Social determinants of sugar-sweetened beverage consumption in the Longitudinal Study of Indigenous Children

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Sugar-sweetened beverages such as non-diet soft drinks, cordial and sports drinks are prime examples of discretionary foods (National Health and Medical Research Council [NHMRC], 2013). They are high in sugar, devoid of nutrients, and provide limited satiety (Malik, Schulze, & Hu, 2006). The average serving of sugar-sweetened beverage contains around ten teaspoons of sugar; this exceeds the new World Health Organization (WHO; 2014) recommended daily limit of sugar for an adult, let alone a child. Sugar-sweetened beverages have been demonstrated to have detrimental impacts on health at the individual and population level: among other impacts, they are associated with dental caries (decay) and erosion (Hector, Rangan, Gill, Louie, & Flood, 2009; Jamieson, Roberts-Thomson, & Sayers, 2010), and growing consumption of these beverages is linked to increasing obesity globally (Basu, McKee, Galea, & Stuckler, 2013). These conditions contribute significantly to healthcare costs in Australia (Hector et al., 2009), as well as to health inequity between Indigenous and non-Indigenous Australians (Christian & Blinkhorn, 2012; Vartanian, Schwartz, & Brownell, 2007; Zhao, Wright, Begg, & Guthridge, 2013).

In 2009, Australia was among the top ten highest consumers of sugar-sweetened beverages globally (Hector et al., 2009). There are limited recent data quantifying Australian sugar-sweetened beverage consumption, but extant data suggest that children are heavy consumers from an early age (Bell, Kremer, Magarey, & Swinburn, 2005; Hector et al., 2009). The consumption of these beverages is particularly concerning among Indigenous Australian children, who experience disproportionately high background rates of dental caries (Christian & Blinkhorn, 2012) and obesity (Australian Bureau of Statistics [ABS], 2013), and have a significantly reduced average life expectancy compared to non-Indigenous Australians (Australian Health Ministers' Advisory Council, 2012). Further, Indigenous children are reported to consume sugar-sweetened beverages more often and in

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larger quantity than non-Indigenous children (Hector et al., 2009).

A 2005 survey of 215 children (82 Indigenous) from rural New South Wales, for example, found that sugar-sweetened beverages were the greatest per capita contributor to daily food intake for all participants, with relatively higher consumption recorded among the Indigenous (compared to non-Indigenous) children (Gwynn et al., 2012). Indigenous boys and girls had average intakes of 457 and 431 kilojoules from sugar-sweetened beverages per day, respectively, constituting 6% and 7% of their total daily energy intake. Across three remote Aboriginal communities in the Northern Territory, 16% of total food expenditure from 2010–11 was on sugar-sweetened beverages, compared to 5% on fruit and vegetables (Brimblecombe, Ferguson, Liberato, & O'Dea, 2013).

The benefit of reducing sugar-sweetened beverage consumption among children—both Indigenous and non-Indigenous—is unequivocal. However, the development of effective policies and programs would require an understanding of the drivers of this behaviour. The evidence on correlates of sugar-sweetened beverage consumption among non-Indigenous populations is sparse; overall, the evidence suggests that factors including gender, parental sugar-sweetened beverage intake, family-level socio-economic status, and area-level socio-economic status may influence sugar-sweetened beverage consumption among children, youths and adults (Giskes, Van Lenthe, Avendano-Pabon, & Brug, 2011; van der Horst et al., 2007; Vereecken, Inchley, Subramanian, Hublet, & Maes, 2005).

The limited information on the correlates of sugar-sweetened beverage consumption from non-Indigenous populations may not be relevant for the Indigenous population (Dance, 2004; Shepherd, Li, & Zubrick, 2012a; Shepherd, Li, & Zubrick, 2012b); however, there is a complete absence of quantitative evidence specific to this group (Daniel, Lekkas, Cargo, Stankov, & Brown, 2011; Shepherd et al., 2012b). In 2012, Shepherd et al. conducted a systematic review of research examining the association between socio-economic status and health for Indigenous Australians, identifying only 16 published papers (Shepherd et al., 2012b). None of these studies examined dietary behaviours.

Quantitative evidence on the association between social, cultural and environmental factors (particularly those meaningful to Indigenous people) (Shepherd et al., 2012a) is required if programs and policies are to effectively decrease sugar-sweetened beverage consumption by Indigenous children. Using data from the fourth wave of the Longitudinal Study of Indigenous Children (LSIC), this cross-sectional study uses multilevel modelling to examine the association between sugar-sweetened beverage consumption and an array of social, cultural and environmental factors, including area-level influences.

Methods

Longitudinal Study of Indigenous Children

LSIC arose from the identified need for a longitudinal study investigating the growth and development of Indigenous children in Australia (Aboriginal Early Childhood Symposium, 2006). The study was developed through an extensive consultation process, and community engagement remains an ongoing priority (Dodson, Hunter, & McKay, 2012). The study is managed by the federal Department of Social Services (DSS), and data collection will remain ongoing as long as the funding and sample retention allow (Department of Families, Housing, Community Services and Indigenous Affairs [FaHCSIA], 2009).

In 2008 and 2009, 1,759 Aboriginal and Torres Strait Islander children up to 5 years of age were sampled from 11 sites, based on lists provided by Centrelink and Medicare Australia (Hewitt, 2012). These sites, ranging from Galiwin'ku (Elcho Island, Northern Territory) to Western Sydney, were selected to represent a wide diversity of geography, remoteness, culture, language and socio-economic status (FaHCSIA, 2013).

In the fourth wave of the study (2011), data were collected on 1,283 children, ranging in age from 3–9 years. This dataset provides the first national longitudinal data on Indigenous Australian children, and is publicly available for analysis. Further details on the study design and methodology are provided elsewhere (FaHCSIA, 2009; Dodson et al., 2012).

Ethics

LSIC has ethical approval from the Departmental Ethics Committee of the Commonwealth Department of Health. The study has obtained additional state, territory and regional approval from the relevant bodies, consistent with the NHMRC (2003) and Australian Institute of Aboriginal and Torres Strait Islander Studies (2011) guidelines. The current analysis of LSIC data is conducted with ethical approval from the Australian National University Human Research Ethics Committee.

Data

Outcome measure

The majority of survey data were provided by the child's primary carer (defined as the person who knew the child best; the child's mother in most cases), rather than by the child him/herself. Carers were asked to report what beverages their child consumed the morning, afternoon and evening of the day preceding the interview. Interviewers coded carers' responses to match the categories provided on the survey instrument (categories were not read aloud to participants). The sugar-sweetened beverage variable was derived from the category, "soft drink, cordial or sports drink—not diet"; a binary variable was created to reflect whether the child had reportedly consumed any of these beverages during any of the three time periods.

Individual-level measures

For categorical variables with more than four response options, the original categories recorded in LSIC were collapsed to form 3–4 categories. The cut-off points for categories were chosen to create the most even distribution across groups. Some variables are missing responses; analyses are performed on the subset of data available for each variable.

The demographic variables of children's age, gender and identification as Aboriginal, Torres Strait Islander or both were considered. A variable related to culture was included in this analysis given the recognised importance of culture to Indigenous wellbeing (Dance, 2004; Henderson et al., 2007) and its limited inclusion in previous studies (Shepherd et al., 2012b). Primary carers were asked: "How often do you teach the study child traditional practices such as collecting food or hunting?" This item was selected from the possible cultural variables because of the immediate relevance to diet.

A literature review was used to identify social and environmental variables to include in the analysis. Household- and area-level measures of socio-economic status were included given their potential impact on food availability and affordability (Barosh, Friel, Engelhardt, & Chan, 2014; Brimblecombe et al., 2013; Brimblecombe & O'Dea, 2009; Browne, Laurence, & Thorpe, 2009; Burns, 2004). However, standard measures of socio-economic status may not accurately represent social positioning within Indigenous communities (Shepherd et al., 2012a). Thus, in this study, multiple measures of socio-economic status are included: conventional measures of income, employment, maternal education and household size; as well as subjective ratings of financial strain, worries about money, food security and housing instability.

Weekly family income (after deductions such as tax and quarantined payments), as reported by the primary carer, was categorised as: (1) less than $399, (2) $400–$599, (3) $600–$999, and (4) $1,000 or more.

Primary carers were categorised as employed if they reported working in one or more jobs, or being currently on leave from a job; and not employed if they reported having no job, being permanently unable to work, being retired, participating in unpaid work only, or "other".

Financial strain was measured by carers' report of their family "money situation", categorised as: (1) we run out of money or are spending more money than we get; (2) we have just enough money to get us through to the next pay day, or there's some money left over each week but we just spend it; or (3) we can save a bit or a lot. Carers also reported whether or not their family had experienced "serious worries" about money in the past 12 months. As an indicator of families' food security (Kendall, Olson, & Frongillo, 1995), this study analysed carers' responses to the question: "In the last 12 months, have you gone without meals because you were short of money?"

At the second wave of LSIC, carers were asked to report on their highest level of educational qualification. This question was repeated in Waves 3 and 4 only for new primary carers. This variable was dichotomised as (1) low education: Year 10 or below, and (2) high education: past Year 10.

Two housing measures were included in the study: household size and housing stability. Household size was categorised as 2–3, 4–5, or 6 or more members. Children were considered to have experienced housing instability if their carers reported feeling too crowded, moving, or having housing problems in the past year.

Area-level measures

The Level of Relative Isolation (LORI) indicates the level of remoteness of the areas in which children live. This scale is based on the Accessibility/Remoteness Index of Australia++ (ARIA++) Scale, which uses a purely geographical approach to determine remoteness—it does not take into account socio-economic status, urban versus rural environment or population size. The ARIA++ scale categorises areas as being highly accessible, accessible, moderately accessible, remote or very remote (Department of Health and Aged Care, & National Key Centre for Social Applications of Geographical Information

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Box 1: Multilevel modelling in LSIC

Adjusting for the clustered sample design

The LSIC dataset includes randomised codes for the Indigenous Areas in which participants live. Indigenous Areas are a spatial measure derived by the ABS to improve the accuracy of mapping for Indigenous communities (Pink, 2011). Indigenous Areas represent medium-sized geographic areas, comparable to the Statistical Area 3 for the overall Australian population. There are a total of 429 Indigenous Areas spanning Australia, and 189 of these are represented in the fourth wave of LSIC (with 1–92 children in each area). Because the Indigenous Area codes are randomised, participants cannot be linked to their actual geographic location, but children living in the same Indigenous Area can be grouped together.

Indigenous Areas were not the sampling unit in the LSIC survey; however, the dataset does not release information on the site from which participants were sampled for the protection of privacy. The Indigenous Areas represent a smaller geographic unit than the 11 non-disclosed sites, and have been demonstrated to effectively adjust for the study's sampling design (Hewitt, 2012).

Alignment of Indigenous Area and area-level variables:

- The boundaries used to define the LORI do not always match with the boundaries of the Indigenous Areas used to define the clusters in this study; as a result, there are a few (less than ten) cases in which the LORI varies within a cluster. To maintain a constant LORI across all children within each cluster, LORI was aggregated at the cluster level, using the mode of the LORI among members of the same Indigenous Area.
- The IRISEO is calculated at the Indigenous Area level, and is thus constant within each cluster.

Model development

The randomised code for Indigenous Area was used to identify the clusters. A two-level model was fit, with children at level 1 (n = 1,173), and the Indigenous Areas representing the clustering at level 2 (n = 175). A logistic model was used because the outcome variable (sugar-sweetened beverage consumption) was binary.

First, the appropriateness of the multilevel structure was tested. The LR test was used to compare an empty model with and without adjustment for clustering. The model's fit was significantly improved with inclusion of the Indigenous Area variable, so the multilevel structure was maintained.

Next, variables were added in steps. The first model included age and gender only; these *a priori* variables were retained in the model regardless of their significance. Variables that were associated with sugar-sweetened beverage consumption in the unadjusted univariate analyses (univariable test p value < .25; Hosmer Jr & Lemeshow, 2000) were added in the subsequent models. The child and household (individual-level) variables were added in the second model; environmental (area-level) variables were added in the next step.

After the addition of each set of variables, the significance of each variable was verified. Variables that did not significantly contribute to the model (Wald Z Statistic p value exceeding .05) were dropped from the model. A new model with only contributing parameters was fit, and compared to the original full model using the LR test and AIC/BIC.* If the reduced model was a significantly better fit than the full model, the reduced model was maintained for subsequent steps.

Variables significant in the third model remained in the final model. At this stage, we tested the independent addition of each of the variables dropped from the model. Regression diagnostics were performed to assess the model's adequacy and fit to the data.

Note: * AIC = Akaike information criteria; BIC = Bayesian information criterion.

Systems, 2001). The levels of relative isolation (none, low, moderate, high and extreme) parallel these accessibility categories. Due to small numbers in each, the two most isolated categories were collapsed into one category in LSIC (high/extreme) for the protection of participants' confidentiality.

The Socio-Economic Indexes for Areas (SEIFA), the standard Australian area-level measures of socio-economic status, are provided in LSIC. However, the current study used an alternative measure of area-level disadvantage, the Index of Relative Indigenous Socio-economic Outcomes (IRISEO). This Index is designed to more accurately reflect the level of disadvantage of Indigenous people (Vidyattama, Tanton, & Biddle, 2013). IRISEO is calculated specifically for Indigenous Australians, based on nine measures of socio-economic status (including employment, education, income and housing) from the 2001–2006 Census (Biddle, 2009). As with the SEIFA index, a lower IRISEO level reflects a greater level of disadvantage for an area. Nearly half of the LSIC sample falls into the most disadvantaged SEIFA decile (lowest 10% of the population); the LSIC sample is more evenly distributed across the IRISEO deciles.

Three categories of area-level disadvantage were created for the LSIC sample, based on these IRISEO population deciles: most advantaged (IRISEO 8–10), mid-advantaged (IRISEO 4–7), and most disadvantaged (IRISEO 1–3).

Statistical methods

Summary statistics of the outcome were calculated across the selected individual-level and area-level characteristics. We tested for differences in the unadjusted proportion of children consuming sugar-sweetened beverages across categories using the likelihood ratio (LR) χ^2 test.

The combined effect of these individual- and area-level variables was explored using multilevel logistic regression, enabling adjustment for LSIC's clustered survey design (see Box 1 for details). For each model, analyses were conducted on the subset of children who had complete data on the variables of interest. The final model includes 91% of the original Wave 4 sample.

Results

According to the primary carer's recall, over half (51%) of LSIC children consumed sugar-sweetened beverages the day prior to the interview.

In the univariate unadjusted analyses, the probability of sugar-sweetened beverages consumption was significantly higher among children who identified as Aboriginal versus Torres Strait Islander, who were not taught traditional practices, who had experienced housing instability, who lived in more urban areas, who lived in more disadvantaged areas, and whose primary carers had lower levels of education, were not employed and reported financial strain (see Table 1). There was not a significant association between children's sugar-sweetened beverage consumption and carers' reports of serious worries about money, but this variable was included in model development as the *p* value was less than the pre-determined cut-off of .25.

Age group and gender were entered in the first model, and retained in all subsequent models (see Table 2 on p. 56). Indigenous

Table 1: Distribution of individual- and area-level characteristics and the unadjusted proportion of children consuming sugar-sweetened beverages within each category, LSIC Wave 4

Variable	Number of children	% consuming sugar-sweetened beverages	95% CI (%)
Total	1,282	51.0	(48, 54)
Child characteristics			
Age (n = 1,282; p = .337)			
Less than 4 years	272	48.9	(43, 55)
4–5 years	447	49.2	(45, 54)
5–7 years	266	55.6	(50, 62)
7 or more years	297	51.5	(46, 57)
Gender (n = 1,282; p = .946)			
Female	630	51.1	(47, 55)
Male	652	50.9	(47, 55)
Indigenous identity (n = 1,282; p < .001)			
Aboriginal	1,137	52.8	(50, 56)
Torres Strait Islander	80	31.3	(21, 41)
Aboriginal & Torres Strait Islander	65	44.6	(33, 57)
Child learns traditional practices such as collecting food or hunting (n = 1,267; p = 0.001)			
Never	555	56.4	(52, 61)
Occasionally or often	712	47.1	(43, 51)
Household characteristics			
Education of primary carer (n = 1,176; p < .001)			
Low (Year 10 or below)	505	59.2	(55, 63)
High (past Year 10)	671	44.9	(41, 49)
Primary carer employed (n = 1,281; p = .003)			
No	820	54.1	(51, 58)
Yes	461	45.6	(41, 50)
Family income (n = 1,180; p = .428)			
< $399 per week	217	50.2	(44, 57)
$400–599 per week	289	54.0	(48, 60)
$600–999 per week	363	54.0	(49, 59)
$1,000 or more per week	311	48.6	(43, 54)
Family financial strain (n = 1,274; p = .049)			
We run out of money	165	53.9	(46, 62)
We have just enough money	610	53.9	(50, 58)
We can save	499	46.9	(43, 51)
Food insecure (n = 1,279; p = .998)			
No	1,183	51.1	(48, 54)
Yes	96	51.0	(41, 61)
Serious worries about money (n = 1,274; p = .117)			
No	918	49.9	(47, 53)
Yes	356	54.8	(50, 60)
Household size (n = 1,282; p = .360)			
2–3 members	206	48.5	(42, 55)
4–5 members	592	49.8	(46, 54)
6+ members	484	53.5	(49, 58)
Housing instability (n = 1,281; p = .001)			
No	754	47.1	(44, 51)
Yes	527	56.7	(53, 61)
Area-level characteristics			
Level of Relative Isolation (n = 1,280; p < .001)			
High/extreme	123	33.3	(25, 42)
Moderate	189	43.9	(37, 51)
Low	611	59.6	(56, 63)
No	357	46.5	(41, 52)
Area-level disadvantage (n = 1,282; p = .001)			
Most advantaged (IRISEO 8–10)	246	40.7	(35, 47)
Middle (IRISEO 4–7)	770	54.4	(51, 58)
Most disadvantaged (IRISEO 1–3)	266	50.8	(45, 57)

Notes: CI = confidence interval. The *p* value listed is for the LR χ^2 test, testing for difference in the proportion of children consuming sugar-sweetened beverages across categories. The sample size varies across variables because some variables are missing data. Data on sugar-sweetened beverage consumption were missing for one participant in Wave 4, for a total of 1,282 observations.

Education of the primary carer, housing stability, remoteness and area-level disadvantage are important factors associated with this dietary behaviour and, therefore, health outcomes including obesity and dental caries.

status, teaching of traditional practices, carer education, carer employment, financial strain, worries about money and housing stability were added in the second model; only carer education and housing stability remained significant and were maintained in subsequent models. The cluster-level variables of LORI and area-level disadvantage were added in the third model, and both were significant. All variables remained significant and were included in the final model.

Children's sugar-sweetened beverage consumption was significantly associated with age, the primary carer's education, housing stability, remoteness and area-level disadvantage (see Table 2). Overall, sugar-sweetened beverage consumption was higher among older children, with significantly higher odds of consumption for children aged 5–7 years compared to children less than 4 years of age. There was no significant difference in consumption between genders. Children had significantly higher odds of consuming sugar-sweetened beverages if their primary carer had low levels of education (odds ratio (OR) = 1.64, CI: 1.27, 2.11) or they experienced housing instability in the past year (OR = 1.35, CI: 1.04, 1.74). Compared to children living in the most remote areas, children living in low isolation areas (OR = 3.56, CI: 1.81, 7.01) and urban areas (OR = 3.18, CI: 1.55, 6.55) were significantly more likely to consume sugar-sweetened beverages.

Discussion

These findings provide the first quantitative evidence on the impact of social, cultural and environmental factors on Indigenous children's sugar-sweetened beverage consumption. Education of the primary carer, housing stability, remoteness and area-level disadvantage are important factors associated with this dietary behaviour and, therefore, health outcomes including obesity and dental caries.

In this study, we did not observe a significant difference in sugar-sweetened beverage consumption by gender, despite research suggesting higher consumption by male compared to female children in the Australian

Table 2: Multilevel models examining the association between individual- and area-level factors and the consumption of sugar-sweetened beverages by children in LSIC

Variable	Model 1 (*n* = 1,282)		Model 2 (*n* = 1,175)		Model 3 (*n* = 1,173)	
	OR [a]	95% CI [b]	OR [a]	95% CI [b]	OR [a]	95% CI [b]
Individual-level variables						
Age group (ref. = < 4 years)						
4–5 years	1.08	(0.78, 1.51)	1.14	(0.80, 1.61)	1.18	(0.84, 1.66)
5–7 years	1.38	(0.96, 1.99)	1.55 *	(1.05, 2.29)	1.55 *	(1.06, 2.28)
7 or more years	1.26	(0.88, 1.81)	1.38	(0.94, 2.02)	1.38	(0.95, 2.02)
Gender (ref. = female)						
Male	0.99	(0.78, 1.25)	1.03	(0.80, 1.32)	1.02	(0.79, 1.30)
Education of primary carer (ref. = past Year 10)						
Year 10 or below			1.72 *	(1.33, 2.23)	1.64 *	(1.27, 2.11)
Housing instability (ref. = no)						
Yes			1.41 *	(1.09, 1.83)	1.35 *	(1.04, 1.74)
Cluster-level variables						
Level of Relative Isolation (ref. = high/extreme)						
Moderate					1.63	(0.80, 3.31)
Low					3.56 *	(1.81, 7.01)
No					3.18 *	(1.55, 6.55)
Area-level disadvantage (ref. = most advantaged [IRISEO 8–10])						
Middle (IRISEO 4–7)					1.61 *	(1.03, 2.51)
Most disadvantaged (IRISEO 1–3)					2.55 *	(1.38, 4.70)

Notes: * Significant at $p = .05$. Odds represent the probability of consuming a sugar-sweetened beverage divided by the probability of not consuming a sugar-sweetened beverage. [a] The OR displayed in the table represent the odds of consuming a sugar-sweetened beverage in one group, compared to the odds in the reference group. A significant OR greater than 1 indicates that there are higher odds of sugar-sweetened beverage consumption in the group compared to the reference group. A significant OR less than 1 indicates that there are lower odds of sugar-sweetened beverage consumption in the group compared to the reference group. [b] There is always uncertainty in the calculation of these statistics; there is a 95% chance that the confidence interval displayed includes the true value for the odds ratio.

population overall (Hector et al., 2009). We observed higher consumption among older children compared to those less than 4 years of age; this might be expected with children's increasing autonomy.

The inclusion of multiple indicators of family socio-economic status enabled identification of factors that might be most relevant in this context. Housing can influence dietary intake through a person's ability to store and cook food (Bailie & Wayte, 2006); further, residential instability can have a detrimental impact on wellbeing (King, Smith, & Gracey, 2009). Education can influence diet through pathways including nutritional awareness; in a qualitative study, Indigenous adults in a remote community described the importance of the caregiver's education in determining food choice (Brimblecombe et al., 2014).

Interestingly, household income, as measured by several indicators, was not a significant predictor of sugar-sweetened beverage consumption. This may indicate that income does not influence sugar-sweetened beverage consumption beyond its impact on parental education and housing. Alternatively, it might indicate that different measures of household socio-economic status are more relevant in this context. The conventional measure of household income, for example, may not be meaningful without considering the sharing of economic resources between members of extended families (Shepherd et al., 2012a).

The use of multilevel modelling allowed the examination of area-level influences, a novel approach in the field of Indigenous health research (Daniel et al., 2011). The observed influence of area-level disadvantage on unhealthy dietary behaviour is consistent with the extant literature (Giskes et al., 2011; Vereecken et al., 2005). One pathway by which area-level socio-economic status influences diet is through the accessibility and affordability of healthy foods. For example, a study in Greater Western Sydney demonstrated that the price disparity between healthy and unhealthy foods was greatest in areas with the highest levels of disadvantage (Barosh et al., 2014).

The use of a national dataset enabled examination of variation in sugar-sweetened beverages consumption by level of remoteness. The increased odds of sugar-sweetened beverage consumption in the more urban areas does not indicate that sugar-sweetened beverage consumption is not an issue in remote areas. As previously described in the literature (Brimblecombe et al., 2013; Butler, Tapsell, & Lyons-Wall, 2011; Gwynn et al., 2012; Lee et al., 1994), sugar-sweetened beverage consumption was still high among LSIC children living in remote and very remote areas; however, this analysis uncovered an even higher level of soft drink consumption among Indigenous children within more urban areas.

There is a paucity of research investigating the health of urban Indigenous children (Eades et al., 2010), and the consumption of sugar-sweetened beverages by urban Indigenous children has not been previously quantified. These findings are unsurprising given the burgeoning availability of sugar-sweetened beverages in urban areas; for example, from 24-hour petrol stations, convenience stores, supermarkets and fast food outlets (Barosh et al., 2014; De Vogli, Kouvonen, & Gimeno, 2014). Given the continuing urbanisation of the Indigenous Australian population, this is an important issue to address (Eades et al., 2010; King et al., 2009).

Some community-driven programs and policies have successfully reduced sugar-sweetened beverage consumption in remote and rural areas. For example, in an isolated remote community of around 400 people in the Anangu Pitjantjatjara Yankunytjatjara (APY) Lands, 46,153 litres of sugar-sweetened beverages were purchased from 2007–08, containing an estimated 6.47 tonnes of sugar (Butler et al., 2011). Concerned over this high sugar-sweetened beverage intake, community members developed a store nutrition policy removing the three top-selling sugar-sweetened beverages from their community store (Butler et al., 2011). This community-directed policy halved the community's consumption of sugar-sweetened beverages.

Some community-driven programs and policies have successfully reduced sugar-sweetened beverage consumption in remote and rural areas.

There is no evidence on efforts to reduce sugar-sweetened beverage consumption within urban areas. However, the impact of the

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recent ban of sugar-sweetened beverages in ACT public schools can be evaluated and, if proven successful and appropriate, this policy could be expanded to other areas (particularly disadvantaged urban areas). This policy in isolation would not address all of the factors shown to influence sugar-sweetened beverage consumption. Effective action would require action on education, housing and disadvantage, as these factors all shape a child's ability to engage in healthy behaviours.

Limitations

This study suffers from several limitations. First, causal associations cannot be drawn, given the cross-sectional nature of this analysis. Future research is needed to investigate longitudinal patterns of these associations, and to examine the association between these factors and health outcomes.

This study did not examine the quantity of sugar-sweetened beverages consumed, but rather examined if a child reportedly consumed any amount of these beverages on the day preceding the interview. Further, sugar-sweetened beverage consumption was not directly measured, but was reported by the child's primary carer. Several forms of bias could influence the reporting of this behaviour, such as recall or reporting bias. These recall data have not been validated; however, a similar recall method was used in the Longitudinal Study of Australian Children (LSAC), and much research has been published using these data—including on sugar-sweetened beverage consumption (Fuller-Tyszkiewicz, Skouteris, Hardy, & Halse, 2012; Magee, Caputi, & Iverson, 2013; Millar et al., 2013).

This study explored only a subset of all variables potentially influencing sugar-sweetened beverage consumption, limited by the measures available in LSIC. There are a range of additional factors at both the individual- and area-level that may be associated with sugar-sweetened beverage consumption, including personal factors, parenting practices, community norms, and marketing and availability of these beverages (Hector et al., 2009). The inclusion of additional variables could alter the results of the model.

Methods of variable selection vary widely by discipline and modelling technique, and employing multiple methods to select the variables used in these models was beyond the scope of this paper. The technique used is similar to that applied in other related epidemiological multilevel modelling studies (Ball, Crawford, & Mishra, 2006; Vereecken et al., 2005).

Children's exact geographic location is not available in LSIC, so spatial clustering in LSIC was identified using Indigenous Area codes. There are limitations associated with using a spatial measure to identify neighbourhoods; for example, the boundaries of these areas may not line up with participants' perception of their neighbourhood boundaries, and they may not correspond to the spatial distribution of food outlets, health services or other environmental features with potential implications for health (Riva, Gauvin, & Barnett, 2007).

This study included only children with complete data on the variables of interest, potentially inducing bias. However, we did not observe any significant differences in the characteristic of the sample included in the final model ($n = 1,173$) compared to the whole Wave 4 sample ($n = 1,283$). As LSIC is not a representative survey, this study is not intended to be representative of the entire population of Aboriginal and Torres Strait Islander children; these findings reflect the 1,173 children providing data on these items in 2011.

Conclusion

Health risk behaviours such as diet tend to track throughout life, accumulating across the life course and resulting in increased disease risk (Pearson, Salmon, Campbell, Crawford, & Timperio, 2011). Thus, early childhood is an opportune time for intervention. Setting

Indigenous children off on a good trajectory could reduce their burden of disease in adulthood and progress efforts to "close the gap".

The observed patterning of this behaviour among Indigenous children suggests that although sugar-sweetened beverage consumption is an individual choice, it is significantly influenced by the broader context. Thus, programs aiming to bring about sustained changes to the dietary behaviour and health of Indigenous children are unlikely to be successful if they do not address the context in which this individual choice is made (Closing the Gap Clearinghouse, 2012; Osborne, Baum, & Brown, 2013). This demonstrates the importance of addressing broader issues not confined to the health portfolio; policy development should occur across sectors, including housing, education, employment, social welfare and community development (Daniel et al., 2011; Friel, Chopra, & Satcher, 2007; Osborne et al., 2013; Sacks, Swinburn, & Lawrence, 2008; Senate Community Affairs References Committee, 2013; Shepherd et al., 2012a).

There is limited evidence on effective cross-sectoral policies and programs to encourage healthy behaviours among Indigenous children. Some exemplars do exist, however, and the uniting principles underlying these successful programs should be used to guide program development. Before expanding programs, it is critical to ensure that the programs are transferable (Wang, Moss, & Hiller, 2006); programs need to reflect local interests, to be tailored to suit the needs of individual communities, and to be based on community support and governance (Wilson, Jones, Kelly, & Magarey, 2012). The elevated cost of such programs should be weighed against their broader benefits for the wellbeing of Indigenous Australians and for health equity (Chi, 2013).

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