

ORIGINAL ARTICLE

Association between soft drink consumption and asthma and chronic obstructive pulmonary disease among adults in Australia

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ABSTRACT

Background and objective: The aim of this study was to examine the association between soft drink consumption and self-reported doctor-diagnosed asthma and COPD among adults living in South Australia.

Methods: Data were collected using a risk factor surveillance system. Each month a representative random sample of South Australians were selected from the electronic White Pages and interviews were conducted using computer-assisted telephone interviewing (CATI).

Results: Among 16 907 participants aged 16 years and older, 11.4% reported daily soft drink consumption of more than half a litre. High levels of soft drink consumption were positively associated with asthma and COPD. Overall, 13.3% of participants with asthma and 15.6% of those with COPD reported consuming more than half a litre of soft drink per day. By multivariate analysis, after adjusting for socio-demographic and lifestyle factors, the odds ratio (OR) for asthma was 1.26 (95% confidence interval (CI): 1.01–1.58) and the OR for COPD was 1.79 (95% CI: 1.32–2.43), comparing those who consumed more than half a litre of soft drink per day with those who did not consume soft drinks.

Conclusions: There was a positive association between consumption of soft drinks and asthma/COPD among adults living in South Australia.

Key words: asthma, chronic obstructive pulmonary disease, epidemiology, soft drink.

SUMMARY AT A GLANCE

Soft drink consumption has been linked to a range of chronic diseases but no previous study was focused on the association with asthma/COPD. Among 16 907 participants aged 16 years and older living in South Australia, a positive association was identified between consumption of soft drinks and the risk of asthma/COPD.

INTRODUCTION

Asthma and COPD are highly prevalent chronic diseases in Western countries, and with increasing age, they may occur concurrently.¹ The prevalence of asthma has increased since the 1960s.² In South Australia (SA), the prevalence of asthma increased significantly between 1990 and 2003, with a doubling among females (females: 7.3–14.6%; males: 7.8–9.4%). The largest relative increases occurred among individuals aged 55 years and older.³ Low socioeconomic status (SES), female gender, smoking and being overweight were all associated with an increased prevalence of COPD and asthma.^{4,5} The burden of COPD and asthma is less in developing than in developed countries. Several hypotheses have been proposed to explain the increased burden of asthma, as well as the difference in prevalence between developed and developing countries, including less exposure to indoor allergens, improved hygiene and use of antibiotics ('hygiene hypothesis'),⁶ increasing levels of obesity, as well as poor diet with low intakes of dietary antioxidants.⁷ Although smoking is the major risk factor for COPD, up to 50% of airways obstruction is not explained by smoking. Thus alternative or novel factors are important but are currently unidentified.⁸

A recent review examined the evidence for the role of nutrition, including antioxidants, fat and vitamin D, in the aetiology of asthma, and concluded that there was evidence for an association between nutrition and asthma.⁹ Since 2007, a few reports have been published on the association between dietary patterns and asthma/COPD.^{10–16} Among these studies,

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two showed associations between dietary patterns and asthma,^{14,16} three showed associations between dietary patterns and COPD,^{10,11,15} and two showed no association.^{12,13}

Soft drinks are an important component of the Western lifestyle and diet. The intake of soft drinks in Australia has grown rapidly from around 47.3 L per person per year in 1969 to 113 L per person (both children and adults) in 1999.¹⁷ A case-control study performed in Sweden showed that children with asthma reported higher consumption of sugar-containing drinks.¹⁸ Sugar consumption increases the risk of dental caries, and there is also concern regarding the relationship between dental caries and asthma.¹⁹ To the best of our knowledge, there has been no large-scale study assessing the relationship between soft drink consumption and the prevalence of asthma/COPD among adults. The objective of this study was to investigate this association among adults, using data from the South Australian Monitoring and Surveillance System (SAMSS).

METHODS

Design of the survey and sample selection

Data was collected from March 2008 to June 2010, using the SAMSS. The SAMSS is designed to systematically monitor the trends over time in diseases, health-related problems, risk factors and other health service issues, among individuals of all ages, for the SA health system.²⁰ Each month, interviews are conducted with a minimum of 600 randomly selected individuals of all ages. All households in SA with a telephone connection and telephone number listed in the electronic White Pages (EWP) are eligible for selection for these interviews. A letter introducing the survey is mailed to the selected household and the person who last celebrated his/her birthday is chosen for interview. There are no replacements for non-respondents. Up to ten calls are made to the household to interview the selected person. Interviews are conducted by trained health interviewers. SAMSS utilizes a computer-assisted telephone interviewing (CATI) system to conduct the interviews. Data are weighted by area of residence (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 whole population of SA.²¹

In the period from March 2008 to June 2010, a total of 18 880 interviews were conducted (64.2% response rate). This analysis was restricted to individuals aged 16 years and older, who were asked questions relating to the prevalence of asthma and COPD, giving a final total of 16 907 respondents.

Data items

Asthma/COPD

Current asthma was defined as a self-reported doctor diagnosis of asthma, with experience of symptoms or

use of prescribed medication for asthma in the past 12 months.²²

The incidence of COPD was assessed by the question 'Have you ever been told by a doctor that you have chronic bronchitis or emphysema?'

Consumption of soft drinks, fruits and vegetables

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 consumed in a day. Total fluid consumption was estimated, 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 split into consumption at levels less than currently recommended by government guidelines (two servings of fruits and five servings of vegetables per day), and consumption at the recommended levels or greater.²³

Demographic variables

Gender, age, area of residence, highest educational attainment and gross annual household income were included in the analyses. The socioeconomic variables have been tested for reliability, which was conducted by the CATI Technical Reference Group, National Public Health Information Working Group (NPHIWG), between 2001 and 2004. As a result of this evaluation of the questions, the members of the CATI Technical Reference Group have collaborated to produce modular sets of questions for use in CATI surveys in Australia. These questions form part of the National Health Data Dictionary.²⁴

Other measurements

A measure of physical activity was derived from the sum of time spent walking and undertaking moderate and/or vigorous activity in a 1-week period, with time spent undertaking vigorous activity being doubled to account for its greater intensity.²⁵ 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 ≥ 25 kg/m². Smoking status and alcohol intake were also assessed.

Data analyses

Chi square tests were used to compare differences in categorical variables. The association between soft drink consumption and the risk of asthma/COPD

was analysed using logistic regression models, with adjustment for multiple covariates. The logistic model controlled for age (continuous), gender, education, income, place of residence, smoking, alcohol consumption, physical activity, intake of fruits and vegetables and being overweight. A test for trend of the risk of asthma/COPD across groups of soft drink consumption was performed by including the median intakes for each group as continuous variables in the logistic regression model. Statistical significance was taken as $P < 0.05$ (two-sided). All data are presented as weighted estimates and all analyses were performed using STATA version 11 software (StataCorp, College Station, TX, USA).

Role of the funding source

The study sponsors did not contribute to the study design and had no role in data collection, data analysis, data interpretation or writing of the report.

Ethics approval for the project was obtained from the University of Adelaide (ethics approval number H-182-2009). All participants gave informed consent.

RESULTS

Overall, 16 907 adults aged 16 years and over (mean 46.7 years, 48.1% male) were interviewed. The prevalence of asthma and COPD was 12.5% (95% confidence interval (CI): 11.8–13.2) and 4.4% (95% CI: 4.1–4.9), respectively.

About 72% of the participants reported that they did not consume soft drinks, whereas 11.4% had a daily soft drink intake of 0.5 L or more (Table 1). Among those with asthma and COPD, 13.3 and 15.6%, respectively, consumed 0.5 L or more of soft drink per day.

High levels of soft drink consumption were associated with a higher prevalence of asthma and COPD (Table 2). Compared with those who did not consume soft drinks, individuals consuming half a litre or more of soft drink per day had a much higher prevalence of asthma (14.7 vs 11.9%) and COPD (6.0 vs 4.2%).

In a multivariate analysis, after adjusting for socio-demographic factors, intake of fruit and vegetables and other life style factors, soft drink intake was significantly associated with asthma and COPD (Table 3). Comparing high consumption with non-consumption of soft drinks, the ORs were 1.79 (95% CI: 1.32–2.43) for COPD, 1.26 (95% CI: 1.01–1.58) for asthma, 2.33 (95% CI: 1.51–3.60) for both asthma and COPD, and 1.32 (95% CI: 1.07–1.62) for either asthma or COPD.

Figure 1 shows the combined effect of soft drink consumption and smoking. Individuals who consumed more than half a litre of soft drink per day and were current smokers had a 6.6-fold greater risk of COPD and a 1.5-fold greater risk of asthma, compared with those who did not consume soft drinks or smoke. Among smokers, there was a substantial increase in the odds ratio (OR) for COPD (4.3 to 6.6) when soft drink consumption increased from <0.5 to >0.5 L/day.

Table 1 Characteristics of the South Australian Monitoring and Surveillance System (SAMSS) population sample aged 16 years and over during March 2008–June 2010

	<i>n</i>	%
Gender		
Male	8 270	48.9
Female	8 637	51.1
Gross annual household income		
≥AU\$20 000	12 047	71.3
<AU\$20 000	1 765	10.4
Not stated	3 095	18.3
Level of education		
Low (no schooling to secondary)	9 055	53.6
Medium (trade, certificate, diploma)	4 130	24.4
High (degree or higher)	3 689	21.8
Place of residence		
Urban (metropolitan Adelaide)	12 301	72.8
Rural (South Australian country)	4 606	27.2
Smoking status		
Non-smoker	7 951	47.0
Ex-smoker	6 344	37.5
Smoker	2 582	15.3
COPD	746	4.4
Asthma	2 118	12.5
Overweight (BMI >25 kg/m ²)	9 116	53.9
Physical activity		
No activity	3 025	17.9
Insufficient activity (~150 min/week)	4 768	28.2
Sufficient activity (>150 min/week)	8 777	51.9
Soft drink consumption (L/day)		
0	12 124	71.7
<0.5	2 853	16.9
≥0.5	1 930	11.4
Intake of fruit (servings/day)		
<2	9 111	53.9
≥2	7 775	46.0
Intake of vegetables (servings/day)		
<5	14 887	88.0
≥5	1 942	11.5

Among individuals who did not consume soft drinks, smoking was not associated with the risk of asthma, although there was a positive association between smoking and COPD. Among non-smokers, there was no association between soft drink consumption and asthma/COPD.

After adjustment for age, gender and being overweight, low income and residence in a rural area were both associated with an increased prevalence of asthma. However, residence in a rural area was associated with a decreased risk of COPD. Level of education was inversely associated with COPD but not asthma. There was a strong interaction between level of education and smoking, in relation to COPD. However, even when this interaction term was included in the model, the association between soft drink consumption and the risk of COPD did not change (data not shown).

Table 2 Prevalence of COPD and asthma according to soft drink consumption among adults aged 16 years and over in South Australia during March 2008–June 2010

	Soft drink consumption (L/day)			P value
	0	0.1–0.5	≥0.5	
<i>n</i>	12 124	2853	1930	
Asthma (%)	11.9 (11.1–12.7)	14.0 (12.2–16.0)	14.7 (12.3–17.2)	0.017
COPD (%) [†]	4.2 (3.8–4.6)	4.4 (3.5–5.5)	6.0 (4.6–7.8)	0.029
Both COPD and asthma (%) [†]	1.4 (1.3–1.7)	1.6 (1.1–2.3)	2.4 (1.7–3.5)	0.039
Either COPD or asthma (%) [†]	14.6 (13.8–15.4)	16.8 (14.9–18.9)	18.3 (15.7–21.1)	0.006

95% confidence intervals are shown in parentheses.

[†] *n* = 16 879 (12 107, 2842 and 1930 across the soft drink consumption groups).

Table 3 Odds ratios (95% confidence interval) for COPD and asthma according to level of soft drink consumption among adults living in South Australia

	Soft drink intake (L/day)			P value for trend
	0	0.1–0.5	≥0.5	
Asthma				
Model 1 [†]	1	1.22 (1.02–1.46)	1.32 (1.06–1.65)	0.004
Model 2 [‡]	1	1.24 (1.03–1.49)	1.26 (1.01–1.58)	0.014
COPD				
Model 1 [†]	1	1.34 (1.03–1.73)	2.09 (1.55–2.83)	<0.001
Model 2 [‡]	1	1.33 (1.01–1.76)	1.79 (1.32–2.43)	<0.001
Both COPD and asthma				
Model 1 [†]	1	1.52 (1.02–2.27)	2.74 (1.79–4.20)	<0.001
Model 2 [‡]	1	1.42 (0.93–2.16)	2.33 (1.51–3.60)	<0.001
Either COPD or asthma				
Model 1 [†]	1	1.25 (1.06–1.47)	1.43 (1.17–1.75)	<0.001
Model 2 [‡]	1	1.26 (1.06–1.50)	1.32 (1.07–1.62)	0.002

[†] Model 1 adjusted for age and gender.

[‡] Model 2 adjusted for age, gender, education, income, area of residence, smoking (non-smoker, ex-smoker, smoker), alcohol consumption (servings/day), physical activity (none, vigorous physical activity <150 or ≥150 min/day), being overweight, intake of fruits and vegetables (servings/day), and intake of water and juice (L/day).

DISCUSSION

In this cross-sectional study we showed that consumption of soft drinks was positively associated with asthma/COPD among adults living in SA. This association was significant for both men and women. Adjusting for SES, lifestyle factors, overweight/obesity, and fruit and vegetable consumption did not change the association. There was an additive interaction between smoking and soft drink consumption in relation to asthma/COPD.

This is the first large population study showing an association between soft drink consumption and asthma/COPD among adults. The results confirm our hypothesis that there is an association between soft drink consumption and asthma/COPD. The results are also consistent with previous findings on the association between sugar consumption and asthma among children.¹⁸ The results showing an interaction between soft drink consumption and smoking in relation to asthma/COPD were consistent with the findings from a study by Shaheen *et al.*, which showed

that the association between a prudent dietary pattern and the risk of COPD among males was stronger in smokers than in non-smokers.¹⁵ The combined effect of soft drink consumption and smoking on asthma/COPD emphasizes the importance of lifestyle factor clustering in the aetiology of asthma/COPD. Promoting a healthy lifestyle should be encouraged as one means of preventing asthma/COPD.

The mechanisms linking soft drink consumption with asthma/COPD are unclear. Several hypotheses can be postulated. Both asthma and COPD are associated with inflammation. Food that may promote oxidative stress and inflammation could theoretically have effects on the pathogenesis of asthma or COPD. Soft drinks contain large amounts of sugar. Sugar consumption increases susceptibility to allergic airway inflammation and activates the innate immune system in the lung. An animal study showed that mice fed sugar had more than twice as much airway inflammation as mice that were fed water.²⁶ It is known that soft drink consumption increases the risk of obesity.²⁷ Obesity is a risk factor for asthma/COPD.^{28,29} However,

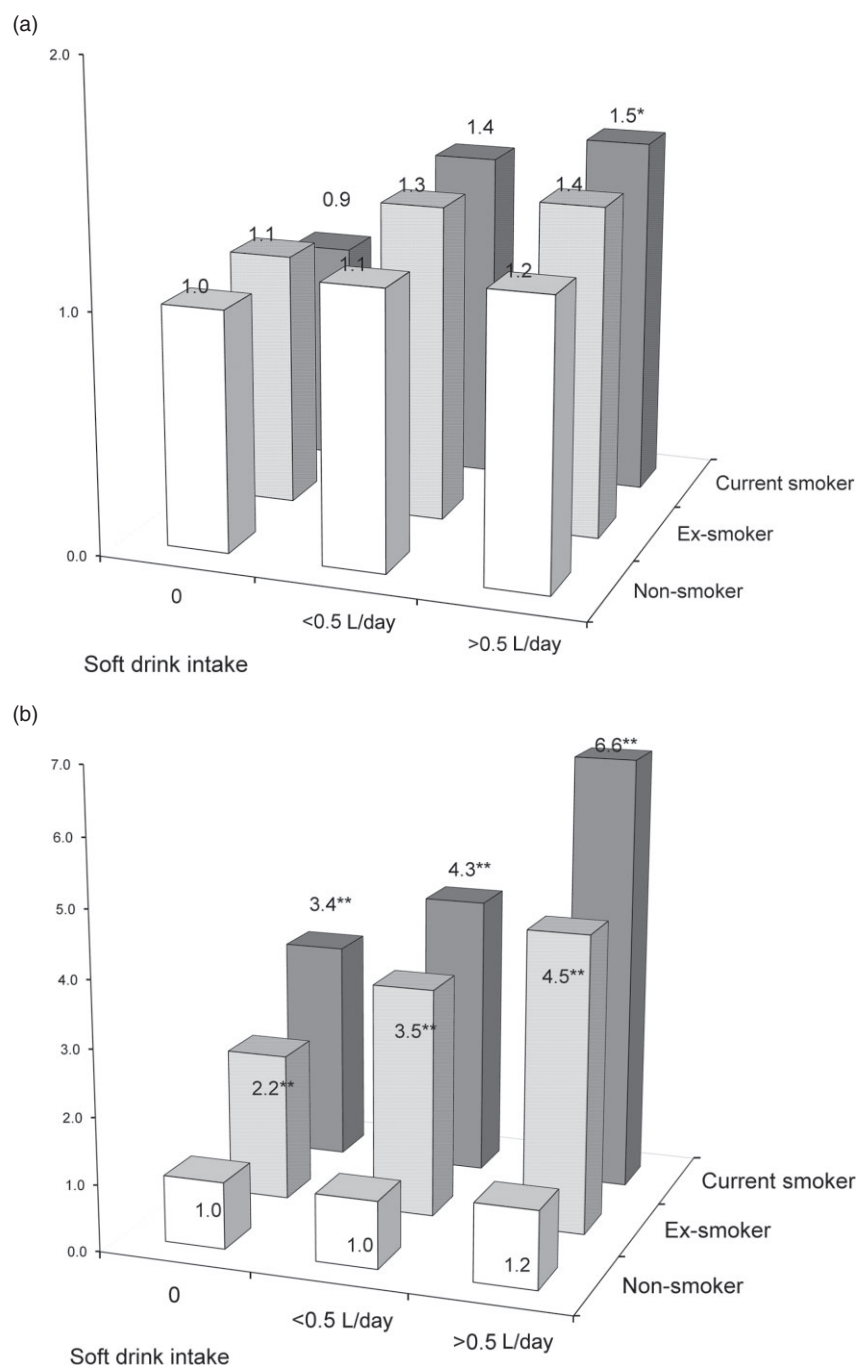


Figure 1 Combined effects of soft drink consumption and smoking in relation to (a) asthma and (b) COPD. Levels of soft drink consumption and smoking were cross-classified into a single categorical variable and the risk of asthma/COPD was evaluated using non-consumption of soft drinks and non-smoking as the reference values. ORs were adjusted for age, gender, level of education, income, area of residence, smoking (non-smoker, ex-smoker, smoker), alcohol consumption (servings/day), physical activity (none, vigorous physical activity <150 or ≥ 150 min/day), intake of fruits and vegetables (servings/day), and intake of water and juice (L/day). *, ** indicate statistically significant odds ratios (ORs).

in the present study, adjusting for obesity did not change the findings. Studies have also shown that chemicals such as phthalates from plastic bottles may be linked to asthma.³⁰ It is also possible that allergy to preservatives such as nitrites and sulphites may

increase symptoms and the likelihood that someone will self-report 'current asthma', especially since the definition depended on current use of medications.

In the present logistic regression analysis, both outcome measures demonstrated a highly significant

association with soft drink consumption. Comparing individuals with a high intake versus non-consumption of soft drinks, the risks of asthma, COPD, either asthma or COPD, or both asthma and COPD were all greater than 1.3. It is known that consumption of soft drinks increases the risk of chronic diseases, including being overweight, which is related to inflammation. Therefore the association between soft drink consumption and asthma may be subject to confounding due to the prevalence of these chronic conditions. In this study, however, the association between soft drink consumption and the risk of asthma or COPD did not change after adjustment for being overweight.

There are a number of potential shortcomings in this study and caution should be exercised in interpreting these findings. Causal relationships could not be established in this cross-sectional study. It is also pertinent that much of the data relied on self-reported information. Information on consumption of hot drinks (tea and coffee) was not collected, and although the majority of soft drinks sold in Australia are sweetened with sugar, there was no data available on whether the increased consumption was due to intake of sugared soft drinks, diet soft drinks or both. There was also no detailed information on the intake of other dietary components known to be associated with asthma/COPD, e.g. a dietary pattern of high consumption of processed/preserved food but low intake of fruits and vegetables. It is acknowledged that these are potentially important issues, and although adjustment for fruit and vegetable consumption may, to some degree, have controlled for quality of diet, further studies incorporating these other variables should be pursued. There was also no detailed information on the history of smoking; the data was only adjusted for smoking status based on categorization of current smokers, ex-smokers and non-smokers. Cumulative exposures, including cumulative data on soft drink consumption, were not available. Because the prevalence of asthma/COPD was based on self-reported information, under-reporting of asthma and COPD (especially the mild forms) was possible.

The use of telephone interviews and use of the electronic White Pages to provide the sampling frame are potential limitations of the study that may have resulted in biased estimates, because individuals without a landline telephone connection, or who were not listed in the White Pages would have been excluded. Previous studies have shown that using the EWP as a sampling frame would underestimate the prevalence of current smoking and asthma.³¹ There may also have been potential under-reporting of soft-drink consumption, as it is seen as an undesirable behaviour. The response rate was only fair (64%) and this may have also resulted in bias.

The strengths of the study include the large and representative sample, so that the conclusions are likely to be generalizable to the entire SA population. The high prevalence of asthma/COPD and the large variation in soft drink consumption provided a good opportunity to study the associations between these parameters.

The present study showed that increased consumption of soft drinks was associated with asthma/COPD among adults in Australia. There was a combined effect of soft drink consumption and smoking. Regardless of whether there is a cause and effect relationship, the public health implications of consumption of large volumes of soft drink are substantial.

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