Trends in soft drink and sugar-sweetened beverage consumption among South Australians, focusing on distribution of intake by subpopulation

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Abstract

Objective: This study focused on describing local trends in sugar-sweetened beverage (SSB) consumption, including variations between subgroups, to inform equitable health policy to curb soft drink consumption.

Methods: Weighted data were obtained from the South Australian Monitoring and Surveillance System, a state-based population health survey that monitors trends in health risk factors and chronic disease via computer-assisted telephone interviewing. From 2008 onwards, participants provided an estimate of the average amount of soft drink they consumed per day.

Results: From 2008–2017, there were significant decreases in the proportion of adults who consumed any SSBs, but the mean consumption per consumer increased. High-risk dietary and lifestyle behaviours are the strongest predictors for consumption of soft drink, but there is also a significant association with socioeconomic status.

Conclusions: Population trends mask increasing inequity. There is a societal trend away from the consumption of SSBs across all subgroups, but at-risk groups who engage in clusters of unhealthy behaviours remain high consumers.

Implications for public health: The identification of at-risk populations allows research to focus more precisely on the structural barriers, beliefs, attitudes and facilitators of ongoing consumption of SSB in order to inform future health promotion efforts.

Key words: SSB, equity, trends, sugar-sweetened beverages

The consumption of energy-dense, nutrient-poor, sugar-sweetened beverages (SSB) is a key public health issue.[1] While there remains debate regarding a causal link between SSB intake and weight gain, possibly due to a number of industry-funded reviews,[1-3] meta-analyses have identified a clear causal association with dental caries[2,4] and type 2 diabetes.[2,5] Additionally, there is developing evidence that higher SSB consumption increases cardiovascular risk by contributing to the development of hypertension, dyslipidaemia, coronary heart disease and stroke.[6-10] SSBs have also been linked, with a smaller effect size, to the development of renal stones, reduced bone density and increased bone fractures.[2,5] Conversely, SSBs do not contribute to any essential nutritional requirements. In 2011, an estimated 0.3% of the total burden of disease in Australia was associated with a diet high in sugar-sweetened beverages.[11]

International literature describes a downward trend in the proportion of adults and children consuming SSBs in developed countries over the past 20 years.[12-15] Although temporal patterns from Australia have also shown a decrease in added sugar consumption, primarily from reductions in SSBs, average intakes still exceed recommended limits.[16,17] Data from the 2016 ABS food and nutrition survey[18] indicated that 52% of the Australian population consume free sugars in excess of the WHO recommendation to limit intake of free sugars to 10% of total energy requirements.[17] This figure rises from 52% to almost 90% if optimal free sugar consumption is considered to be less than 5% of total energy, as is recommended by the UK Scientific Advisory Committee on Nutrition.[17] In the Australian diet, the primary source of free sugars are soft drinks and sports and energy drinks, which account for as much as 18% of free sugar consumption.[18]

Dietary behaviours are strongly patterned by socioeconomic status (SES).[19,20] People living in disadvantage are more likely to consume diets high in energy-dense, nutrient-poor foods and beverages, whereas those more advantaged have a higher quality overall diet.[21,22] Studies in children have demonstrated an association between consumption of SSBs and parents who are less educated and have lower incomes, or who have a greater level of disadvantage.[15,23-26] There are fewer high-quality studies in adults, but Rehm et al. and Park found high odds of regular SSB consumption among low-SES American adults,[27,28] and Han found low SES was associated with higher odds of heavy SSB consumption for all ages.[15] A clear social gradient with lower SSB consumption at higher levels of education was also observed by Elfassy.[14]

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Very few studies have assessed temporal distribution patterns of SSB intake in adults by subpopulation or investigated whether broad temporal changes at the population level are masking developing inequities. Understanding differences among subpopulations is critical, as health interventions that do not adequately take at-risk populations into account may create further disparity through failure to overcome structural inequities.[22] This study focused on describing local trends in SSB consumption, including variations between subgroups, to inform equitable health policy to curb soft drink consumption.

Methods

Data

Repeated cross-sectional survey data were used to describe trends over time. Data were obtained from the South Australian Monitoring and Surveillance System (SAMSS), an ongoing state-based population health survey that has monitored trends in health risk factors and chronic disease in South Australia since 2002. Data are collected via computer-assisted telephone interviewing for approximately 600 randomly selected people each month. Detailed SAMSS methodology has been published elsewhere.[29]

Study population

We used a weighted sample from SAMSS data collected from 2008 to 2017 from participants who were aged 16–64 years at the time of the survey. Participants aged 16 and 17 years were included in the 'adult' cohort as they participated directly in the CATI survey and received the same set of questions as those 18 years and older; whereas, participants under the age of 16 were surveyed as children via an adult proxy with a subset of questions. Adults 65 years and older were excluded from this paper as traditionally this group has a lower consumption of SSBs and expected differences in demographic and lifestyle factors post-retirement had the potential to skew results.

Soft drink consumption

Participants were asked to provide an estimate in millilitres of the volume of soft drink they consumed on an average day. The primary outcome variable was regular consumption (versus non-consumption) of soft drink. Participants who reported consuming >0mL/day were considered 'consumers'. The smallest volume reported was 125mL/day so there was clear delineation between consumers and non-consumers. Volume of consumption was considered a secondary variable.

In these data, the term 'soft drink' is assumed to refer to any sweetened, non-alcoholic carbonated beverage, and examples provided to participants included Coke, lemonade and flavoured mineral water. Both sugar-sweetened and non-nutritionally/artificially sweetened (diet) carbonated beverages are included in the term 'soft drink'. Intake of non-carbonated beverages, such as sports and energy drinks and juice, was asked about in separate questions, and participants were expected to exclude these when reporting on 'soft drink' consumption. Sweet beverages, such as flavoured milks and fruit juices, were excluded from analysis as, despite high sugar contents, they provide some nutritional value and were felt to present a different category of risk to consumers. Hereafter 'SSB' is used in place of 'soft drink'.

Covariates

Other variables reported on included sociodemographic indicators, health behaviour indicators and self-reported measures of wellbeing.

The sociodemographic characteristics included were age (in years), sex, country of birth (stratified into born in Australia or not born in Australia), highest educational attainment (bachelor degree or higher, trade apprenticeship certificate or diploma, completed secondary education, less than secondary education), gross household income, work status (employed full time, employed part-time, not employed, student, retired), rurality based on health region (metropolitan Adelaide, country South Australia), housing (owns own home, private rental, government-funded housing, other) and SES measured by Socio-Economic Indexes for Areas (SEIFA) Index of Relative Disadvantage.[30]

Health behaviours included smoking (daily smokers, occasional smokers, ex-smokers, non-smokers), fruit and vegetable intake (<1 serve, below recommended[31] serves, at least recommended serves), consumption of discretionary 'junk foods'[31] (fast foods and fried potato snacks only, never, less than weekly, more than weekly but not daily, daily or more) and physical activity[32] (no activity, some activity, >150mins/week).

Measures of wellbeing included self-reported health status (coded as good or better, fair, poor or worse), being managed for a mental health condition (yes, no), and presence of limitations due to a significant health problem 'disability' (present, not present). This study also considered people currently being treated for a mental health condition as a proxy for the subgroup of people living with a mental health condition.

Several variables were used to describe at-risk populations. Individual measures such as education level, household income, housing status and employment were examined separately and included in multivariate analysis as markers of socioeconomic disadvantage.

Ethics approval

Ethics approval was granted by the South Australian Department for Health and Wellbeing Human Research Ethics Committee (HREC/17/SAH/13).

Data analysis

SAMSS data were weighted with a raked weighting system so that results were representative of the South Australian population (Australian Bureau of Statistics' Census 2016). Technical documents describing SAMSS use of post-stratification weighting are available.[33]

Data were analysed using STATA version 15 and IBM Statistical Package for the Social Sciences (IBM SPSS) version 24. For each year, the proportion of the sample consuming soft drink for each variable of interest was calculated. Time trends were assessed using Joinpoint 4.7.0.0 regression analyses. This is a statistical method that divides the assessed time period into several continuous linear time periods. These line segments are joined at several time points, called change points or joinpoints. Joinpoint regression analysis identifies the best fitting piecewise continuous log-linear model. In order to assess the relative change in proportion between populations across the time period, the average annual percentage change (APC) for time periods was calculated. Differences were considered significant when the p-value was <0.05. Logistic regression was used to calculate the odds ratio to measure associations between indicator variables, and consumption of soft drink. Models

were adjusted for all variables found to be significant on univariate analysis and both unadjusted and adjusted data are presented.

For those who reported consuming soft drink, mean consumption per year for each variable of interest was calculated. Trends over time were assessed with linear regression. Differences were considered significant when the *p*-value was <0.05 (one-tailed significance test). To assess whether demographic or health behaviours were significant predictors for 'heavy' consumption, self-reported volume of consumption was dichotomised into categorical variables, (0 = consumption below the 90th percentile, or <1000mL/day, and 1= consumption greater than or equal to the 90th percentile, or ≥1000mL/day). Logistic regression was used to assess for associations between demographic and risk factors, and heavier consumption of soft drink. Non-consumers, and those consumers who did not report volume of consumption, were excluded from all analyses examining volume of consumption.

Results

The overall weighted sample available for analysis was 47,201, but missing data restricted the final analytic sample to 46,302. Sociodemographic characteristics of the weighted SAMSS sample are presented in Table 1. The sample included only persons between the ages of 16 and 64 years and the proportion by age groups reflects this selection criteria. The sample population did not include a large enough number of people identifying as Aboriginal or Torres Strait Islander to make separate inferences about this population. The demographics of this weighted cohort are generally comparable to the Australian population.

Trends in prevalence and distribution of SSB consumption

From 2008 to 2017, the proportion of South Australian adults consuming SSBs decreased by an annual percentage change (APC) of 9.6% (Table 2, see tables for all CI). The decrease was observed across all demographic subgroups. The greatest reductions in the proportion of adults consuming SSBs were observed in those who were more socioeconomically advantaged (higher SEIFA) (-12.4%), household income >$100,000 (-14.0%), and those who had a lower risk-factor profile (non-smokers

Table 1: Weighted baseline demographics of adult SAMSS respondents between 2008–2017 according to soft drink consumption status, and mean consumption for each demographic group.

Characteristic (by year group)	All Participants (n= 46,302)		Non-consumer (n= 35,600)		Consumer (n=10,701)		Mean consumption (all participants)
	#	%	#	%	#	%	millilitres
Sex							
Male	22,403	48.4	16,138	45.3	6,265	58.5	157
Female	23,899	51.6	19,463	54.7	4,436	41.5	88
Age Group (years)							
16–24	9,121	19.7	6,819	19.2	2,303	21.5	123
25–44	18,389	39.7	13,617	38.2	4,772	44.6	140
45–64	18,791	40.6	15,165	42.6	3,626	33.9	102
Rurality							
Metro Adelaide	33,159	71.6	25,648	72.0	7,511	70.2	118
SA Country	13,142	28.4	9,952	28.0	3,190	29.8	129
SEIFA							
Lowest quintile (most disadvantaged)	9,032	19.5	6,367	17.9	2,665	25.0	177
Low quintile	8,949	19.4	6,632	18.7	2,317	21.7	139
Middle quintile	9,219	20.0	7,100	20.0	2,120	19.9	115
High quintile	8,944	19.4	7,178	20.2	1,766	16.5	96
Highest quintile (least disadvantaged)	10,058	21.8	8,249	23.2	1,809	16.9	84
Country of Birth							
Australia	35,895	77.7	26,861	75.7	9,034	84.5	135
Other	10,288	22.3	8,630	24.3	1,658	15.5	76
Aboriginal[a]							
No	45,621	98.8	35,140	99.0	10,482	98.1	120
Yes	568	1.2	365	1.0	203	1.9	265
Household income (annual)							
<$20,000	1,060	6.3	841	6.1	219	6.9	142
$20,001–$40,000	1,869	11.1	1,524	11.1	345	10.9	102
$40,001–$60,000	2,313	13.7	1,851	13.5	462	14.6	112
$60,001–$80,000	2,681	15.9	2,124	15.5	557	17.6	109
$80,001–$100,000	2,678	15.9	2,142	15.6	536	16.9	94
$100,001–$150,000	3,665	21.7	3,001	21.9	665	21.0	96
More than $150,000	2,611	15.5	2,230	16.3	381	12.0	70
Employment							
Full-time	21,877	47.3	16,327	45.9	5,549	51.9	132
Part-time	11,283	24.4	9,126	25.7	2,158	20.2	89
No employment	6,844	14.8	5,139	14.5	1,706	15.9	165
Student	4,776	10.3	3,740	10.5	1,036	9.7	101
Retired	1,466	3.2	1,220	3.4	247	2.3	81
Housing							
Owns	33,325	72.4	26,078	73.7	7,247	68.1	107
Housing trust	3,241	7.0	2,243	6.3	998	9.4	200
Private rental	9,249	20.1	6,911	19.5	2,338	22.0	146
Other	206	0.4	148	0.4	58	0.5	125
Education							
Less than high school	13,233	28.6	9,631	27.1	3,602	33.7	153
Completed high school	9,895	21.4	7,450	21.0	2,445	22.9	125
TAFE/Trade	14,463	31.3	11,132	31.3	3,331	31.2	122
Tertiary	8,623	18.7	7,310	20.6	1,314	12.3	68
Disability							
Yes	8,977	19.4	6,699	18.8	2,278	21.3	154
No	37,242	80.6	28,840	81.2	8,402	78.7	113

Note:

a: Aboriginal, identifies as Aboriginal or Torres Strait Islander

Table 2: Trends in proportion of adults aged 16-64 years consuming soft drink in South Australia from 2008 to 2017 (SAMSS).

Variable		n=(46,302)	APC1	CI
All	All	46,302	-9.6	[-11.1, -8.3]
Sex	Male	22,403	-9.5	[-10.8, -8.1]
	Female	23,899	-9.9	[-12.2, -7.5]
Age	16-24	9,121	-15.2	[-17.1, -13.2]
	25-44	18,389	-8.5	[-11.3, -5.6]
	45-64	18,791	-7.3	[-8.7, -5.9]
Country of Birth	Aus	35,895	-9.4	[-10.9, -7.9]
	Other	10,288	-13.3	[-19, -7.1]
Rurality	Metro. Adelaide	33,159	-10	[-12, -8.0]
	SA Country	13,142	-8.9	[-9.8, -8.0
SEIFA	Lowest quintile	9,032	-8.4	[-10.9, -5.8]
	Low quintile	8,949	-8.7	[-10.9, -6.5]
	Middle quintile	9,219	-8.9	[-10.8, -6.8
	High quintile	8,944	-10.9	[-14.1, -7.6]
	Highest quintile	10,058	-12.4	[-15.7, -9.1]
Household income	<$20,000	1,060	10	[-5.1, 27.5]
	$20,001 - $40,000	1,869	3.3	[-15.4, 26.2]
	$40,001 - $60,000	2,313	1.4	[-15.7, 22.1]
	$60,001 - $80,000	2,681	-7.2	[-21.4, 9.5]
	$80,001 - $100,000	2,678	-5.3	[-13.6, 3.7]
	$100,001 - $150,000	3,665	-14	[-20.4, -7.0]
	>150,000	2,611	-12.3	[-22.3, -1.0]
Employment	Full time employed	21,877	-9.1	[-10.3, -7.9]
	Part time employed	11,283	-9.5	[-11.9, -7.1]
	Unemployed	6,844	-7	[-10.4, -3.4]
	Student	4,776	-17.8	[-20.8, -14.7]
	Retired	1,466	-18	[-26.2, -8.8]
Housing	Owns	33,325	-11	[-12.3, -9.6]
	Housing trust/community housing	3,241	-4.8	[-9.0, -0.5]
	Private rental	9,249	-7.7	[-9.7, -5.7]
	Other	206	1	[-7.9, 10.8]
Education	< High school	13,233	-8.7	[-10.5, -6.8]
	High school	9,895	-10.1	[-12.6, -7.6]
	TAFE/diploma	14,463	-9	[-11.1, -6.9]
	Tertiary	8,623	-10.9	[-14.2, -7.5]
Health Status	Good or better	39,464	-10.3	[-11.8, -8.9]
	Fair	5,143	-7.5	[-10.0, -4.9]
	Poor	1,695	-4.5	[-8.0, -0.9]
Disability	Yes	8,977	-6.6	[-10.0, -3.0]
	No	37,242	-10.5	[-11.5, -9.5]
Mental Health Mx3	yes	6,223	-7.5	[-12.0, -2.8]
	No	39,943	-10.3	[-11.6, -9.1]
Physical activity	No Activity	8,265	-8	[-10.0, -5.9]
	Some Activity	13,557	-8.5	[-10.4, -6.7]
	150min or more	24,476	-11.5	[-13.7, -9.3]
Vegetable intake	1 or less serves	11,506	-7.9	[-10.0, -5.8]
	Less than recommended serves	29,852	-10.6	[-12.5, -8.7]
	at least recommended serves	4,727	-12.9	[-15.9, -9.7]
Fruit intake	1 or less serves	11,181	-7.7	[-8.6, -6.8]
	Less than recommended serves	15,828	-9.8	[-11.9, -7.7]
	At least recommended serves	19,235	-11.4	[-13.8, -9.0]
Fastfood	Never	19,349	-8.6	[-10.8, -6.4]
	<Weekly	14,372	-10.9	[-13.9, -7.8]
	1–6 days/week	12,443	-7.3	[-9.4, -5.1]
	Daily or more	119	3.2	[-5.4, 12.6]

(-11.0%), achieving recommended fruit and vegetable intake (-11.4% and -12.9%, respectively), and participating in >150minutes of physical activity/ week (-11.5%)). The slowest rate of change was observed in participants with poor self-reported health (-4.5%), those who resided in public housing (-4.8%) and those who were daily smokers (-6.3%).

Predictors of SSB consumption

Adjusted multivariate analysis (Table 3) demonstrates that high-risk dietary and lifestyle behaviours are the strongest predictors for the consumption of SSBs. Consuming junk food regularly was the strongest predictor of consumption of SSBs, with a dose-dependent association (daily junk food consumption OR=6.94, weekly consumption OR=2.89, and monthly OR=1.39, compared to no consumption). Smokers were more likely to consume SSBs than non-smokers (OR=1.54) and dose dependency was again observed. Low intake of fruit and vegetables and sedentary lifestyle without physical activity predicted SSB consumption. Those who were less educated (less than high school compared with tertiary, OR=1.50) and individuals whose SEIFA quintile reflected the greater level of disadvantage (lowest quintile compared with highest, OR=1.44) were also likely to be consumers of SSBs, and odds of consuming fell as the level of advantage and education rose.

Trends in volume of SSBs consumed by regular consumers

Despite a reduction in prevalence across all adults, the mean volume of consumption per consumer increased by 11.6% over the same time period (528mL/day to 589mL/day, $p<0.001$), see Figure1. An increase in mean consumption was observed across almost all demographic and risk factor subgroups; the only group to demonstrate a reduction in mean consumption were those consumers who also met the recommended daily serves for vegetables.

Predictors for heavy SSB consumption

Table 4 shows that co-existing high risk dietary and lifestyle factors, when adjusted for potentially confounding factors, are also significant predictors for heavy SSB consumption among regular consumers. Heavy consumption, defined as >1000mL (the 90th centile for this sample), was more

likely to be seen in consumers who smoked (compared to non-smokers, OR 1.94), who had one or less serves of vegetables/day (compared to meeting requirements, OR 2.03), who consumed junk food daily, (compared to non-consumers, OR 1.99) and who did no physical activity (compared to >150min/week, OR 1.48). A positive association was also found between markers of relative disadvantage and heavier SSB consumption and consumers who were currently being treated for a mental illness.

Table 2 cont.: Trends in proportion of adults aged 16-64 years consuming soft drink in South Australia from 2008 to 2017 (SAMSS).

Variable		n=(46,302)	APC1	CI
Potato snacks	Never	9,146	-10.6	[-13.0, -8.1]
	<Weekly	11,653	-11.1	[-14.1, -7.9]
	Weekly but not daily	25,398	-9.4	[-11.0, -7.8]
	Daily or more	37	missing data	
Smoking status	Daily	6,827	-6.3	[-8.7, -3.9]
	Occasional	1,485	-7.8	[-12.9, -2.5]
	ex-smoker	10,388	-8.5	[-10.7, -6.2]
	Never smoked	27,574	-11	[-13.5, -8.4]
Number of cigarettes	nil	738	-7.6	[-13.1, -1.7]
	Moderate (<12.5/day)	3,669	-5.8	[-9.4, -2.0]
	Heavy smoker	3,827		[-9.6, -2.8]

Discussion

In line with global trends across developed nations,[12-15] the proportion of South Australian adults consuming soft drinks has fallen significantly since 2008, with a reduction in prevalence observed across all demographic subgroups. This parallels findings from Elfassy et al. who found a decline in mean SSB consumption from 2007 to 2015 across all sex, age, race/ethnicity, education, poverty and neighbourhood poverty groups.[14] Similarly, in their repeated cross-sectional investigation of dietary intake over 13 years, Rehm et al. found a comparable reduction in intake of SSB across subgroups, with stable disparities observed by socioeconomic strata.[27]

Despite a reduction in prevalence across all subgroups, an association between socioeconomic disadvantage and SSB consumption was observed. We found low SES to be a determinant for higher odds of regular and heavy SSB consumption. Having lower levels of education or residing in public housing rather than private rentals/

Figure 1: Trends in the proportion of adults consuming SSB (%), and the mean consumption (mL per day) across all adults, and stratified by sex, age and SEIFA.

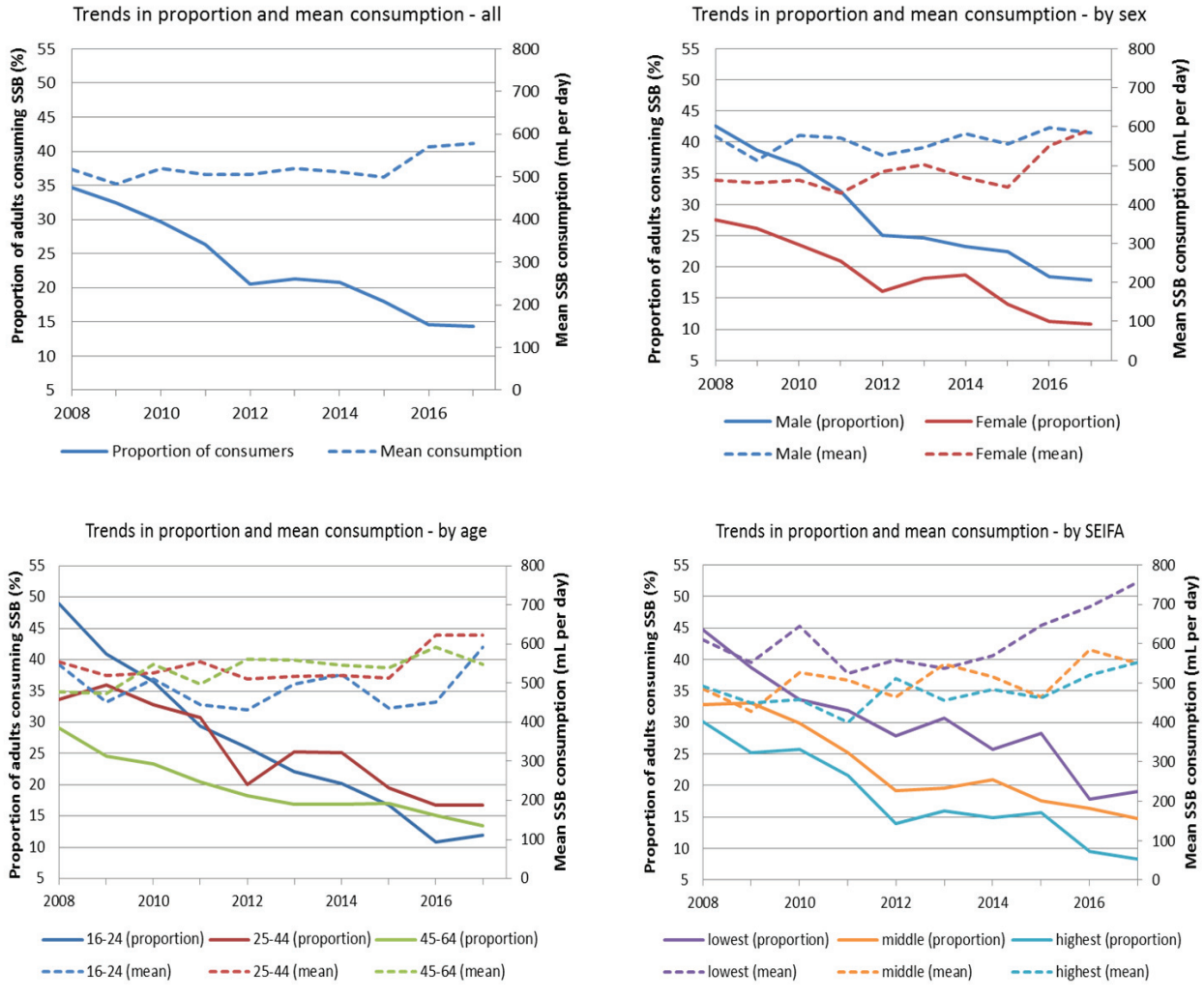

Table 3: Logistic regression for demographic and behavioural factors associated with soft drink consumption for South Australian adults aged between 16 years and 64 years, (SAMSS 2008-2017).

Variables	Categories and reference	(n= 46,302)	Unadjusted		Adjusted[b]	
			OR[a]	CI	OR	CI
Sex	Male	22,403	1.70	[1.63, 1.78]	1.34	[1.27, 1.41]
	Female (Ref)	23,899				
Age	16–24	9,121	1.41	[1.33, 1.5]	1.20	[1.11, 1.31]
	25–44	18,389	1.47	[1.4, 1.54]	1.31	[1.24, 1.39]
	45–64 (Ref)	18,791				
Rurality	SA Country	13,142	1.09	[1.04, 1.15]	0.92	[0.87, 0.97]
	Metro. Adelaide (Ref)	33,159				
SEIFA	Lowest quintile	9,032	1.91	[1.78, 2.04]	1.44	[1.34, 1.56]
	Low quintile	8,949	1.59	[1.49, 1.71]	1.33	[1.24, 1.44]
	Middle quintile	9,219	1.36	[1.27, 1.46]	1.18	[1.09, 1.27]
	High quintile	8,944	1.12	[1.04, 1.21]	1.04	[0.96, 1.13]
	Highest quintile (Ref)	10,058				
Country of Birth	*Aus (Ref)*	35,895				
	Other	10,288	0.57	[0.54, 0.61]	0.68	[0.64, 0.73]
Employment	*Full time (Ref)*	21,877				
	Part time	11,283	0.70	[0.66, 0.74]	0.75	[0.7, 0.8]
	No employment	6,844	0.98	[0.92, 1.04]	0.84	[0.78, 0.91]
	Student	4,776	0.82	[0.76, 0.88]	0.70	[0.63, 0.77]
	Retired	1,466	0.59	[0.52, 0.68]	0.93	[0.79, 1.08]
Housing	*Owns*	33,325				
	Housing trust	3,241	1.60	[1.48, 1.73]	1.27	[1.15, 1.39]
	Private rental	9,249	1.22	[1.15, 1.28]	1.07	[1.01, 1.14]
	Other	206	1.41	[1.04, 1.91]	1.25	[0.9, 1.73]
Education	*Teriary (Ref)*	8,623				
	TAFE/Trade	14,463	1.66	[1.55, 1.79]	1.23	[1.14, 1.33]
	Completed high	9,895	1.83	[1.69, 1.97]	1.47	[1.35, 1.59]
	< High school	13,233	2.08	[1.94, 2.23]	1.50	[1.38, 1.63]
Disability	Yes	8,977	1.17	[1.11, 1.23]	1.06	[0.99, 1.13]
	No (Ref)	37,242				
Physical activity	No Activity	8,265	1.39	[1.31, 1.47]	1.17	[1.1, 1.25]
	Some Activity	13,557	1.22	[1.16, 1.28]	1.14	[1.08, 1.21]
	150min or more (Ref)	24,476				
Smoking status	Daily	6,839	2.05	[1.94, 2.18]	1.54	[1.44, 1.64]
	Occasional	1,486	1.39	[1.24, 1.57]	1.18	[1.04, 1.35]
	Ex-smoker	10,394	1.08	[1.02, 1.14]	1.13	[1.06, 1.2]
	Non-smoker (Ref)	27,616				
Daily veg intake	1 or less serves	11,506	1.90	[1.75, 2.07]	1.23	[1.12, 1.35]
	>1 but < recommended	29,852	1.24	[1.14, 1.34]	1.02	[0.94, 1.11]
	At least recommended (Ref)	4,727				
Daily fruit intake	1 or less serves	11,181	2.00	[1.89, 2.11]	1.30	[1.22, 1.39]
	>1 but < recommended	15,828	1.45	[1.37, 1.52]	1.18	[1.12, 1.25]
	at least recommended Ref)	19,235				
Junk Food	Daily or more	839	10.06	[8.61, 11.75]	6.94	[5.88, 8.2]
	Weekly, but not daily	22,297	3.63	[3.35, 3.93]	2.89	[2.66, 3.15]
	<Weekly	16,040	1.51	[1.39, 1.65]	1.39	[1.27, 1.52]
	Never	7,106				
Mental Health Mx[c]	Yes	6,223	1.23	[1.16, 1.31]	1.19	[1.11, 1.28]
	No (Ref)	39,943				
Food Insecurity	Yes	2,164	1.25	[1.13, 1.38]	0.88	[0.79, 0.98]
	No (Ref)	42,884				

Notes:
a: OR = Odds ratio
b: Adjusted for all demographic and risk factors listed in this table
c: Self reported as currently being managed for a diagnosed mental health condition

owning home were predictors for regular SSB consumption and being unemployed or experiencing food insecurity independently increased the likelihood of consuming high volumes of SSBs. The linear relationship observed between level of disadvantage and prevalence of SSB consumption reflects the findings of other large-scale repeated cross-sectional studies.[12,14,15,27] It also is in keeping with the large body of literature that has found dietary behaviours to be strongly associated by SES.[19-20]

Consistent with the literature,[2,28,34] we demonstrated 'clustering of unhealthy behaviours', with an independent association between high-risk dietary and lifestyle behaviours and increased consumption of SSBs. There was also a clear, dose-dependent relationship between these two variables. Similar to findings by Miller,[4] among behavioural risk factors, the strongest association observed was between self-reported junk-food intake and SSB consumption, followed by smoking. In addition, we demonstrated a linear relationship between 'healthy' behaviours and reduced SSB consumption. The cardiovascular, metabolic and other health risks posed to this subpopulation by regular and heavy SSB consumption occur in addition to, and are amplified by, concurrent health-risking activities.

Implications for public health

A detailed understanding of subpopulation variations provides critical information for the design and implementation of health policies to curb SSB consumption. This study looks to answer the question: "Have all South Australians benefited equally from the observed decline in consumption of SSBs?" From an equity perspective, the answer is nuanced. The downward trend observed across all demographic subgroups in our study is a positive finding. Although the rate of change does vary to some extent by level of disadvantage, the trajectory for all subgroups is downward, and at roughly comparable rates. This observation suggests that the catalyst for changing consumption habits has been far-reaching and has affected change at all levels of the socioeconomic spectrum. This is significant as intervention generated inequalities are the unfortunate side effects of many population-based interventions.[22]

Our findings, however, suggest that there is a group of people who exhibit clustered high-risk behaviours and do not demonstrate population-level behavioural trends of reduced intake of SSBs. A clear social gradient is observed among this group, with those living with the greatest level of social and economic disadvantage more likely to be part of this 'consuming' cohort and representing a disproportionate percentage of the heaviest (>90th centile) consumers. People living in disadvantage have also been found to be at greater risk of clustered health-risking behaviours,[35] such as smoking and low vegetable consumption, which are behaviours that we found independently increased the likelihood of consuming SSBs (additive effect). The consequence of these interacting trends is that, contrary to our initial observation, the inequity gap continues to increase. Potential reasons for disparities in beverage consumption by SES could include differences in health literacy, access to, availability or affordability of SSBs or perceptions regarding social desirability of SSBs.[22,23]

This study shows that a complex relationship exists between health-risking behaviours and the social and physical environmental contexts within which they occur. The clustering of risk behaviours is an accepted phenomena[35,36] and presents policy makers with new opportunities to invest in targeted interventions that address multiple at-risk behaviours concurrently. Multiple behaviour change strategies (MBCS) are hypothesised to deliver cost-effective, resource-efficient intervention strategies with the potential to reduce multiple risk factors concurrently.[37,38] Methodologically sound studies assessing the efficacy of MBCSs are lacking but present interesting opportunities for future policy. The growing inequity observed reiterates the need for strategies that target high-risk cohorts and addresses the social determinants that are barriers for individual behavioural change.

Comparison to existing evidence

Some differences exist between our study and the findings of comparable studies, which may warrant further consideration. Young adults have been reported to be the highest consumers of SSBs.[12,39] We found, however, that there has been a steeper decline in the proportion of young people consuming SSBs in recent years. Indeed, in 2017 a smaller proportion of adults aged

Table 4: Logistic regression for demographic and behavioural factors associated with heavy[a] soft drink consumption amongst soft drink consumers[b] (SAMSS 2008–2017), South Australian adults aged between 16 and 64 years.

Variables	Categories and reference	(n=10,701)	Unadjusted		Adjustedc	
			OR	CI	OR	CI
Sex	Male	6,265	1.60	[1.43, 1.8]	1.68	[1.47, 1.93]
	Female (Ref)	4,436				
Age	16–24	2,303	0.68	[0.58, 0.8]	0.59	[0.48, 0.74]
	25–44	4,772	0.98	[0.87, 1.1]	0.87	[0.75, 1]
	45–64 (Ref)	3,626				
Rurality	SA Country	3,190	0.97	[0.86, 1.09]	0.85	[0.74, 0.98]
	Metro (Ref)	7,511				
SEIFA	Lowest quintile	2,665	2.01	[1.68, 2.4]	1.73	[1.41, 2.11]
	Low quintile	2,317	1.48	[1.22, 1.79]	1.32	[1.08, 1.63]
	Middle quintile	2,120	1.16	[0.95, 1.42]	1.05	[0.84, 1.3]
	High quintile	1,766	1.11	[0.9, 1.37]	1.03	[0.82, 1.3]
	Highest quint Ref)	1,809				
COB	*Aus (Ref)*	9,034				
	Other	1,658	0.74	[0.63, 0.88]	0.66	[0.55, 0.8]
Employment	*Full time (Ref)*	5,549				
	Part time	2,158	0.66	[0.56, 0.78]	0.72	[0.6, 0.87]
	No employment	1,706	1.87	[1.63, 2.14]	1.54	[1.29, 1.85]
	Student	1,036	0.61	[0.48, 0.76]	1.06	[0.79, 1.41]
	Retired	247	0.91	[0.62, 1.33]	1.05	[0.69, 1.59]
Housing	*Owns*	7,247				
	Housing trust	998	1.59	[1.34, 1.9]	0.77	[0.62, 0.94]
	Private rental	2,338	1.50	[1.32, 1.7]	1.13	[0.98, 1.31]
	Other	58	0.35	[0.11, 1.19]	0.20	[0.04, 0.92]
Education	*Tertiary (Ref)*	1,314				
	TAFE/Trade	3,331	1.83	[1.48, 2.26]	1.29	[1.03, 1.63]
	Completed high	2,445	1.49	[1.19, 1.87]	1.26	[0.99, 1.61]
	< High school	3,602	1.94	[1.57, 2.4]	1.18	[0.93, 1.5]
Disability	Yes	2,278	1.63	[1.44, 1.85]	0.98	[0.83, 1.14]
	No (Ref)	8,402				
Physical activity	No activity	2,231	1.71	[1.5, 1.95]	1.48	[1.28, 1.72]
	Some activity	3,321	0.96	[0.84, 1.1]	0.88	[0.76, 1.02]
	150min or more (Ref)	5,150				
Smoking status	Daily	2,367	2.67	[2.35, 3.04]	1.94	[1.67, 2.25]
	Occasional	393	1.54	[1.15, 2.06]	1.44	[1.05, 1.97]
	Ex-smoker	2,267	1.33	[1.15, 1.54]	1.24	[1.05, 1.46]
	Non-smoker (Ref)	5,662				
Daily veg intake	1 or less serves	3,408	2.11	[1.66, 2.69]	2.03	[1.53, 2.68]
	>1 but < recommended	6,409	1.28	[1.01, 1.63]	1.56	[1.19, 2.04]
	At least recom.(Ref)	856				
Daily fruit intake	1 or less serves	3,410	1.84	[1.61, 2.11]	1.22	[1.05, 1.41]
	>1 but < recommended	3,816	1.00	[0.86, 1.15]	0.80	[0.68, 0.94]
	at least recom. (Ref)	3,463				
Junk Food	Daily or more	462	2.06	[1.56, 2.73]	1.99	[1.44, 2.74]
	Weekly, but not daily	6,905	0.90	[0.73, 1.1]	0.91	[0.72, 1.14]
	<Weekly	2,530	0.64	[0.51, 0.81]	0.67	[0.52, 0.87]
	Never	782				
Mental health[d]	Yes	1,643	2.03	[1.78, 2.31]	1.81	[1.54, 2.13]
	No (Ref)	9,019				
Food insecurity	Yes	578	2.77	[2.29, 3.35]	1.49	[1.2, 1.86]
	No (Ref)	9,703				

Notes:

a: Heavy consumption is defined as consuming 1000mL or more soft drink/day (90th percentile for consumers), consumptioncoded as categorical variable <1000mL = 0, >1000mL = 1)

b: Analysis includes consumers only (non consumers, and consumers who did not report volume consumed are excluded)

c: Adjusted for all demographic and risk factors listed in this table

d: Self reported as currently being managed for a diagnosed mental health condition

16–24 years consumed SSBs than any other age group. Among the heaviest consumers, there was an overrepresentation of adults aged 45–64 years, with younger age a notable protective factor for heavy consumption. This differs to findings from the 2017 ABS National Health Survey,[40] which despite identifying a similar proportion of consumers in this younger age (13.6% of 18–24 years, compared to 14% 16–24 years) found that rates of consumption declined as age increased.

Strengths and weaknesses of this study

Strengths and potential limitations for this study should be considered. SAMSS is a large-scale repeated cross-sectional survey that allows for evaluation of changes over time at the population level (weighted). Direct comparisons across population subgroups in this study were facilitated by consistent data collection methods in the time period examined. Cross-sectional analysis, however, is limited by the inability to make a causal inference, and population-level data demonstrate relationships for groups that may not necessarily hold for all individuals.

SAMSS methodology for collecting dietary data is via a self-reported food frequency questionnaire (FFQ) for mean consumption estimates. Despite examples of 'SSB' being provided, classification errors are possible. An estimate of average consumption on a usual day remains subjective and provides a crude estimate of actual intake. Social desirability bias may also have led to error through underreporting of usual consumption,[27] and it is possible that the effect of social desirability bias will have exerted a greater effect on those who were more health-literate, falsely widening the gap between subgroups. Other studies use 24-hour dietary intakes to estimate 'usual intake' with greater accuracy[41]; this methodology, however, remains susceptible to recall precision error, and may not as effectively account for the high day-to-day or seasonal variability in discretionary food consumption.[42]

A further difference to the existing literature is that SAMSS does not separate nutritively (sugar) sweetened carbonated beverages, from non-nutritively (artificially) sweetened carbonated beverages. Sales reports from the Australian Beverage Industry report a shift towards the sale non-sugar-sweetened carbonated SSB and water in recent years.[16] There is a lack of comprehensive data available regarding distribution of intake of, or predictive factors for, diet versus sugar-sweetened beverage consumption. It is difficult to quantify how the lack of distinction between the two categories of beverages may have impacted our findings but, given findings of a recent meta-analysis regarding the health risk posed by artificially sweetened beverages,[43] it is unlikely this distinction bears significance when determining intervention strategies.

Future research

This study has identified some potentially at-risk groups that warrant consideration in future research. We found that a higher proportion of people with mental illness consume SSBs (OR 1.8) and are more likely to be among the heaviest consumers (OR 1.2). Shi et al. found a positive association between SSBs and mental health problems in South Australian adults, but the direction of the relationship was unable to be established.[44]

Finally, using SAMSS data we were unable to obtain statistically significant sample size to make separate inferences on consumption of SSBs among Aboriginal and Torres Strait Islander people. This is an important subpopulation due to health disparity observed between Aboriginal and Torres Strait Islander and non-Aboriginal Australians. Review of existing literature and data gathered as part of the National Aboriginal and Torres Strait Islander Nutrition and Physical Activity Survey (NATSINPAS) have found the prevalence of SSB consumption is disproportionately high among Aboriginal people.[45,46]

Conclusion

In response to the increasingly robust evidence base linking the consumption of SSBs with poor health outcomes, this study describes population-level variations in consumption patterns and identifies factors that may predict ongoing and heavier consumption patterns among individuals. We found that there is a societal trend away from the consumption of SSBs across all subgroups, but that at-risk groups who engage in clusters of unhealthy behaviours are continuing to consume SSBs in higher volumes. The identification of these at-risk populations provides a platform from which future research may better investigate structural barriers, beliefs, attitudes and facilitators of ongoing consumption of SSBs.

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Supporting Information

Additional supporting information may be found in the online version of this article:

Supplementary Figure 1: Trends in the proportion of adults consuming SSB (%), and the mean consumption (mL per day) stratified by health related behaviours.