently carried out on a spreadsheet and the information was analysed according to the headings in the coding schedule.

The matching score for the transport coding schedule was calculated using two children's data over one day each.

Results

A total of 46 children were assessed from a sample population of 72 children. Of those 46 children, two had unusable data and so the results shown here are from 44 children. Of those 44 children, 20 are female and 24 are male. 22 of the children attend a rural school and 22 attend an urban school.

The characteristics of the children assessed are shown in table (10) as follows:

Table 10: Demographics of children selected for transport coding

Sex	Female: n=20	Male: n=24
Location	Urban: n=22	Rural: n=22

Figure 17 shows how many children used which mode of transport to and from school on a Friday in Tonga. It shows that most children walked to and from school (64%). Only 25% of the children whose photos we looked at used a car, while the smallest amount used both modes of transport (11%).

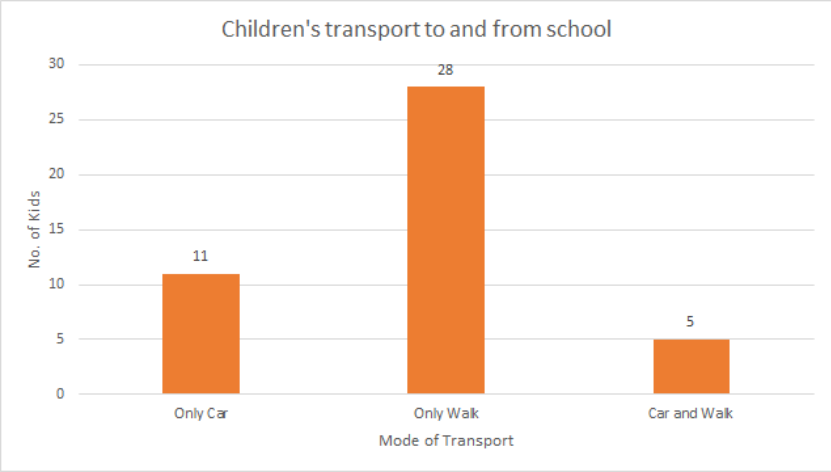

Figure 17: Modality of transport to and from school

Figure 18 shows that on average, a child spends a longer time in a car than walking if that is their mode of transport to and from school. On average a child spends 21 minutes and 16 seconds walking and 31 minutes and 25 seconds travelling by car on Friday as part of their journey to and from school.

Figure 19 shows the average time a child spends in a car or walking depending on their journey to or from school. A child spends much more time on average when going home from school with a car (39 minutes and 48 seconds). Children walking from school also spend a slightly longer time on average (15 minutes and 33 seconds) than children going to school on any mode of transport. The children that walked or took a car to school spent on average 13 minutes and 8 seconds each travelling.

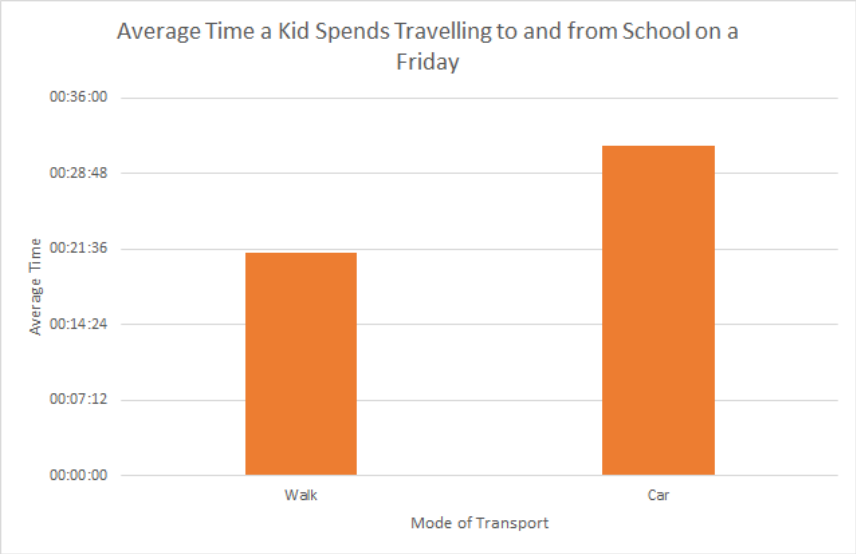

Figure 18: Average time travelling to and from school per child

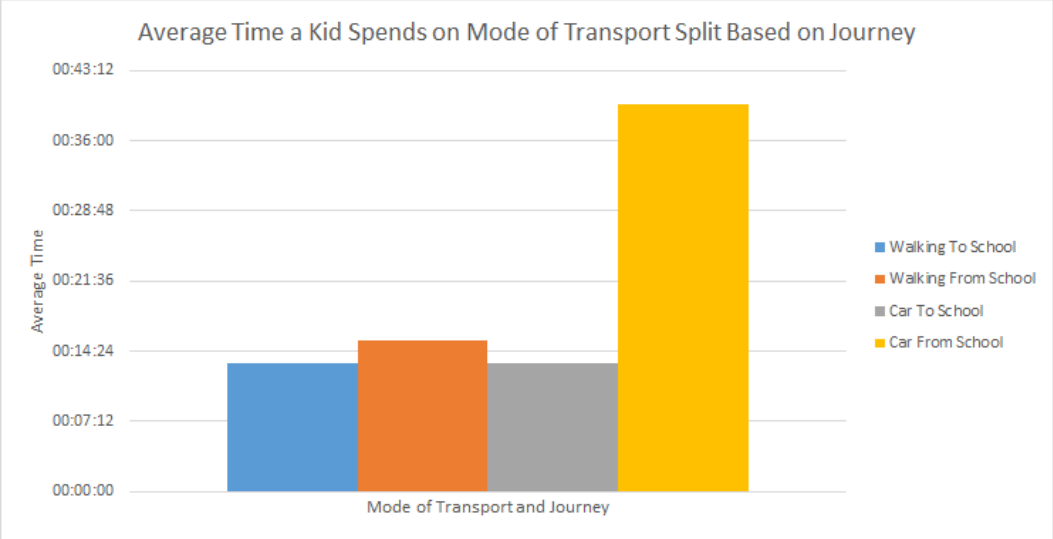

Figure 19: Average transport time per journey split by modality

We compared the mode of transport of children attending a rural school to those attending an urban school. . Figure 20 shows 16 children walked if they attended a rural school, while 5 used a car and only 1 child used both modes of transport. 13 children walked if they attended an urban school, slightly less than the rural school children. The same amount (five) used a car in urban schools as with rural schools while 4 children took both modes of transport in urban schools.

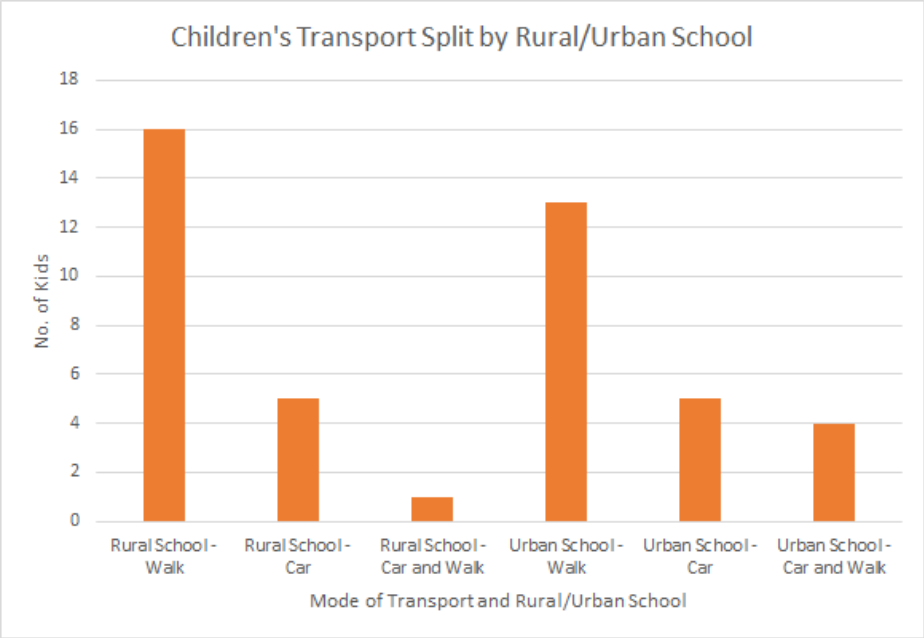

Figure 20: Transport modality split by rural/urban location

The study also looked into the average time a child spends on each mode of transport depending on their attendance in a rural or urban school. Figure 21 shows that the children that attended a rural school spent a much longer time travelling via car (50 minutes and 52 seconds) on a Friday to and from school than anybody else. Those that walked and attended a rural school spent on average 21 minutes and 25 seconds travelling. That is about the same average time as the urban schooled children who walked and took a car - 19 minutes and 52 seconds and 21 minutes and 57 seconds respectively.

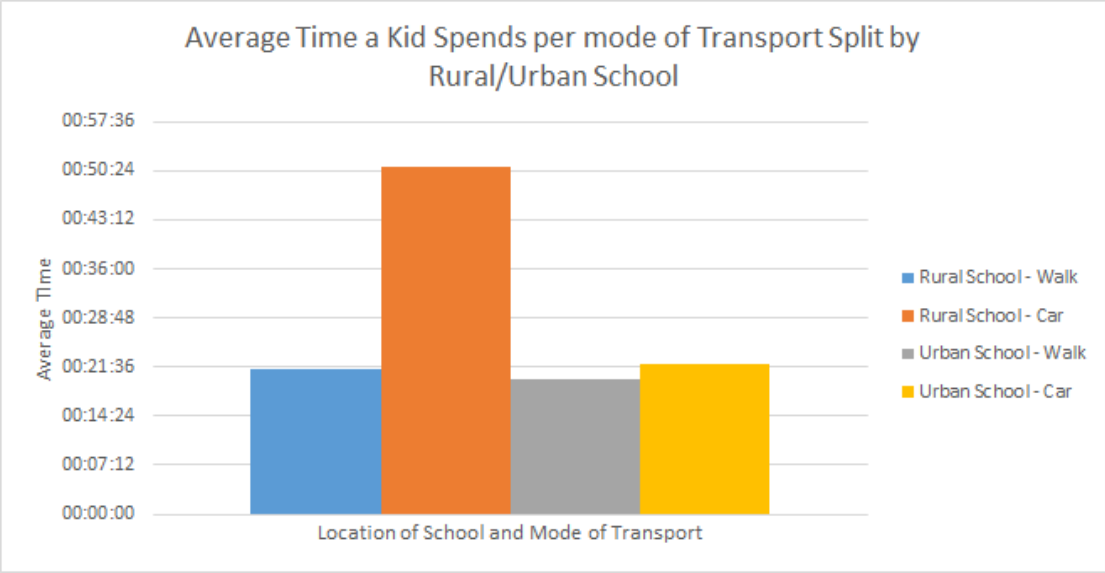

Figure 21: Average transport time split by modality and by location

In addition, gender differences in transport time was also measured and on average, males spent on average an average of 11 minutes and 9 seconds to school and 20 minutes and 1 second from school.

For females, an average of 16 minutes and 16 seconds were spent on the way to school and 17 minutes and 31 seconds from school. There does not appear to have large differences between males and females in this aspect of transport. This is shown by Figure 22.

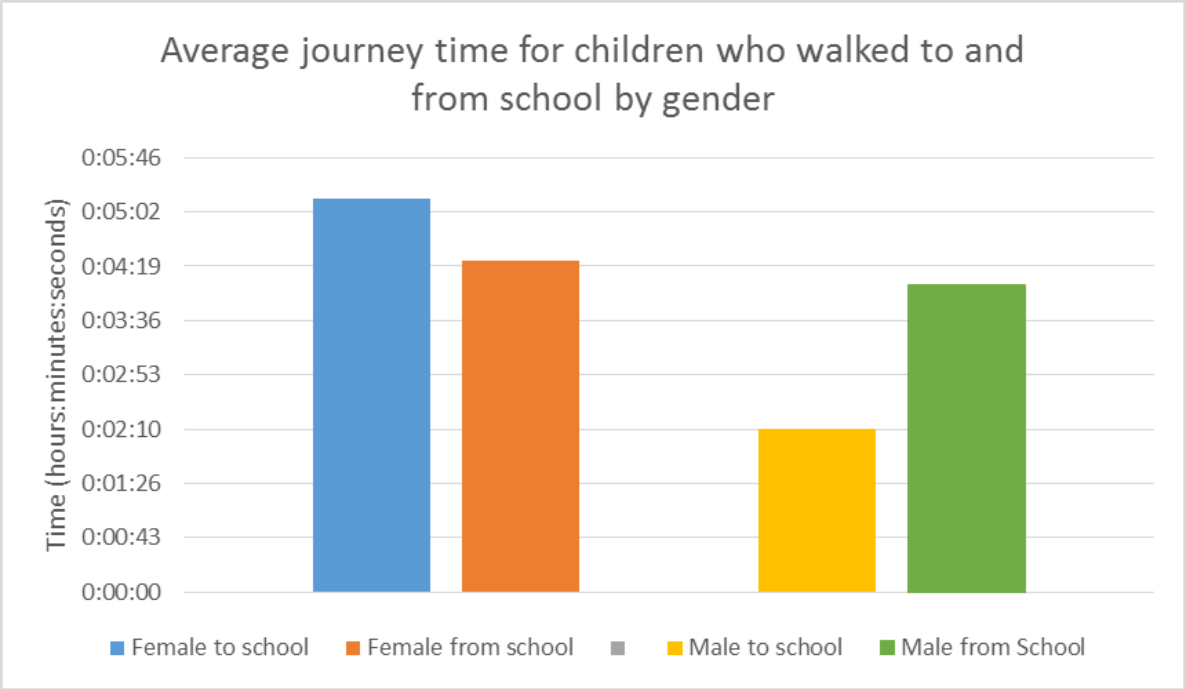

Figure 22: Walking journey time split by child's gender

As part of the study the reasons for the children stopping in their journey to and from school was analysed. Table 11 and Figure 23 show that the reason most children had in pausing their journey between home and school was for food (18 instances). Stopping at a building occurred in 13 instances, while stopping to play happened 8 times. There was only one instance where a child stopped waiting in a car, and one 'other' instance, when a car stopped because the family had to fill the car with water.

Table 11: Frequency of reasons for stopping

Reason for Stopping	**Instances**
Food	18
Building	13
Playing	8
In Car	1
Other - Fills car with Water	1

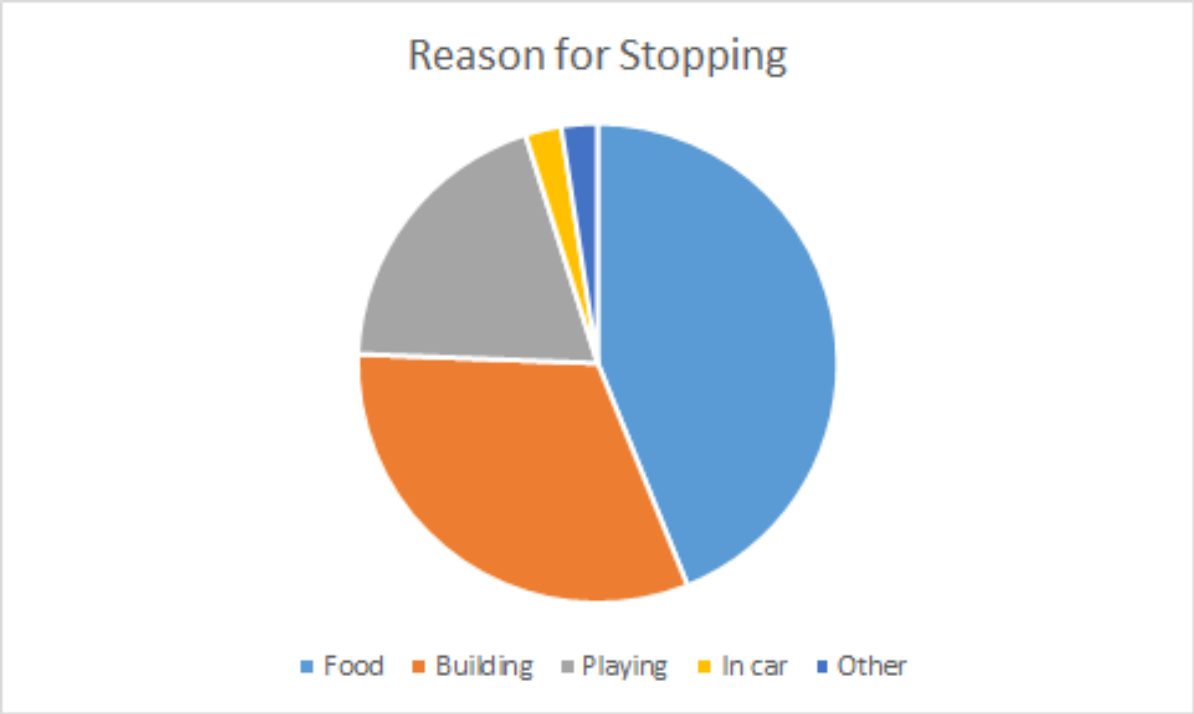

Figure 23: Proportions of reasons for stopping

The matching score for the transport coding schedule was 0.867. This indicates a high degree of inter rater reliability

Recommendations for Interventions

Because we have sampled a large proportion of the children selected from Kids'Cam Tonga, we can have confidence in our results and our recommendations.

From the results it was shown that there is not a problem the children's active transport to and from school as most walked rather than ride in a car as shown in graph 1. This is probably due to how close the children's homes are to school - shown by the average time they are spending walking to and from school in a day in figure 18 - making walking a very viable option. Also, cars are not as commonplace in Tonga as they are in New Zealand, though the number of automotives are growing (31).

Figure 18 also shows that children who took the car to and from school spent a longer time travelling on average. This could be because those who use a car as a mode of transport of getting to and from school live further away and walking is not as viable as an option. This is supported by Figure 21 as well where children who attended a rural school and used a car spent much more time on average travelling than rural school children who walked and all the urban children. It shows that a big reason children who do travel by car do so is because they live far away from school where walking might take too long. Children who attend urban school are more likely to live in urban areas where everything is more compact than in rural areas.

So based on this it is not appropriate we believe to recommend that more children have to walk to school because they are lazy. It appears that most children are already engaging in active transport to and from school, and those that use a car do so because they live far away. Drawing from these results we believe that children's transport to and from school in Tonga is not a non-communicable disease risk and that a recommendation to affect their transport would be fruitless. Changing government policy to intervene in the transport of children of this age is likely to result in perverse outcomes, rather than beneficial outcomes.

Smoking

Aim

The purpose of this section of the study was to determine how often children were being exposed to smoking and tobacco products, and where exposure was most common.

Methods

We analysed the photographs by first referring to the demographics sheet provided to us. This provided us much information, including gender, and whether or not they were exposed to smoking in the home or in other areas. We decided to only analyse the photos of those that reported smoking in the home, as it quickly became obvious that children spent most of their time at home on the weekends. As such, this would maximise our chances of seeing exposure to smoking or tobacco products.

Two members of the group would then take the subsections, listed in the demographics sheet, and pick out those that answered yes to being exposed to smoking at home. From the eligible 36 in the first 6 schools visited, 18 of those indicated smoking at home.

Each member would then look at each photo taken by the child, regardless of whether they were at home or not. If any smoking was suspected, the other member of the pair would confirm or question it, and the child number, time, and date would be noted down. This also occurred for other items like tobacco products and cigarette packing.

Incidence of exposure to 'smoking kills' signs were also noted down in a similar manner.
This search strategy was validated by having another group assess whether the photographs contained instances of something smoking related.

Results

From the 18 children that met the eligibility criteria, 178,807 images were analysed. As the images were taken every 7 seconds, this equates to 14.5 days of real time.

From our analysis done, we found 3 incidents of smoking exposure from being around smoking adults, 2 incidents of interaction with cigarette packaging, and 6 "smoking kills" signs.
From this, we can conclude that from the children we analysed, those that reported smoking at home

were exposed to smoking once every 5 days. However, we can also make the statement that those that reported smoking exposure at home were exposed to ‘smoking kills’ signs every 2.5 days. This is possibly because these were mainly seen in the *fale koloa* and shops.

Recommendations for Interventions

From the limited results we were able to find, we can say that the children who were exposed to smoking at home were seeing ‘smoking kills’ signs more frequently than exposure to actual smoking. However what we do not know is whether these ‘smoking kills’ signs were being noticed by the children, let alone having a thoughtful impact on their attitude to smoking.

We therefore find it may be appropriate to conduct another study, targeting the same age group of children, but interviewing them about their attitudes towards smoking, their relevant to exposure to smoking, and their perception on these ‘smoking kills’ signs.

Discussion

Key Conclusions from Each Section

The consumption of drinks in Tonga amongst these children appears to be split evenly between water and drinks high in sugar. Drinks high in sugar are evenly split between soda, fruit drink and fruit juice. These children have a high intake of sugary drinks compared to recommendations (32).

Overall these children use active modes of transport where appropriate. Children who spend long periods of time in cars are generally travelling further than children who are walking, suggesting that intervention in this area is unlikely to improve rates of active transport.

The *fale koloa* was visited frequently by children in Tonga. However, there were low levels of advertising stimulus. Although unhealthy and processed food products were present to children at their eye level, they were largely inaccessible, and it is unclear how salient those stimuli are to the children. Purchases were largely unhealthy products.

The children who report that they are exposed to smoking at home experience a very low rate of exposure to smoking, and are in fact exposed much more often to anti-smoking messages than to smoking.

This study found that the children were engaged in moderate levels of screen time, and that half of this time was spent watching television, and half of this time was spent on other screen modalities.

The children's diet does not adhere to recommendations for fruit and vegetable consumption. It would appear that while at school, high levels of processed food consumption is occurring.

General Impressions of Risk Factors for NCD's in Tonga

These children are active children. The children who participated in this study appear to spend a lot of time outdoors and are generally active during that time. These children do not appear to eat a lot of unhealthy food, and are generally engaged in active transport. Overall, while there is some area for improvement, such as reducing access to unhealthy products at the *fale koloa* and increasing the percentage of water intake, the children studied have on balance seem to have a healthy lifestyle.

This study observed the risk factors for NCD's in children 11 - 13 years old in Tonga. Reports like the STEPS report (1) and the census data (18) suggest that the children at the age of 13 - 18 are picking up some of the risk factors that make population of Tonga at such a high risk of adverse NCD outcomes. Broadly, unhealthy diet is the most prevalent risk factor for these children, and some recommendations can be made to improve the health of these children in this domain. However, other risk factors are not as substantial for the children. These children engage in active transport and largely consume water as opposed to sugary drinks. These children are also not exposed to a lot of smoking.

Potentially there is an accumulation of risk factors beyond the age of 13 for these children. In order to make firm recommendations for areas of intervention which may lead to significant health gains, it would be good to know whether food and drink consumption change over these children's teenage years, and whether they switch from active modes of transport into inactive modes of transport. It would be

particularly interesting to consider how exposure to smoking changes over the children's teenage years because the census data suggests that the children are picking smoking up between the ages of 15 to 18.

Comparison to Literature

There is very little literature on health and NCD risk factors in Tonga. Using 'Tonga' as a keyword search in MEDLINE (Ovid SP) produces 226 results, of which 67 were immediately relevant to the parameters of this study.

Similarly to adults in the STEPS report (1), most of the children analysed are not meeting recommended intakes of fruit and vegetables. The Global School Based Student Health survey reported the prevalence of the children aged 13 -15 achieving adequate intake of fruit and vegetables is 38.7%, although this number is likely to be much higher than the true value, due to social acceptability bias (2). These younger children are not meeting the recommendation over the days measured.

In line with a study by Cacavas et al (24), it would appear that diet habit for these children at school if poorer than elsewhere. The study by Cacavas et al (24) included a large number of adolescents between the ages of 11 and 22. They also suggest that school would be a good place to target dietary interventions for this reason.

In the Tongan children there does not appear to be a difference between the sexes in the energy expenditure in transport. This is in contrast to the STEPS study (1) which showed that men expend more transport related energy than women. This is likely to be due to the social structure of Tonga, and boys and girls have much more similar expectations than adult men and women.

Amongst 13 to 15 year olds in the Global School Based Student Health survey (2), 28.8% reported watching more than three hours of TV per day. Our study found that children on average watched screens for around 2 hours over three days, which is much lower than what you would expect if the 11-13 year olds had the same rate of watching television as the older children and the amount of screen watching was normally distributed. Our findings suggest that amongst the children who watch screens, there is a sub group who watched a lot of screens. It may also suggest that older children watch television more than the 11 -13 year olds. The Global School-Based Student Health Survey may underestimate the screen time that children are exposed to, because roughly half of screen time is not on the television.

This study is the first that we are aware of that looks the nature of the *fale koloa* in Tonga, or anywhere in the Pacific. This study shows that the *fale koloa* does not appear to contribute substantially to the visual burden of NCD risk factors, but purchases from there are largely unhealthy products.

In line with the census data, much of the lighting in the houses was provided by mains electricity, and many of the houses use gas as their main source of energy for cooking (18).This study shows that cooking often doesn't take place in the house, it often takes place in a separate structure. It also showed what was happening on the inside of the houses. Specifically, this study showed that there was hazardous use of wiring within households, which could be a significant hazard.

This study showed that children in this age group are not exposed to too much smoking in the home, and are exposed to more anti-smoking messages than smoking. This is in-line with the census data (18) which suggests that children pick up smoking between the ages of 15 and 18.

Kids'Cam Methodology

The advantage of using the Kids'Cam method is that the behaviour of the child and the people around them appear to be largely unaffected by the presence of the camera. For example, the images show that some children made multiple trips to dairies during the day, which they might not have made in the presence of an observer. Also, we have found some instances of adults smoking around the children. They may be less likely to engage in those kinds of behaviours if they are being observed by someone associated with health research. Using this methodology we can gain a real life observation of the activities of the children themselves, their peers and the adults around them.

The main methodological limitation of Kids'Cam is that the reliability of the coding decreases as the depth of interpretation increases. When asked to code for the presence or absence of an object within the frame of reference, there is a high degree of inter rater agreement. However, when asked to code for an event that happens outside the frame of reference, there is a much higher degree of uncertainty between coders, and there is further uncertainty when the coder is asked to make a judgement about the images i.e whether there are unhygienic cooking conditions. Therefore, there is a high degree of confidence in findings which show the presence or absence of an object, but a low degree of confidence over any kind of finding that required interpretation of the images. Therefore future studies of the Kids'Cam images should be confined to the presence or absence of objects within the images, rather than trying to make interpretations about what the children might be doing. Where this is being attempted a group of researchers need to agree on a set of definitions and train on the data set for an extended period of time before the coding commences.

One limitation that is particularly relevant to dietary intervention is that we can only assess the type of food and drink consumed rather, and can only make very rough estimates about the quantities consumed. We have identified the type of food as a potential NCD risk factor, but we are unable to accurately quantify this with this data. Quantities are likely to have an influence on the risk of developing obesity, and therefore it would be good to learn more about nature of food consumption in this age group.

Recommendations for Future Research

There is not a lot a lot of health research conducted on risk factors in Tonga. Kids'Cam represents a relatively low cost and non-invasive way of measuring the risk factors for NCDs that are present in view of children who largely have yet to develop adverse outcomes such as obesity, smoking and diabetes. However, given the limitations the technology, and the large amount of time required to extract the information from the images, it would be good to quantify the technology against more standard methods, particularly in the Tongan context. One way this could be done is to run a dual modality study. This would involve placing an observer in somewhere such as a classroom at the same time as some children had the Kids'Cam and assess the prevalence of risk factors (such as processed foods and drinks) using both methods. This would highlight the strengths of each method, and assess the value of the Kids'Cam methodology beyond traditional surveys of risk factors.

Although this methodology allows the researcher to see the environment in which the children are living, it does not tell us what the children notice and what parts of their environment they are paying attention to. It is important to pair Kids'Cam data with interview data from the children. Questions could include "when you go to the *fale koloa*, what do you see? How does what you see make you feel?" and "Do you notice stop smoking signs? Do you see them more or less often than you see people smoking? What does that make you think about?" These kinds of question would start to address a more fundamental question, what are children thinking about the world around them. This is particularly relevant to diet. It is likely

some of the observed risk factors within the context of Tongan schools are culturally determined, such as children buying food for lunch during the day and having unstructured meal times during the day. This matters for determining the efficacy of intervention efforts, because having healthy meal available to the school children is unlikely to make a difference if the children are unlikely to uptake that initiative. Future studies could look at specifically what children of this age group think about meal times during school, and what they think about different kinds of food.

Conclusions and Key Recommendations

These children appear to live quite healthy lives in general. The biggest risk factor identified in this study is the children's diet. Interventions based in Tongan schools, such as providing lunch in schools might go a long way to improving the diet of these children. Decreasing access to unhealthy foods in the *fale koloa* by creating incentives for these institutions to stock healthier food items. Other potential sources of risk for NCDs do not appear to be as important for the Tongan context, such as passive forms of transport or excessive screen-time. Our data indicate that there are reassuring aspects of the world which the Tongan children are seeing, and some interventions that might go some way to improving the burden of NCD's in the future.

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Appendices

Appendix: Food

Data Item	Definition	Format
ID	Pre-defined study variable	
Date	DD:MM	DD:MM
Start Time	Time where the food item first appears on photos	HH:MM:SS
End Time	Time where the food item no longer appears on the screen	HH:MM:SS
Cereal		
Milk Products		
Confectionary	Chocolate and confectionary, chocolate coated products	Yes=1
Cookies, cakes and biscuits	Cakes, muffins, sweet biscuits, sweet and savoury pies, sweet and savoury pastries, slices, scones, sausage rolls	Yes =1
Iced confectionary	Ice cream and iced confectionary	Yes=1
Processed meats	Salami, sausages, rissoles and hamburgers, beef jerky and dried meats, bacon, ham, delicatessen meats; chicken nuggets, tinned meats e.g. corned beef or spam	Yes =1
Meats	Non-processed meats	Yes=1
Fruit and vegetables	Any fruit and vegetable	Yes=1
Packaged carbohydrates	Noodles, chips, popcorn	Yes=1
Breads	Any bread type including bread rolls	Yes=1
Sharing	The food items were shared with 1 or more people	Yes=1
Unknown	Any foods that are unidentifiable	Yes=1
Comments		

Appendix: Drinks

In order to gather workable data from the photographs gathered over the three-day exposure in Tonga, we developed a coding schedule. This was based initially on the coding schedule used by the drinks team who worked on KidsCam however was adjusted to be applicable to the Tongan setting. In order to gather information which would be most useful in a public health setting a more detailed analysis was completed on the Fridays when the children were at school, where beverages were coded whenever they were encountered and then subsequently coded when available, consumed or bought. On other days when the children were not at school general beverage encounters were not coded for and only drinking episodes were recorded.

Definitions

- Setting coding: Setting was coded for following the general setting schedule for the project.
- Encounter: When a new drink item is clearly identified in an image. Drink items contain a liquid beverage for consumption. They can include, but are not limited to bottles, cans, and glasses. Powdered drinks are also included, in packets, tins or boxes. Water cylinders from which there are taps to drink/gather water are also included if the child is in close proximity (5m).
- Available: For a drink to be coded as available it must have been in a photograph and also have been easily accessible to the child. The child must have had the opportunity to take the drink if he/she so desired
- Consumed: For a beverage to have been coded as consumed there must have been clear supporting evidence in the image series that the child was drinking the beverage. This can either be through the observation of the drink being lifted and then dropped again, or by the changing level of liquid in the container where no other person has had access to the beverage in question.

The consumption of a beverage was only recorded once per drinking episode. A drinking episode was defined as a continuous possession and/or consumption of a drink with no breaks longer than 4 minutes. If the same beverage was seen several times during the same drinking episode it was only recorded once. However if it was seen after it had been unrecorded for longer than 4 minutes this was recorded as a separate drinking episode.

- Purchasing Drinks: For a beverage to have been coded as 'bought' there must have been clear supporting evidence in the previous images of a transaction taking place which led to the beverage being acquired by the child. This transaction must have been carried out by the child themselves rather than a parent, guardian or other.

Beverage Type Classification

Beverage Type	**Definition**
Milk - standard	Milk from cows that contain no less than 32g/kg of milkfat (FSANZ 2014) (eg dark blue or silver label)
Soda - sugar	Carbonated beverages, soft drinks
Fruit drink	Prepared from one or more of the following: fruit juice, fruit puree, concentrated fruit juice, concentrated fruit puree, comminuted fruit, orange peel extract and one or more of the following: water, mineralized water, and sugars. Contains no less than 50ml/L of fruit (except for passionfruit drink which must contain no less than 35ml/L passionfruit) (FSANZ 2014) eg (e2, G Force, Keri Kids)
Fruit juice	The liquid portion, with or without pulp, obtained from fruit. In the case of citrus fruit, other than lime - the endocarp only of the fruit; It also includes products that have been concentrated and later reconstituted with water (FSANZ 2014) (eg Just Juice, Keri Apple & Mango Juice, Keri Premium Orange Juice)
Fruit Smoothies	A smoothie made from blended whole, raw fruits

Drink powder	Powder bases to be added to milk or water that has NOT yet been mixed; also cordials and concentrates (eg Milo, Nesquik, Raro)
Water - glass	Water contained in a glass
Water - tap	Water from a tap (subcode outside tap/inside tap)
Water - bottled	Water that has been packaged in a bottle; commercial product; may include flavouring but not sugar (eg H2Go)
Undetermined	Drinks that cannot be determined

Appendix: Fale Koloa

Definitions

- Fale Koloa :According to Tongan language, *fale koloa* is translated to 'house of goods'. In the context of Tonga, the definition of *fale koloa* is very loose, but for this project the majority of *fale koloa* were the traditional concrete-type where most products were located behind the counter so were inaccessible to consumers. Although there was some variation to this. Markets and roadside stalls were not included, along with larger, more commercial super markets and mini-marts. We have used the term *'fale koloa*' interchangeably with the New Zealand term 'dairy',

- Home: This was identified as the residential house/location where the child spent most time out of school. This was synonymous with the location of where the images were first taken when the children woke up.

Annotation of Images

The following headings outline how the data that was coded using a Microsoft Excel spreadsheet. The data headings were coded using a Yes/No (Applicable/Not applicable) coding schedule and then further sub-coded according to the information detailed in the definition column below.
GPS data for the children, and the *fale koloa* they accessed, could not be used, therefore proximity of *fale koloa* to schools could not be analysed.

DATA ITEM	**DEFINITION**	**FORMAT**
ID	Pre-defined study variable	Number e.g. 101
Date	Date pertaining to KidsCam database. Participant images were taken from the Friday/Saturday data which was also recorded in the coding schedule.	DD/MM/YYYY
Time in	Time taken from when the dairy was more than 50% of first image	HHMMSS

Time out	Time taken from the image from when the child was 'clearly' leaving the vicinity of the dairy (the 3-clean-image-rule). This is largely up to the coder to define.	HHMMSS
Total time spent	Difference between Time out and Time in. Calculated using online time difference calculator tool (https://www.timeanddate.com/date/duration.html)	MM:SS
Social context:	Whether the child is alone, accompanied by an adult and/or with peers of a similar age	Applicable to child = 1, Not applicable to child = 0. E.g. Alone = 1, Adults = 0, Peer = 0.
Journey:	Whether the journey to the dairy was a detour (on the way to another destination) or the primary destination.	Applicable to child = 1, Not applicable to child = 0.
Product placement:	Identified the location of products within the dairy and any relevant comments about the location of products. The coding schedule included whether products were located on the front bench, hanging from a doorway or roof, outside the dairy, in a fridge/freezer, on a shelf on the back wall or any other shelving. Comments were recorded for bench and hanging items.	Applicable to dairy=1 Not applicable to dairy=0 Comments = what the products were.
Drinks:	Identified any sugary drinks or bottled water. Sugary drinks includes powdered raro, juice, Milo, energy drinks (V, Powerade etc.), fizzy drinks (e.g. Coca Cola, lemonade).	Applicable to dairy = 1 Not Applicable to dairy = 0
Food:	This identified the following: Imported sweet snacks includes confectionery (chocolate and lollies), biscuits, iced confectionery (ice cream and ice blocks) Imported savoury snacks includes noodles, chips, crackers, popcorn Fatty meats includes canned corned beef, chicken etc. Imported simple carbs includes doughnuts, bread, cabin biscuits, rice Fruit/veg includes both canned and fresh	Applicable to dairy = 1 Not Applicable to dairy = 0
Other goods:	This identified the following: Other imported food/condiments included sauces, oil, milk, other canned food (e.g. spaghetti etc.), spreads (e.g. jam, peanut butter), mayonnaise, salt,	Applicable to dairy = 1 Not Applicable to dairy = 0 Comments = what the

	coffee/tea, baking goods, vinegar, baby formula Imported Health & Beauty products included sanitary products, shampoo/conditioner, oral hygiene products, soap, make-up, razors, tissues, clothing and accessories, deodorant, perfume Household products included cleaning products, washing powder, dishwashing liquid, toys, stationery, decorations Other food products included eggs, peanuts which may be locally grown, comments were recorded about what the 'other goods'.	products were.
Outside appearance:	This identified whether the dairy had any visible advertising and recorded what/who was being advertised	Applicable to dairy = 1 Not Applicable to dairy = 0 Comments = what/who is being advertised.
Purchases: Purchase? Items purchased	This identified whether the child purchased any items from the dairy and recorded what the products were. NB: A value of 0 could mean no purchase was made *or* we were unable to visibly see any transaction being made in the images.	Applicable to Child = 1 Not Applicable to Child = 0 Comments = product purchased.
Other	A description of any additional interesting/relevant information which did not fit under any of the above categories.	What the relevant comments were.

Food Definitions

Data Item	Definition	Format
ID	Pre-defined study variable	
Date	DD:MM	DD:MM
Start Time	Time where the food item first appears on photos	HH:MM:SS
End Time	Time where the food item no longer appears on the screen	HH:MM:SS
Cereal		Yes=1
Milk Products		Yes=1

Confectionary	Chocolate and confectionary, chocolate coated products	Yes=1
Cookies, cakes and biscuits	Cakes, muffins, sweet biscuits, sweet and savoury pies, sweet and savoury pastries, slices, scones, sausage rolls	Yes =1
Iced confectionary	Ice cream and iced confectionary	Yes=1
Processed meats	Salami, sausages, rissoles and hamburgers, beef jerky and dried meats, bacon, ham, delicatessen meats; chicken nuggets, tinned meats e.g. corned beef or spam	Yes =1
Meats	Non-processed meats	Yes=1
Fruit and vegetables	Any fruit and vegetable	Yes=1
Packaged carbohydrates	Noodles, chips, popcorn	Yes=1
Breads	Any bread type including bread rolls	Yes=1
Sharing	The food items were shared with 1 or more people	Yes=1
Unknown	Any foods that are unidentifiable/unknown	Yes=1
Comments		

Appendix: Transport

Definitions

Code	Definition
Transport	
Car	Inside a car, van or truck. Includes if child is on the back of a truck. (Counted once child is inside or on vehicle until outside car).
Bus	Inside a bus (once child is inside bus until child is outside bus).
Walk	Walking or running or jogging (once child is on and until child leaves the street/footpath).
Bicycle	Riding a bicycle anywhere (once child is on bicycle until child leaves bicycle).
Waiting - bus	Standing/sitting at a bus stop
Journey	
To school	Origin of journey is home and final destination is school. (Might stop by at some places on the way).
From school	Origin of journey is school and final destination is home. (Might stop by at some places on the way).
Stopped journey for some reason	
Food	Child stops journey to have food or snack of any kind. Stopped for food in any setting including dairy, restaurants, cafes, etc.
Building	Child stops journey to visit building (could be friend's house, office, unidentifiable building).
Playing	Child stops journey to play or just hang out alone or with friends usually. Includes if playing in playground.

In Car	Car stops and child waits inside/on the vehicle.
Other	Any other reason child stops journey.

To school:
Time starts as soon as the student leaves the house and stops as soon as they appear to have crossed the school gate.

From School:
Time starts as soon as the student appears to have left the school gates and stops as soon as they arrive indoors.

Appendix: Screen-time

Definitions

These are taken from a Master's thesis by Lowe, B (27).

Table 1: 'Screen' categories

Medium	Definition
Television (TV)	Generally an electronic screen that could stand alone, or mounted to the wall
Computer	Includes desktop computer and laptops
Tablet	An electronic screen that does not require a keyboard or mouse, most commonly used for surfing the internet and running applications. E.g. iPads or Samsung Galaxy tabs
Mobile Device	A handheld device, most commonly used for surfing the internet and running applications. Includes smart phones and iPods

Table 2: 'Activity' categories

Activity	Definition
Programme	Watching any form of programme or movie, seen most commonly on a television screen.
Games	Content of the screen appeared to present some goal or objective, with rules and restrictions around obtaining it.
Social	Activities that involved interacting with others. Encompassed activities such as Facebook, Instagram, Snapchat, text-messaging etc. and were most

	often carried out on mobile devices.
Internet	Using websites other than those used for social or gaming activity, and included online shopping and watching videos on YouTube.
Background	Whenever a screen was present in the child's immediate vicinity, and the child did not appear to be fully engaged with it, but could still be influenced by it.
Other	Images where it was clear the child was engaging with a screen, but the annotator was uncertain what was occurring on the screen, this situation most commonly occurred due to an interference of light.
Undetermined	Any screen-based activity other than those described above such as listening to music on iTunes, or running offline programmes such as Microsoft Word and Microsoft PowerPoint

Eighteen image rule

In the event of a completely blocked image, the eighteen image rule was devised to ensure consistency throughout the analysis process.

The eighteen image rule states that a series of fully blocked images can be counted as screen time if the images before and after the blocked image show a screen, and that not more than eighteen images (approximately 2-3 minutes) occur in between. If more than eighteen blocked images occur between two images with screens, the blocked images cannot be included as screen time; they are also removed from total time. The rule, and the choice of eighteen images, was based on previous wearable camera research.

If nineteen or more images elapsed between the images in which a screen is seen, the blocked images would be annotated as 'Uncodable', and also excluded from total time. The argument for the eighteen image rule is that even if the television was obstructed for up to eighteen images (2-3 minutes), if an image showing the screen on appears subsequently, it is unlikely the screen was switched off.

Partially blocked images

The eighteen image rule was also applied when images that were partially blocked, such as by a hand, or when images show a screen and in subsequent images the screen is blocked or not in the view of the camera despite no change in context or environment. If nineteen or more images lapsed between the first and last instance of certain screen-time, they could not be included as screen time, however they would be counted as total time to calculate rates. Partially blocked images were included as total time because it was still possible to determine the setting of the image, and whether the child was still wearing the camera. This is in contrast to images that were fully blocked, as in those instances it was possible that the child had removed the camera, and thus the images were not representative of their true surroundings.

50% Certainty Rule

The 50% certainty rule was used for instances where it was unclear whether a child was watching a screen or not. This situation may occur when the camera did not capture the screen in the image, however from previous and subsequent images it is clear that the screen is still on, and the setting has not changed. If the annotator was more than 50% certain that the screen was still present, and did not breach the eighteen image rule, the image could be annotated as screen time. In any instance where the annotator was 50% or less certain that there was a screen present in the image, the image was annotated as 'not screen time'.

The 50% percent rule was also used when determining whether a screen was on or not, in the instance where the annotator was less than 50% sure that a screen was on, it was not annotated as screen time. This rule was also used when annotating for screen activities. If the annotator was at least 50% sure of what was being carried out on the screen, it could be annotated accordingly. However, if the annotator was less than 50% certain, it would be coded as 'undetermined'.