Soft drink consumption and mental health problems among adults in Australia

Zumin Shi[1,2,*], Anne W Taylor[1,2], Gary Wittert[2], Robert Goldney[3] and Tiffany K Gill[1,2]
[1]Population Research and Outcome Studies Unit, Department of Health, PO Box 287, Rundle Mall, South Australia 5000, Australia: [2]Department of Medicine, University of Adelaide, Adelaide, South Australia, Australia: [3]Discipline of Psychiatry and the Hanson Institute, University of Adelaide, Adelaide, South Australia, Australia

Abstract

Objective: To examine the association between soft drink consumption and mental health problems, including self-reported doctor-diagnosed anxiety, stress-related problem and depression, suicidal ideation and psychological distress, among adults in South Australia.
Design: Data were collected using a risk factor surveillance system. Each month a representative random sample of South Australians was selected from the Electronic White Pages with interviews conducted using computer-assisted telephone interviewing.
Setting: South Australia.
Subjects: Participants were aged 16 years and above.
Results: Among 4741 participants, 12·5 % reported daily soft drink consumption of more than half a litre. High levels of soft drink consumption were positively associated with depression, stress-related problem, suicidal ideation, psychological distress and a current mental health condition, but not anxiety. Overall, 24·0 % of those having suicidal ideation reported consuming more than half a litre of soft drink per day. In the multivariate analysis, after adjusting for socio-demographic and lifestyle factors, those who consumed more than half a litre of soft drink per day had approximately 60 % greater risk of having depression, stress-related problem, suicidal ideation, psychological distress or a current mental health condition, compared with those not consuming soft drinks. The soft drink to total fluid consumption ratio had similar associations with mental health problems.
Conclusions: There is a positive association between consumption of soft drinks and mental health problems among adults in South Australia.

There is a relationship between nutrition and depression[1–3]. Deficiencies of folate, vitamin B_{12}, Fe, Zn and Se tend to be more common among depressed than non-depressed persons[2]. Adherence to a Mediterranean dietary pattern has been linked to depression prevention in a previous cohort study[3]. An ecological study suggested a positive association between sugar consumption and depression[4]. The protective effect of *n*-3 fatty acids on depression has also been documented[2,5].

Soft drink consumption has become a public health concern because of its association with many medical conditions including obesity, diabetes and dental caries[6,7]. The intake of soft drinks in Australia has grown rapidly from around 47·3 litres per person per year in 1969 to 113 litres per person (children and adults) in 1999[8]. Soft drink consumption increases the level of insulin resistance[9,10], diabetes[11,12] and obesity[13]. These conditions are all related to depression. A cross-sectional study from Norway linked soft drinks with hyperactivity, mental distress and conduct problems among adolescents[14]. Little is known as to whether there is a direct association between soft drink consumption and mental health problems among adults and there are no population studies that have been done in this field. Moreover, any such relationship may be bidirectional, as previously shown in relation to folate consumption, obesity and mental health[15,16]. Using data from the South Australian Monitoring and Surveillance System (SAMSS), the objective of the present study was to describe the association between soft drink consumption and mental health problems among adults in South Australia.

Corresponding author: Email zumin.shi@health.sa.gov.au

Methods

Survey design and sample selection

Data for the present study were collected using the SAMSS from March 2008 to December 2008. SAMSS is designed to systematically monitor the trends of diseases, health-related problems, risk factors and other health service issues for all ages over time for the South Australian (SA) health system[17]. Interviews are conducted on a minimum of 600 randomly selected people (of all ages) each month. All households in SA with a telephone connected and the telephone number listed in the Electronic White Pages are eligible for selection in the sample. A letter introducing the survey is sent to the selected household and the person with the last to have a birthday within a 12-month period is chosen for interview. There are no replacements for non-respondents. Up to ten call backs are made to the household to interview the selected persons. Interviews are conducted by trained health interviewers. SAMSS utilises a computer-assisted telephone interviewing system to conduct the interviews. Data are weighted by area (metropolitan/rural), age, gender and probability of selection in the household to the most recent SA population data, so that the results are representative of the SA population[18].

In the period March 2008 to December 2008 a total of 5961 interviews were conducted (62·1 % response rate). The questions related to having a mental health problem are asked only of respondents aged 16 years and over. The present analysis is therefore limited to 4741 respondents.

Data items

Mental illness

Suicidal ideation is based on four questions contained in the twenty-eight-item General Health Questionnaire (GHQ-28)[19]. These are: 'Over the past few weeks have you…' '…felt that life isn't worth living?', '…thought of the possibility that you might do away with yourself?', '…found yourself wishing you were dead and away from it all?' and '…found that the idea of taking your own life kept coming into your mind?' The first and third questions have the responses of 'not at all', 'no more than usual', 'rather more than usual' or 'much more than usual'; and the second and fourth have the responses of 'definitely not', 'I don't think so', 'has crossed my mind' or 'definitely has'. The questions are scored by applying the binary method to the four questions to produce a score ranging from 0 to 4, where a score of 1 or more indicated suicidal ideation[20,21]. The inclusion of suicidal ideation questions in a surveillance system initially highlighted some methodological issues, with concerns expressed by interviewers and ethics consultants regarding the sensitive, and perhaps influencing, nature of the four questions. Specialist psychiatric advice was obtained which indicated little cause for concern. Notwithstanding, a toll-free number, providing mental health advice, is offered to all respondents.

Other questions related to mental health included having been diagnosed by a doctor in the previous 12 months with anxiety, depression, a stress-related problem or another mental health problem. Self-reported current mental health problem is defined as either reporting doctor-diagnosed mental health problems, or currently receiving treatment for anxiety, depression, stress-related problem or another mental health problem. The level of psychological distress of respondents was determined using the Kessler Psychological Distress ten-item scale (K10)[22]. This scale was developed to measure anxiety and depressive disorders in a general population. The response categories of each of the ten questions are converted to Likert scales and reverse-scored. The ten items in the scale are summed to give scores ranging from 10 (no distress) to 50 (high risk of anxiety or a depressive disorder). The scores are grouped in four categories: low (10–15), moderate (15–21), high (22–29) and very high (30–50). Participants having a K10 score higher than 22 were defined as having psychological distress[22].

Soft drink, fruit and vegetable consumption

Soft drink consumption was assessed by the question 'On average, how many litres of soft drink and sports drink (e.g. Coke, lemonade, flavoured mineral water, Powerade, Gatorade) do you usually have in a day?' Participants were also asked how many glasses of water and juice they have in a day. Total fluid consumption was constructed based on the consumption (in litres) of soft drink, water and fruit or vegetable juice. Participants were asked how many servings of fruit and vegetables they usually ate per day. The fruit and vegetable consumption variable was divided into those eating less than current government recommendations (two servings of fruits and five servings of vegetables per day) and those eating at the recommendation level or more[23].

Demographic variables

Sex, age, area of residence, highest educational attainment and gross annual household income were included in the analyses.

History of chronic diseases

Participants were asked whether they had medically confirmed diabetes, current asthma, CVD (heart attack, angina, heart disease and/or stroke), arthritis, osteoporosis or chronic obstructive pulmonary disease (COPD). These conditions were used to calculate the number of chronic conditions.

Other measurements

A measure of physical activity was derived from the sum of the time spent undertaking walking, moderate and/or vigorous activity in a one-week period, with vigorous activity doubled to account for its greater intensity[24]. Sufficient activity to provide a health benefit was defined

as physical activity greater than or equal to 150 min/week. BMI was derived from self-reported weight and height. Overweight was defined as $BMI \geq 25\,kg/m^2$. Smoking status and alcohol intake were also determined.

Data analyses

The χ^2 test was used to compare differences in categorical variables. In order to exclude the possible confounding of total fluid needs, a soft drink to total fluid consumption ratio was constructed. The association between soft drink consumption, soft drink:total fluid ratio and the risk of mental illness was analysed using logistic regression models, adjusting for multiple covariates. The logistic model controlled for age (continuous), gender, education, income, residence, smoking, alcohol consumption, physical activity, intake of fruit and vegetables, overweight and chronic disease (diabetes, asthma, CVD, arthritis, osteoporosis, COPD). A test for trend of the risk of mental illness across groups of soft drink consumption was undertaken by putting median intake in each group as continuous variables in the logistic regression. Statistical significance was considered when $P < 0.05$ (two-sided). All data presented herein are weighted by age, sex, area of residence to the latest Census or Estimated Residential Population from the Australian Bureau of Statistics, and the probability of selection in the household. All analyses were performed using the STATA statistical software package version 10 (StataCorp, College Station, TX, USA).

Results

Overall, 4741 adults aged 16 years and above (mean 46·7 years, 48·1% male) were interviewed. The prevalence of doctor-diagnosed mental illness was 5·2% (anxiety), 6·9% (depression) and 4·4% (stress-related problem). The prevalence of suicidal ideation was 4·6%. In addition, 9·0% of the participants had psychological distress according to the K10 score. Overall, 14·0% of the participants reported a diagnosed and/or treated mental health condition.

About 70% of the participants reported no consumption of soft drinks, while 12·5% had a daily soft drink intake of half a litre or more (Table 1). In total, 6·6% of the participants had soft drink:total fluid ratio of 0·5 or greater. Among those with suicidal ideation, 24·1% consumed half a litre or more of soft drink per day.

High levels of soft drink consumption were positively associated with depression, suicidal ideation, psychological distress and a current mental health condition, but not anxiety (Table 2). The positive association between soft drink consumption and stress approached significance. Compared with non-consumers of soft drinks, those consuming half litre or more of soft drink had a much higher prevalence of psychological distress (15·0% v. 7·7%). Similar associations were found between the soft drink:total fluid ratio and mental illness.

Table 1 Characteristics of the South Australian Monitoring and Surveillance System (SAMSS) sample aged 16 years and above during March 2008–December 2008

	n	%
Gender		
Male	2311	48·7
Female	2431	51·3
Gross annual household income ($AU)		
≥20 000	3365	71·0
<20 000	516	10·9
Not stated	860	18·2
Education		
Low (no schooling to secondary)	2566	54·2
Medium (trade, certificate, diploma)	1108	23·4
High (degree or higher)	1057	22·4
Residence		
Urban (metropolitan, Adelaide)	3443	72·6
Rural (SA country)	1298	27·4
Smoking status		
Non-smoker	2261	47·7
Ex smoker	1763	37·2
Smoker	718	15·1
Diabetes	342	7·2
COPD	212	4·5
Asthma	595	12·6
CVD	347	7·3
Arthritis	1051	22·2
Osteoporosis	215	4·5
Overweight (BMI ≥ 25 kg/m²)	2471	57·3
Physical activity		
No activity	788	17·2
Activity not sufficient (<150 min/week)	1369	29·9
Sufficient activity (≥150 min/week)	2420	52·9
Soft drink consumption (litre/d)		
0	3319	70·0
<0·5	828	17·5
≥0·5	594	12·5
Soft drink:total fluid ratio*		
0	3207	69·5
<0·2	424	9·2
0·2–0·3	370	8·0
0·3–0·5	313	6·8
≥0·5	304	6·6
Intake of fruit (servings/d)		
<2	2641	55·7
≥2	2099	44·3
Intake of vegetables (servings/d)		
<5	4217	89·4
≥5	501	10·6

SA, South Australia; COPD, chronic obstructive pulmonary disease.
*Total fluid includes soft drinks, water and fruit juice.

Using multivariate analysis (Table 3), after adjusting for sociodemographic factors, the intake of soft drinks was significantly associated with depression, stress, suicidal ideation and psychological distress. The odds ratios for stress, suicidal ideation and psychological distress comparing high consumption and non-consumption of soft drinks were all above 1·60. Additional adjustment for lifestyle, fruit and vegetable intakes, and chronic diseases slightly attenuated the association. All of the associations remained significant, except that between soft drinks and suicidal ideation which approached significance.

People with mental illnesses are more likely to report increased thirst[25,26]; therefore we examined the association between soft drink:total fluid ratio and mental

Table 2 Prevalence of anxiety, depression, stress-related problem, suicidal ideation, psychological distress and current mental health condition according to soft drink intake among adults aged 16 years and above in South Australia, March 2008–December 2008

	Soft drink consumption (litre/d)				Soft drink:total fluid ratio*					
	0	<0·5	≥0·5	P	0	<0·2	0·2–0·3	0·3–0·5	≥0·5	P
n	3319	828	594		3207	424	370	313	304	
Anxiety (%)	4·9	5·5	6·5	0·431	5·0	4·3	6·2	9·3	4·3	0·071
Depression (%)	6·1	8·1	9·6	0·018	6·1	7·8	7·1	6·8	14·1	0·001
Stress-related problem (%)	3·9	5·3	6·4	0·056	3·9	4·0	6·1	4·9	8·7	0·030
Suicidal ideation (%)†	4·0	3·9	8·4	0·011	3·9	4·4	3·2	3·5	13·0	0·0001
Psychological distress (K10 score) (%)	7·7	10·0	15·0	<0·001	7·7	9·6	8·1	17·2	15·0	0·0001
Current mental health condition (diagnosed and/or receiving treatment) (%)	12·9	15·6	18·6	0·008	13·0	14·1	16·2	15·0	23·9	0·001

K10, Kessler Psychological Distress ten-item scale.
*Total fluid includes soft drinks, water and fruit juice.
†Nine hundred and thirty-two participants did not respond.

Table 3 Odds ratios and 95 % confidence intervals for anxiety, depression, stress-related problem, suicidal ideation, psychological distress and current mental health condition by soft drink consumption level among adults 16 years and above in South Australia, March 2008–December 2008

	Soft drink intake (litre/d)						
	0		<0·5		≥0·5		
	OR	95 % CI	OR	95 % CI	OR	95 % CI	P for trend
Anxiety							
Model 1*	1·00	ref	1·17	0·77, 1·80	1·43	0·91, 2·25	0·116
Model 2†	1·00	ref	1·13	0·70, 1·81	1·21	0·74, 1·98	0·432
Depression							
Model 1*	1·00	ref	1·52	1·08, 2·15	1·93	1·29, 2·90	<0·001
Model 2†	1·00	ref	1·52	1·04, 2·21	1·63	1·03, 2·58	0·016
Stress-related problem							
Model 1*	1·00	ref	1·53	0·97, 2·42	1·98	1·22, 3·24	0·002
Model 2†	1·00	ref	1·55	0·96, 2·50	1·79	1·06, 3·04	0·014
Suicidal ideation							
Model 1*	1·00	ref	0·96	0·55, 1·70	2·16	1·12, 4·17	0·049
Model 2†	1·00	ref	0·88	0·47, 1·65	1·87	1·03, 3·38	0·067
Psychological distress (K10 score)							
Model 1*	1·00	ref	1·42	1·04, 1·94	2·34	1·59, 3·44	<0·001
Model 2†	1·00	ref	1·41	0·99, 2·00	1·72	1·11, 2·66	0·008
Current mental health problem (diagnosed and/or receiving treatment)							
Model 1*	1·00	ref	1·44	1·11, 1·88	1·95	1·43, 2·65	<0·001
Model 2†	1·00	ref	1·42	1·07, 1·90	1·59	1·13, 2·23	0·002

K10, Kessler Psychological Distress ten-item scale; ref, reference category.
*Model 1 adjusted for age and gender.
†Model 2 adjusted for age, gender, education, income, area of residence, smoking (non-smoker, ex smoker, smoker), drinking (servings/d), physical activity (none, physical activity <150 or ≥150 min/d), overweight, diabetes, asthma, CVD, arthritis, osteoporosis, chronic obstructive pulmonary disease, intake of fruit and vegetables (servings/d).

illness. In the multivariate models (Table 4), comparing those with a soft drink:total fluid ratio ≥0·5 with non-consumers (ratio = 0), the odds ratios for depression, stress and suicidal ideation were all above 2·00. In the full model, there was a higher risk of psychological stress when the soft drink:total fluid ratio was 0·3. Excluding participants with chronic diseases in the multivariate analysis did not change the association (data not shown).

Discussion

In the current cross-sectional study we found that consumption of soft drinks was positively associated with mental health problems including depression, stress-related problem, suicidal ideation and psychological distress among adults living in South Australia. The association was significant in both men and women. Adjusting for socio-economic status, lifestyle factors, and fruit and vegetable consumption did not change the association.

Soft drinks contain a large amount of sugar. In ecological studies, sugar is found to be related to a higher prevalence of depression[4]. Westover and Marangell hypothesised several possible mechanisms linking sugar and depression, including increased level of β-endorphins and oxidative stress[4]. It is well documented that increased visceral fat and insulin resistance are prevalent among depressed patients[10], and are associated

Table 4 Odds ratios and 95 % confidence intervals for anxiety, depression, stress-related problem, suicidal ideation, psychological distress and mental health condition by ratio of soft drink to total fluid consumption among adults 16 years and above in South Australia, March 2008–December 2008

	Soft drink:total fluid ratio										
	0 (*n* 3207)		<0·2 (*n* 424)		0·2–0·3 (*n* 369)		0·3–0·5 (*n* 313)		≥0·5 (*n* 304)		
	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	*P* for trend
Anxiety											
Model 1*	1·00	ref	0·86	0·48, 1·56	1·36	0·79, 2·35	2·10	1·19, 3·71	0·96	0·51, 1·80	0·093
Model 2†	1·00	ref	0·82	0·44, 1·54	1·31	0·73, 2·35	1·87	1·00, 3·53	0·77	0·37, 1·60	0·648
Depression											
Model 1*	1·00	ref	1·45	0·91, 2·31	1·35	0·84, 2·18	1·30	0·71, 2·40	2·95	1·83, 4·76	<0·001
Model 2†	1·00	ref	1·48	0·91, 2·42	1·33	0·81, 2·21	1·22	0·62, 2·38	2·25	1·32, 3·84	0·004
Stress-related problem											
Model 1*	1·00	ref	1·12	0·61, 2·04	1·79	0·95, 3·36	1·44	0·70, 2·95	2·71	1·51, 4·86	0·001
Model 2†	1·00	ref	1·18	0·64, 2·16	1·78	0·92, 3·44	1·56	0·73, 3·33	2·21	1·14, 4·28	0·006
Suicidal ideation											
Model 1*	1·00	ref	1·09	0·54, 2·21	0·78	0·34, 1·78	0·83	0·35, 2·00	3·49	1·68, 7·23	0·023
Model 2†	1·00	ref	1·04	0·49, 2·18	0·89	0·38, 2·11	0·53	0·21, 1·36	2·85	1·44, 5·64	0·034
Psychological distress (K10 score)											
Model 1*	1·00	ref	1·35	0·89, 2·04	1·16	0·73, 1·85	2·78	1·72, 4·49	2·38	1·40, 4·05	<0·001
Model 2†	1·00	ref	1·49	0·96, 2·31	1·15	0·70, 1·90	2·42	1·36, 4·31	1·25	0·73, 2·13	0·042
Current mental health problem (diagnosed and/or receiving treatment)											
Model 1*	1·00	ref	1·26	0·89, 1·80	1·53	1·06, 2·22	1·45	0·95, 2·21	2·65	1·81, 3·89	<0·001
Model 2†	1·00	ref	1·27	0·88, 1·84	1·50	1·00, 2·25	1·29	0·81, 2·07	2·05	1·34, 3·13	<0·001

K10, Kessler Psychological Distress ten-item scale; ref, reference category.
*Model 1 adjusted for age and gender.
†Model 2 adjusted for age, gender, education, income, area of residence, smoking (non-smoker, ex smoker, smoker), drinking (servings/d), physical activity (none, physical activity <150 or ≥150 min/d), overweight, diabetes, asthma, CVD, arthritis, osteoporosis, chronic obstructive pulmonary disease, intake of fruit and vegetables (servings/d).

with oxidative stress, and increased inflammation and circulating cytokines are associated with depression. Because the glycaemic index of soft drinks is high, a large intake increases the total glycaemic load. In animal studies, intake of sucrose-sweetened water induces insulin resistance and exacerbates memory deficits[27]. In a population study, sugar-sweetened drink consumption was positively associated with fasting insulin[9]. It is also possible that soft drink consumption increases the risk of obesity, diabetes and other chronic diseases[6,7], which in turn increases the risk of mental illness. Other chemicals in soft drinks may also play a role, but further research is needed to elucidate this.

Despite this evidence, human data regarding the association between soft drink consumption and mental illness are sparse. To our knowledge the current study is the first cross-sectional study suggesting a positive association between soft drink consumption and mental illness among adults. The results are consistent with findings among adolescents[14]. In the current study, with the exception of anxiety, the outcome measures in the logistic regression including depression, stress, suicidal ideation and psychological distress, based on the K10, were all highly significantly associated with soft drink consumption. Comparing high intake *v.* non-intake of soft drinks, the odds for depression, stress, suicidal ideation and psychological stress were all around 1·6. It is known that consumption of soft drinks increases the risk of

chronic diseases including overweight and diabetes which are related to inflammation. At the same time, chronic diseases like diabetes[28] and asthma[29] are related to mental illness. Thus the association between soft drinks and mental health/illness could be confounded by these chronic conditions. In the present study, however, the association between soft drink consumption and mental illness did not change after we adjusted for having at least one of five chronic diseases. Furthermore, excluding those with chronic diseases did not change the association.

Risk behaviours often cluster and therefore soft drink consumption may be a marker of other dietary and lifestyle factors. The associations remained significant except for suicidal ideation which still approached significance, albeit attenuated, after adjusting for some lifestyle and sociodemographic factors.

There are a number of potential shortcomings in the study and caution should be exercised in interpreting its findings. The response rate of 62·1 % may limit generalisability, although the weighting of the data counteracts the non-response bias. In addition, other studies undertaken using SAMSS data have indicated comparable estimates across a range of measures[30–34], and the prevalence of overweight was similar to that in the AusDiab study in Australian adults aged 25 years and above (57·3 % *v.* 59·8 %)[35]. The cross-sectional study design precludes the establishment of causal relationships and

the direction of those relationships. It is also pertinent that much of the information obtained relies on self-report. Indeed, under-reporting of body weight is common among obese participants[36] and adjusting for BMI may not be free of residual confounding. Information on hot drinks (tea and coffee) was not collected, and although the majority of soft drinks sold in Australia are sugar-sweetened, we did not have data to determine whether the increased intake was limited to sugared soft drinks, diet soft drinks or included both. We also did not have detailed information on the intake of other dietary factors known to be related to mental health, e.g. *n*-3 fatty acids[2,5]. It is acknowledged that these are potentially important issues, and although adjusting for fruit and vegetable consumption may to some degree have controlled for the diet quality, further studies incorporating these other variables should be pursued.

Notwithstanding these caveats, strengths of the study include its large and representative sample, the use of different outcome measures related to mental health problems, and the consistency of the relationships.

Conclusions

The current study provided novel evidence that increased soft drink consumption is associated with mental health problems among adults in Australia. Whether this relates directly to the sugar content, or some other pleasurable quality of soft drinks, remains to be determined; as does the temporal relationship to the onset of depression, as well as its severity and natural history. Regardless of the cause-and-effect relationship, the public health implications of consumption of large volumes of soft drinks are substantial from both a mental health and a metabolic perspective.

Acknowledgements

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