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The association between adolescent tobacco, alcohol and illicit drug use and individual and environmental resilience protective factors

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Title: The association between adolescent tobacco, alcohol and illicit drug use and individual and environmental resilience protective factors

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ABSTRACT

Objectives: Research suggests individual and environmental resilience protective factors may be associated with adolescent substance use, however the associations between a broad range of such factors and use of various types of substances has not been examined. The study aimed to determine the association between a comprehensive range of adolescent individual and environmental resilience protective factors and measures of tobacco, alcohol and illicit substance use.

Design: Cross sectional study

Setting: 32 Australian secondary schools

Participants: Grade 7-10 students (aged 11-17 years)

Measures: Data regarding 14 student individual and environmental resilience protective factors and seven substance use measures (tobacco, alcohol, marijuana, other illicit drug use) were obtained via an online self-report survey. Adjusted multivariate logistic regression analyses examined the association between all student resilience protective factors and seven substance use measures.

Results: Inverse univariate associations were found for 108 of 112 relationships examined (n=10,092). Multivariate analyses found: consistent inverse associations between two of 14 protective factors and all substance use measures ('goals and aspirations', 'pro-social peers'); inverse associations between four protective factors with multiple substance use measures ('home support' (5 of 7), 'school support' (3 of 7), 'self-awareness' (2 of 7), 'community meaningful participation' (2 of 7)); positive associations between two resilience protective factors with multiple measures of substance use ('community support' (3 of 7), 'peer caring relationships' (5 of 7)); and six protective factors not to be associated with any substance use measure. .

Conclusions: Despite individual relationships between the majority of resilience protective factors and substance use types, the protective benefit of such factors for adolescent substance use was limited to only a small number of such factors when considered collectively. Such results suggest interventions seeking to reduce adolescent substance use may need to target specific protective factors to address specific types of substance use.

Trial registration: Australia and New Zealand Clinical Trials Register (Ref no. ACTRN12611000606987) http://www.anzctr.org.au/

ARTICLE SUMMARY

Strengths and limitations of this study

- This study represents the most comprehensive examination of the associations between a broad range of individual and environmental resilience protective factor and multiple measures of adolescent substance use.

- Design strengths of the study include: the large sample of adolescents, comprehensive measurement of individual and environmental resilience protective factors using a tool validated in an Australian population, use of multiple accepted measures of substance use, and analyses that accounted for a range of known confounders, potential clustering effects within schools and sensitivity analyses of data with imputation for missing data

- Although the study was reliant upon adolescent self-report of substance use and subject to the known limitations of self-report in this population, strategies to increase the validity of adolescent report were utilised including a web-based survey and confidential participation by students.

- Whilst a non-response bias may exist, consistency of results with comparative national data suggest the likelihood of such bias may be limited

- The cross sectional design of the study does not allow for investigation of causal pathways of the associations between resilience protective factors and adolescent substance use.

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BACKGROUND

Tobacco, alcohol and illicit substance use are responsible for more than 12% of deaths worldwide[1] and cost more than $600 billion (USD) annually in the United States[2-5] and $46.5 billion (USD) in Australia.[6] Initiation of tobacco, alcohol and illicit substance use in high income countries primarily occurs during adolescence.[7-9] The younger the age of initiation of substance use, the greater the likelihood of ongoing use, dependence and harm in later life.[7, 10-12] In the United States, United Kingdom and Australia, between 23-45% of adolescents (aged 11 to 17 years) have smoked a cigarette,[9, 13, 14] 43-74% have consumed an alcoholic drink,[9, 13, 14] 22-29% have consumed at least five alcoholic drinks on one occasion,[9, 13] and between 15-40% have taken an illicit substance.[9, 13, 14] The prevention of substance use among adolescents is a recommended strategy for reducing substance use related harms throughout the lifecourse.[15-17]

Historically, research regarding the determinants of adolescent substance use has focused on risk factors such as access to substances, socioeconomic disadvantage and substance use by parents, peers and siblings.[18-22] More recent research has explored a range of factors that may be protective of adolescent substance use,[23] including individual factors such as self-esteem [23-26] and problem solving ability,[27] and environmental factors such as connection to school,[23, 26, 28-33] family,[19, 23, 26, 28, 34] and pro-social peers.[34, 35]. Such factors have been considered to be factors protective of an adolescents' 'resilience',[25, 36-41] broadly described as a process, capacity or outcome of successfully adapting to challenging or threatening life circumstances.[42-44] As a consequence, enhancement of such protective factors is recommended as a strategy for reducing adolescent substance use.[15-17] The specific protective factors to be addressed by such interventions however are only broadly defined or are limited to a few examples in such recommendations. [15-17]

Although considerable research has been reported regarding the association between adolescent resilience protective factors and adolescent substance use,[23, 27-30, 32, 45-65] such research using multivariate analyses have only considered a limited number of resilience protective factors (six at

most [46]) or created aggregate scores of such factors[65], with the latter precluding assessment of associations for particular factors. In such studies, inconsistency of findings is apparent in terms of both the presence and direction of the associations between resilience protective factors and substance use. For example, adolescents have been reported to be either less, more, or no more or less likely to use a substance if they have low self-esteem,[23, 54, 63] low school connectedness,[23, 28, 29, 32] or low academic aspirations.[28, 47, 50, 58, 61] Inconsistency is similarly evident between substances in their reported association with specific protective factors. For example, in one study a significant negative association was reported between educational aspirations and both alcohol and marijuana use, but not tobacco use.[50] In other studies significant negative associations have been reported between community involvement and both tobacco and marijuana use, but not alcohol use.[49]. Such contrasting findings between studies may be attributable, in part, to the different measures of such factors across studies, and to the inconsistent inclusion of protective factors.

To date, no peer-reviewed study has reported the associations between a comprehensive range of adolescent individual and environmental resilience protective factors and multiple types of substance use. To address this gap and provide information that may guide future development of interventions targeting adolescent substance use, a study was conducted to determine the association between fourteen adolescent individual and environmental resilience protective factors and seven measures of tobacco, alcohol and illicit substance use in a population of Australian adolescents.

METHODS

STUDY DESIGN AND SETTING

A cross sectional study was conducted in one Health District of New South Wales, Australia. The District encompasses metropolitan, regional, rural and remote areas with a population of approximately 114,000 people aged 10 to 19 years.[66] The data were collected as baseline data for a randomised controlled trial for which Human Research Ethics Committee (Hunter New England Health Ref:09/11/18/4.01; University of Newcastle Ref:H-2010-0029) and other study approvals were obtained. The methods of the larger study are described in detail elsewhere.[67]

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PARTICIPANTS AND RECRUITMENT

Secondary schools

Eligible schools were either Government or Catholic secondary schools located in a disadvantaged Local Government Area,[68] with enrolments in Grades 7 to 10 (typically aged 12 to 16 years) on one campus, and with more than 400 total student enrolments. Independent, special needs, selective, central (schools catering for children aged 4 to 18 years), boarding schools or schools that were not co-educational were ineligible.

Eligible schools were approached for study participation according to a randomly ordered list of schools. If a school declined, the next school was invited to participate until a quota of 32 schools was recruited.

Students

All students enrolled in Grade 7 (usually aged 12 to 13 years) to Grade 10 (usually aged 15 to 16 years) in the 32 selected schools were eligible to participate (n=18,310). Parents of students were mailed a study information sheet, a consent form and a reply paid envelope. Two weeks following, non-responding parents were telephoned by school-affiliated staff to prompt return of the consent form.

DATA COLLECTION PROCEDURES

Students with parental consent were invited to complete a self-report anonymous web-based survey in class time (August-November 2011).

MEASURES

Student and school characteristics

Student age, school grade, gender, Aboriginal and Torres Strait Islander status and residential postcode were collected via the student survey.

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Substance use

Students' reported tobacco, alcohol, marijuana and other illicit drug use (7 outcomes) via the web-based survey (Table 1). The substance use items were sourced from a national triennial survey of school students' health behaviours.[9]

Table 1. Student substance use and resilience protective factor items

	Indicator	Survey item	Response options
Substance use			
Tobacco	Ever use	Have you ever smoked even part of a cigarette? [9]	Yes/No
	Recent use	Have you smoked a cigarette in the last week?	Yes/No
Alcohol	Ever use	Have you ever had a drink of alcohol? E.g. beer, wine or alcopops/pre-mix drinks (do not count sips or tastes)	Yes/No
	Recent use	Have you had any alcoholic drinks, such as beer, wine or alcopops/pre-mix drinks in the last week? (do not count sips or tastes)	Yes/No
	'Risky' use	In the last 4 weeks, how many times have you had 5 or more alcoholic drinks in a row? [9]	None/Once/Twice/3-6 times/7 or more times
Marijuana	Recent use	How many times in the last four weeks have you smoked or used marijuana/cannabis (grass, hash, dope, weed, mull, yarndi, ganga, pot, a bong, a joint) [9]	None/Once or twice/3-5 times/6-9 times/10-19 times/20-39 times/40 or more times
Other illicit drugs	Recent use	How many times in the last four weeks have you used any other illegal drug or pill to get "high", such as inhalants, hallucinogens (eg LSD, acid, trips), amphetamines (eg. speed, ice), ecstasy, cocaine or heroin?	None/Once or twice/3-5 times/6-9 times/10-19 times/20-39 times/40 or more times
Resilience protective factors			
Individual	Cooperation and communication	2 items; e.g. "I enjoy working together with other students my age"	1: Never true, 2: True some of the time; 3: True most of the time; 4: True all of the time
	Self-efficacy	4 items; e.g. "I can do most things if I try"	As above
	Empathy	3 items; e.g. "I try to understand what other people feel and think"	As above
	Problem solving	3 items; e.g. "When I need help I find someone to talk with"	As above
	Self-awareness	3 items; e.g. "I understand why I do what I do"	As above
	Goals and aspirations	3 items; e.g. "I have goals and plans for the future"	As above
Environmental	School support	6 items; e.g. "At my school there is an adult who really cares about me"	As above

School meaningful participation	3 items; e.g. "At my school, I help decide things like class activities or rules"	As above
Community support	6 items; e.g. "Outside of school and home, there is an adult whom I trust"	As above
Community meaningful participation	3 items; e.g. "I am part of clubs, sports teams, church/temple, or other groups"	As above
Home support	6 items; e.g. "At home, there is an adult who listens to me when I have something to say"	As above
Home meaningful participation	3 items; e.g. "I do fun things or go fun places with my parents or other adult from my home"	As above
Peer caring relationships	3 items; e.g. "I have a friend who helps me when I'm having a hard time"	As above
Pro-social peers	3 items; e.g. "My friends try to do what is right"	As above

Resilience protective factors

The Resilience and Youth Development module of the California Healthy Kids Survey, a measure of 14 adolescent individual and environmental resilience protective factors (termed internal and environmental assets), was used to measure protective factors (51 items: 4 point Likert scale –'1: Never true' to '4: True all of the time').[69] The survey incorporates items that addressed six individual factor subscales and eight environmental factor subscales (Table 1).[69] Consistent with reports from the tool developers,[69] the data from the current study confirms the survey tool is an internally consistent and valid measure (Cronbach alpha coefficients for individual factor subscales: 0.55-0.81; environmental factor subscales: 0.71-0.91). Additionally, confirmatory factor analysis using data from this study demonstrates the individual and environmental subscale factor structure to be a good model fit (Comparative fit index 0.92, Standardized Root Mean Square Residual 0.04, Root Mean Square Error of Approximation 0.04, Adjusted Goodness of Fit 0.90); with such results being similar to those reported by the tool developers.[69]

STATISTICAL ANALYSIS

All analyses were undertaken using SAS Software Version 9.3.[70]

Student characteristics and substance use

Participants who did not answer any substance use items (that is, they started the online survey but dropped out of the survey before getting to the substance use items) were excluded from all analyses (n=16). Participants who did not answer items for a particular substance were excluded from analyses for that particular substance. Consent and participation rates, demographic and substance use data were examined using descriptive statistics. Socio-economic status and remoteness of residential location were calculated from student-reported residential postcode using the Australia Bureau of Statistics Socio-Economic Indexes for Areas[68] and the Accessibility/Remoteness Index of Australia [71] respectively.

The response options for 'risky' alcohol use were collapsed ('none' versus 'once'/'twice'/'3-6 times'/'7 or more times'), as were the response options for marijuana and other illicit drug use ('none' versus 'once or twice'/'3-5 times'/'6-9 times'/'10-19 times'/'20-39 times'/'40 or more times').

Differences by gender and grade for each of the seven substance use outcomes were assessed through logistic regression analysis via a Generalised Estimating Equation (GEE) framework [72, 73] to account for potential clustering of students within schools.

Resilience protective factors

Sixteen protective factor scores (six individual factor subscales, total individual factors, eight environmental factor subscales, total environmental factors) were created. Protective factor subscale scores were calculated by averaging the responses to all items in a subscale for each student. Similarly, total individual and total environmental factor scores were calculated by averaging all relevant subscale scores for each student.[69] All such scores ranged from 1 to 4.

Correlation between resilience protective factors

Correlation analysis was undertaken to determine the correlations between all individual and environmental resilience protective factors scores. Pearson correlation coefficients were calculated for each.

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Associations between resilience protective factors and substance use

To examine the univariate and multivariate associations between resilience protective factors and student substance use, logistic regression analyses were conducted within a Generalised Estimating Equation (GEE) framework [72, 73] to account for potential clustering of students within schools. Individual backward stepwise logistic regression models were conducted for each of the seven substance use outcomes (dependent variables) and each factor measure (independent variables: total individual factors, total environmental factors, 14 protective factor subscales) to determine univariate associations (112 models). Multivariate logistic regression analyses explored the association between all individual and environmental protective factor subscales (14 in all, six individual, and eight environmental) and the seven substance use outcomes (7 models). In all models, factor score was used as a continuous variable (mean score). All models included potential demographic confounders of substance use, including: school size (400-800 medium/>800 large), school type (government/Catholic school) and student characteristics (gender, grade, remoteness of residential location, socio-economic and Aboriginal/Torres Strait Islander status). Odds ratios and 95% confidence levels were calculated for each model. In addition, the odds and probability of use of each substance was derived from the models for specific values of factors (factor score of 2 and 3), in order to calculate the difference in the probability of substance use for a one unit change in factor score.

Missing data from substance use items were imputed using the recommended method for cross sectional data in single item measures; 'hot deck' imputation.[74] Logistic regression analyses were repeated using the imputed dataset and any differential results reported.

To account for multiple testing a criterion for statistical significance of $p \leq 0.0004$ was used (Bonferroni-corrected).

RESULTS

SAMPLE

Of the 172 eligible secondary schools in the study area 47 schools were eligible to participate. Across the 32 participating schools (73% school consent rate), parental consent was granted for 13,440 students (73.4%) of which 10,244 students completed at least part of the student survey (participation rate: 55.9% of total enrolled students; 76.2% of students with parental consent). Those students who completed at least one substance use item (n=10,092; 55.1%) are reported in the analysis, the demographic characteristics of whom are shown in Table 2.

Table 2. Description of participating students (N=10,092)

Student demographics	Student sample N (%)	State comparison data[a] %
Gender		
Male	5066 (50.2)	51.4
Grade		
Year 7	3080 (30.5)	24.7
Year 8	2646 (26.2)	24.8
Year 9	2476 (24.5)	25.1
Year 10	1890 (18.7)	25.3
Age		
Younger than 12	11 (0.1)	0.4
12	1265 (12.5)	18.8
13	2926 (29.0)	24.9
14	2646 (26.2)	25.1
15	2215 (22.0)	24.4
16	1000 (9.9)	6.2
Older than 16	29 (0.3)	0.2
Aboriginality		
Aboriginal and/or Torres Strait Islander	1143 (11.3)	5.2
Socioeconomic status*		
Quintile 1 (most disadvantaged)	551 (5.5)	
Quintile 2	3000 (29.7)	
Quintile 3	5334 (52.9)	
Quintile 4	1124 (11.1)	
Quintile 5 (least disadvantaged)	68 (0.7)	
Remoteness (ARIA)*		
Major Cities	4246 (42.1)	
Inner Regional	2856 (28.3)	
Outer Regional/Remote	2975 (29.5)	

*Postcode missing for 15 students therefore SES and remoteness could not be calculated
[a] State comparison data for students in Years 7 to 10 attending government and Catholic schools in 2011 [85]

SUBSTANCE USE

Twenty-three per cent of students had ever used tobacco and 7% had recently used tobacco, with both

forms of use increasing by Grade (Table 3), with no difference by gender.

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Table 3. Proportion of students reporting substance use by grade and gender (n=10,092)

Substance use	All students % (n)	Grade 7 %	Grade 8 %	Grade 9 %	Grade 10 %	p value	Male %	Female %	p value	National comparison data[e] %
Ever used tobacco	22.5 (2272)	11.2	20.0	29.8	35.0	<0.0001	23.4	21.6	0.0920	23.3%
Recent tobacco use	6.9 (700)	2.3	6.1	9.7	12.2	<0.0001	7.3	6.6	0.2724	6.7%
Ever consumed alcohol[a]	50.5 (5080)	30.3	45.5	62.8	74.6	<0.0001	54.2	46.8	<0.0001	74.0%
Recent alcohol use[b]	13.6 (1367)	5.7	10.3	18.8	24.5	<0.0001	15.9	11.3	<0.0001	13.6%
Risk alcohol use[c]	14.8 (1488)	5.2	11.6	19.4	29.0	<0.0001	16.4	13.2	<0.0001	
Recent marijuana use[d]	6.3 (630)	1.5	4.7	9.4	12.2	<0.0001	7.9	4.7	<0.0001	6.8%
Recent other illicit drug use[d]	2.6 (259)	1.0	2.3	3.5	4.4	<0.0001	3.3	1.9	<0.0001	2.9%

[a] 35 missing (n=10,057); [b] 37 missing (n=10,055); [c] 40 missing (n=10,052); [d] 66 missing (n=10,026);

[e] Data from the 2011 Australian Secondary Students' Alcohol and Drug Survey (n= 26,194) [9]

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For alcohol use, 51%, 14% and 15% of students reported having ever used, recently used or 'risky' use of alcohol respectively. Alcohol use significantly increased by Grade across all three measures. A higher proportion of males reported use of each of the three alcohol measures.

Six percent of students reported recent marijuana use and 3% reported recent other illicit drug use. Both marijuana and other illicit drug use increased by Grade, with more males reporting use of marijuana and other illicit drugs.

RESILIENCE PROTECTIVE FACTORS

The mean scores for each measure of student resilience protective factors are shown in Table 4. The means varied from 2.36 (SD 0.74) to 3.42 (SD 0.75).

Table 4. Student mean resilience protective factor scores

Protective factor	Protective factor score	
	Mean	Std Dev
Total individual protective factors	3.01	0.47
Total environmental protective factors	3.01	0.50
Individual protective factor subscales:		
Cooperation and communication	3.03	0.66
Empathy	2.98	0.71
Goals and aspirations	3.15	0.71
Problem solving	2.78	0.70
Self-awareness	3.07	0.70
Self-efficacy	3.03	0.53
Environmental protective factor subscales:		
School support	2.88	0.74
School meaningful participation	2.36	0.74
Community support	3.21	0.77
Community meaningful participation	3.02	0.85
Home support	3.38	0.61
Home meaningful participation	2.89	0.70
Pro-social peers	2.91	0.63
Peer caring relationships	3.42	0.75

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CORRELATION BETWEEN RESILIENCE PROTECTIVE FACTORS

Significant correlations were found between all resilience protective factor subscale scores. Little to weak positive correlations between all individual (0.25-0.53) and environmental resilience protective factor subscales were found (0.26-0.61) (see Appendix A).

ASSOCIATIONS BETWEEN RESILIENCE PROTECTIVE FACTOR SCORES AND SUBSTANCE USE

Univariate associations

Total individual and total environmental resilience protective factor scores were significantly inversely associated with all measures of substance use (see Table 5). With four exceptions, all measures of substance use were inversely associated with all individual and environmental resilience protective factor subscale scores.

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Table 5. Univariate associations between mean resilience protective factor scores and substance use[a]

Protective factor	Ever used tobacco		Recent tobacco use		Ever used alcohol[b]		Recent alcohol use[c]		Risk alcohol use[d]		Marijuana use[e]		Other illicit drug use[e]	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Total individual protective factors	2.96*	2.60-3.37	3.59*	2.77-4.64	2.46*	2.15-2.83	2.49*	2.11-2.92	2.59*	2.25-2.99	3.40*	2.67-4.24	4.94*	3.46-7.05
Total environmental protective factors	3.01*	2.65-3.43	3.27*	2.67-4.01	2.41*	2.13-2.73	2.33*	2.02-2.68	2.40*	2.07-2.80	3.30*	2.73-3.99	4.24*	3.11-5.79
Individual protective factors:														
Cooperation and communication	1.65*	1.50-1.81	1.81*	1.57-2.08	1.42*	1.32-1.52	1.48*	1.32-1.66	1.14*	1.29-1.55	1.79*	1.52-2.12	2.22*	1.78-2.77
Empathy	1.35*	1.23-1.49	1.47*	1.24-1.73	1.39*	1.29-1.50	1.38*	1.23-1.55	1.40*	1.26-1.54	1.53*	1.31-1.79	2.15*	1.68-2.75
Goals and aspirations	1.76*	1.64-1.90	2.23*	1.97-2.53	1.71*	1.56-1.87	1.73*	1.60-1.88	1.97*	1.82-2.15	1.93*	1.68-2.21	2.30*	1.89-2.79
Problem solving	1.66*	1.54-1.80	1.75*	1.49-2.05	1.53*	1.43-1.63	1.60*	1.45-1.76	1.54*	1.42-1.67	1.95*	1.69-2.26	2.50*	1.99-3.15
Self-awareness	1.84*	1.69-2.01	2.03*	1.77-2.32	1.58*	1.46-1.71	1.58*	1.42-1.74	1.58*	1.43-1.74	1.91*	1.65-2.20	2.18*	1.72-2.75
Self-efficacy	1.95*	1.77-2.15	2.21*	1.79-2.72	1.65*	1.50-1.81	1.59*	1.39-1.82	1.68*	1.50-1.89	1.84*	1.51-2.24	2.56*	1.93-3.41
Environmental protective factors:														
School support	1.76*	1.63-1.89	1.80*	1.58-2.05	1.73*	1.61-1.85	1.60*	1.47-1.74	1.68*	1.53-1.86	1.86*	1.61-2.15	2.11*	1.68-2.67
School meaningful participation	1.66*	1.53-1.81	1.79*	1.54-2.08	1.45*	1.36-1.56	1.45*	1.28-1.64	1.46*	1.32-1.61	1.87*	1.63-2.16	1.98*	1.48-2.65
Community support	1.38*	1.30-1.46	1.39*	1.24-1.56	1.26*	1.20-1.33	1.27*	1.18-1.36	1.21*	1.11-1.32	1.43*	1.29-1.59	1.77*	1.49-2.10
Community meaningful participation	1.51*	1.42-1.63	1.69*	1.53-1.87	1.27*	1.20-1.35	1.26*	1.18-1.34	1.32*	1.23-1.42	1.48*	1.35-1.63	1.69*	1.51-1.90
Home support	2.25*	2.07-2.45	2.19*	1.89-2.52	2.21*	2.02-2.41	2.07*	1.88-2.29	2.07*	1.89-2.28	2.27*	1.96-2.63	2.63*	2.08-3.34
Home meaningful participation	1.71*	1.55-1.87	1.81*	1.55-2.11	1.49*	1.37-1.61	1.41*	1.27-1.58	1.46*	1.34-1.60	1.84*	1.61-2.10	2.02*	1.59-2.57
Peer caring relationships	1.14*	1.07-1.22	1.18	1.06-1.32	1.04	0.98-1.10	1.11	1.01-1.22	1.07	0.99-1.16	1.27*	1.13-1.43	1.53*	1.28-1.77
Pro-social peers	3.19*	2.85-3.58	3.82*	3.20-4.56	2.79*	2.51-3.10	2.92*	2.58-3.30	3.15*	2.76-3.59	3.75*	3.32-4.23	4.26*	3.41-5.31

[a] Models adjusted for school clustering, gender, grade, Aboriginal/Torres Strait Islander, socio-economic status, remoteness, school size, and school type;

[b] 35 missing (n=10,057); [c] 37 missing (n=10,055); [d] 40 missing (n=10,052); [e] 66 missing (n=10,026);

* $p<0.0004$.

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Multivariate associations

The final multivariate model for each substance use measure contained between four and ten of the 14 resilience protective factor subscales (Table 6). Of the resilience protective factors that remained in each final model, the majority had an inverse association with substance use (Table 6).

Across all substance use models, two protective factors were found to have an inverse association with substance use ('goals and aspirations' and 'pro-social peers'). A one unit decrease in mean subscale score significantly increased the odds of smoking (both measures), having consumed alcohol (all three measures), having used marijuana or another illicit substance by between 1.20 and 1.65 times for 'goals and aspirations', and between 2.30 and 3.64 times for 'pro-social peers'.

Four resilience protective factors were inversely associated with a least one substance use measure ('home support' (5 of 7 substance use measures), 'school support' (3 of 7), 'self-awareness' (2 of 7), 'community meaningful participation' (2 of 7)). Two resilience protective factors were found to have a consistent positive association with at least one substance use measure ('community support' (3 of 7 substance use measures), 'peer caring relationships' (5 of 7)). The remaining six resilience protective factors were not associated with any substance use outcome.

Data for between 2 and 5 variables were missing for 81 of 10092 participants, with no identified pattern of missingness. Identical analyses using imputation for missing data did not show a differential pattern of results.

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Table 6. Multivariate associations between mean resilience protective factor scores and substance use[a]

	Ever used tobacco		Recent tobacco use		Ever used alcohol[b]		Recent alcohol use[c]		Risk alcohol use[d]		Marijuana use[e]		Other illicit drug use[e]	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Resilience protective factors														
Individual														
Goals and aspirations	1.20*	(1.13-1.27)	1.54*	(1.39-1.70)	1.27*	(1.16-1.38)	1.29*	(1.18-1.40)	1.49*	(1.35-1.67)	1.31*	(1.14-1.51)	1.62*	(1.35-1.96)
Self-awareness	1.27*	(1.14-1.40)	1.42*	(1.23-1.64)	-	-	-	-	-	-	-			
Environmental									-	-				
School support	1.21*	(1.11-1.31)	-	-	1.38*	(1.26-1.51)	-	-	1.28*	(1.15-1.42)	-	-	-	-
Community support	0.82*	(1.76-0.89)	-	-	0.78*	(0.72-0.85)	-	-	0.74*	(0.67-0.82)	-	-	-	-
Community meaningful participation	1.17*	(1.09-1.24)	1.26*	(1.14-1.40)	-	-	-	-	-	-	-	-	-	-
Home support	1.53*	(1.39-1.69)	-	-	1.75*	(1.58-1.94)	1.60*	(1.44-1.79)	1.62*	(1.43-1.83)	1.43*	(1.22-1.69)	-	-
Peer caring relationships	0.71*	(0.65-0.77)	0.69*	(0.61-0.78)	0.69*	(0.65-0.74)	0.75*	(0.67-0.83)	0.71*	(0.66-0.77)	-	-	-	-
Pro-social peers	2.49*	(2.24-2.77)	3.10*	(2.63-3.65)	2.29*	(2.08-2.52)	2.46*	(2.14-2.81)	2.62*	(2.26-3.04)	2.96*	(2.60-3.36)	3.67*	(2.93-4.60)

[a] Models adjusted for school clustering, gender, grade, Aboriginal/Torres Strait Islander, socio-economic status, remoteness, school size, and school type;

[b] 35 missing (n=10,057); [c] 37 missing (n=10,055); [d] 40 missing (n=10,052); [e] 66 missing (n=10,026);

* $p<0.0004$.

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DISCUSSION

This study explored the associations between 14 adolescent individual and environmental resilience protective factors and seven measures of adolescent substance use. Of the 14 factors examined, six had an inverse and two had a positive association with at least one type of substance use. Of the resilience protective factors found to be inversely associated with substance use, only two were associated with all substance use measures. Such findings suggest that the protective benefit of resilience protective factors for adolescent substance use may be limited to only a small number of such factors and then, primarily, only for some substances.

No previous single peer reviewed study has reported the associations between a comprehensive range of individual and environmental protective factor measures and a broad range of adolescent substance use measures. Nonetheless, the inverse associations found between eight of the individual and environmental protective factor measures and substance use are generally consistent with the direction of previous studies of single or small numbers of factors and substance use.[23, 29, 30, 47-50, 58] Similarly, the findings of no association between six such factors and substance use are consistent with previous studies.[27, 48, 64] In contrast, the consistent positive association found between the protective factors of 'peer caring relationships' and use of some substances, differs from a previous study that have reported no evidence of an association.[30] Whilst the reason for such contrast is unknown, it may be at least partly attributable to the different measurement of resilience protective factors and substance use between studies.[30] No previous studies could be identified that examined the association between adolescent substance use and 'community support'. Further research is required to confirm the contrasting findings, and if confirmed, to understand the mechanisms for such an association such that interventions promoting these factors do not have an untoward effect.

The findings that six factors conferred a protective benefit for adolescent substance use appear to align with models of adolescent substance use prevention, such as the social development model (grounded in Bandura's social learning theory and control theory),[19] and models of resilience,[23, 25, 29, 36, 40-44, 75] which focus on individual capacities or assets, and bonding with family, school

and peers as protection against the risk factors for substance use. However despite the consistency in the direction of such associations, there was a lack of consistency of association across types of substances. For example lower 'community meaningful participation' was only associated with tobacco use (ever and recent) and lower 'school support' only associated with some measures of tobacco (ever) and alcohol use (ever and risk). Such findings suggest the protective benefit of such factors is variable across different types of substance use, rather than being generalised. The finding of no association or a positive association between a number of resilience protective factors and substance use however may challenge such models of substance use prevention, or at least the breadth of factors described by such models.

The finding of an inverse association between some resilience protective factors and different forms of adolescent substance use suggests that interventions and programs that seek to reduce such use by increasing resilience protective factors may be more likely to be effective if they target specific protective factors to address specific types of substance use. A number of studies have demonstrated that interventions can successfully increase resilience protective factors among young people, [76-79] including individual factors such as self-efficacy[80], and environmental factors related to family and community connection.[77] For example, a randomised controlled trial in Hong Kong examining the efficacy of a positive youth development intervention targeting a range of resilience protective factors (including self-efficacy, beliefs in the future, bonding, and prosocial involvement) to reduce adolescent substance use, reported an increase in some targeted protective factors (such as self-efficacy and bonding) and decreases in substance use.[80] Further research is required to determine whether intervention approaches focused on the enhancement of the specific resilience protective factors found to be associated with adolescent substance use in this study have a beneficial effect on such use.

As previous research has demonstrated that risk factors such as access to substances, substance use by parents, and by peers and siblings [18-22] are associated with adolescent substance use, further research exploring the association of resilience protective factors with adolescent substance use in the

context of such risk factors is warranted. Such research is needed to identify the specific set of individual and environmental resilience protective factors and risk factors, that are associated with adolescent substance use, the relative contribution of each type of factor, and to determine the consistency of association between such factors and different types of substances. Whilst some studies investigating both risk and protective factors generally have found risk factors to be stronger predictors of tobacco, alcohol and marijuana use, such studies have only examined a limited number of resilience protective factors and types of substance use.[49, 81]

The findings of this study should be viewed in light of a number of the study characteristics. First, the study included a number of design strengths, including: a large sample of adolescents; use of a tool validated in an Australian adolescent population; comprehensive measurement of both individual and environmental resilience protective factors; use of multiple accepted measures of substance use; and analyses that accounted for a range of known confounders and potential clustering effects within schools. Although the study was reliant upon adolescent self-report of substance use and subject to the known limitations of self-report in this population,[82] self-report is an accepted method of measuring substance use by adolescents. To optimise validity of report, a web-based survey was utilised [83] as was confidential participation by students, strategies that have been found to increase the validity of adolescent report of sensitive questions, such as substance use.[84]

Although a non-response bias may exist, the demographic characteristics and prevalence of adolescent substance use found in this study are consistent with those reported in Australian triennial nation-wide surveys.[9, 85] Such consistency suggests that the likelihood of bias may be limited, despite the study being conducted in one local health district of New South Wales Australia. Finally, the study is limited by its cross sectional design which does not allow for investigation of the causal pathways of the association findings. Further longitudinal and intervention-based research is required to address these questions.

AUTHORS' CONTRIBUTIONS

Contributors: RKH contributed to the design of the data collection tools, monitored the data collection, led conception of the paper, cleaned and analysed the data, drafted and revised the paper. MF, JB and JW contributed to the design of the data collection tools and conception of the paper, monitored the data collection, provided critical revision and approved the final version of the paper. LW, KG and JD contributed to the critical revision of the manuscript and approved the final manuscript. CL provided statistical advice.

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FUNDING STATEMENT

COMPETING INTERESTS STATEMENT

We have read and understood BMJ policy on declaration of interests and declare that we have no competing interests.

DATA SHARING

Requests for additional unpublished data should be forwarded to

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Appendix A. Correlation between individual and environmental resilience protective factor subscales

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Cooperation and communication (1)	1.00													
Empathy (2)	0.48*	1.00												
Goals and aspirations (3)	0.30*	0.39*	1.00											
Problem solving (4)	0.43*	0.38*	0.31*	1.00										
Self-awareness (5)	0.45*	0.25*	0.30*	0.44*	1.00									
Self-efficacy (6)	0.48*	0.32*	0.37*	0.42*	0.53*	1.00								
School support (7)							1.00							
School meaningful participation (8)							0.58*	1.00						
Community support (9)							0.53*	0.42*	1.00					
Community meaningful participation (10)							0.36*	0.41*	0.42*	1.00				
Home support (11)							0.50*	0.38*	0.52*	0.38*	1.00			
Home meaningful participation (12)							0.48*	0.53*	0.50*	0.41*	0.61*	1.00		
Pro-social peers (13)							0.35*	0.30*	0.29*	0.26*	0.38*	0.32*	1.00	
Peer caring relationships (14)							0.33*	0.26*	0.40*	0.26*	0.36*	0.34*	0.30*	1.00

* $p<0.0001$

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-9
Bias	9	Describe any efforts to address potential sources of bias	8-9
Study size	10	Explain how the study size was arrived at	9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-9
		(*b*) Describe any methods used to examine subgroups and interactions	n/a
		(*c*) Explain how missing data were addressed	7-9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	8-9
		(*e*) Describe any sensitivity analyses	9

Results

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9-10
		(b) Give reasons for non-participation at each stage	9-10
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	24
		(b) Indicate number of participants with missing data for each variable of interest	24-26
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	24
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	25-26
		(*b*) Report category boundaries when continuous variables were categorized	24-26
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	na
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	25

Discussion

Key results	18	Summarise key results with reference to study objectives	12-13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14-15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	15

Other information

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Cover page

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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The association between adolescent tobacco, alcohol and illicit drug use and individual and environmental resilience protective factors

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Title: The association between adolescent tobacco, alcohol and illicit drug use and individual and environmental resilience protective factors

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Word count: 3261

ABSTRACT

Objectives: Research suggests individual and environmental resilience protective factors may be associated with adolescent substance use, however the associations between a broad range of such factors and use of various types of substances has not been examined. The study aimed to determine the association between a comprehensive range of adolescent individual and environmental resilience protective factors and measures of tobacco, alcohol and illicit substance use.

Design: Cross sectional study

Setting: 32 Australian secondary schools

Participants: Grade 7-10 students (aged 11-17 years)

Measures: Data regarding 14 student individual and environmental resilience protective factors and seven substance use measures (tobacco, alcohol, marijuana, other illicit drug use) were obtained via an online self-report survey. Adjusted multivariate logistic regression analyses examined the association between all student resilience protective factors and seven substance use measures.

Results: Inverse univariate associations were found for 94 of 98 relationships examined (n=10,092). Multivariate analyses found: consistent inverse associations between two of 14 protective factors and all substance use measures ('goals and aspirations', 'pro-social peers'); inverse associations between four protective factors with multiple substance use measures ('home support' (5 of 7), 'school support' (3 of 7), 'self-awareness' (2 of 7), 'community meaningful participation' (2 of 7)); positive associations between two resilience protective factors with multiple measures of substance use ('community support' (3 of 7), 'peer caring relationships' (5 of 7)); and six protective factors not to be associated with any substance use measure.

Conclusions: Despite individual relationships between the majority of resilience protective factors and substance use types, the protective benefit of such factors for adolescent substance use was limited to only a small number of such factors when considered collectively. Such results suggest interventions seeking to reduce adolescent substance use may need to target specific protective factors to address specific types of substance use.

Trial registration: Australia and New Zealand Clinical Trials Register (Ref no. ACTRN12611000606987) http://www.anzctr.org.au/

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ARTICLE SUMMARY

Strengths and limitations of this study

- This study represents the most comprehensive examination of the associations between a broad range of individual and environmental resilience protective factor and multiple measures of adolescent substance use.

- Design strengths of the study include: the large sample of adolescents, comprehensive measurement of individual and environmental resilience protective factors using a tool validated in an Australian population, use of multiple accepted measures of substance use, and analyses that accounted for a range of known confounders, potential clustering effects within schools and sensitivity analyses of data with imputation for missing data

- Although the study was reliant upon adolescent self-report of substance use and subject to the known limitations of self-report in this population, strategies to increase the validity of adolescent report were utilised including a web-based survey and confidential participation by students.

- Whilst a non-response bias may exist, consistency of results with comparative national data suggest the likelihood of such bias may be limited

- The cross sectional design of the study does not allow for investigation of causal pathways of the associations between resilience protective factors and adolescent substance use.

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BACKGROUND

Tobacco, alcohol and illicit substance use are responsible for more than 12% of deaths worldwide[1] and cost more than $600 billion (USD) annually in the United States[2-5] and $46.5 billion (USD) in Australia.[6] Initiation of tobacco, alcohol and illicit substance use in high income countries primarily occurs during adolescence.[7-9] The younger the age of initiation of substance use, the greater the likelihood of ongoing use, dependence and harm in later life.[7, 10-12] In the United States, United Kingdom and Australia, between 23-45% of adolescents (aged 11 to 17 years) have smoked a cigarette,[9, 13, 14] 43-74% have consumed an alcoholic drink,[9, 13, 14] 22-29% have consumed at least five alcoholic drinks on one occasion,[9, 13] and between 15-40% have taken an illicit substance.[9, 13, 14] The prevention of substance use among adolescents is a recommended strategy for reducing substance use related harms throughout the lifecourse.[15-17]

Historically, research regarding the determinants of adolescent substance use has focused on risk factors such as access to substances, socioeconomic disadvantage and substance use by parents, peers and siblings.[18-22] More recent research has explored a range of factors that may be protective of adolescent substance use,[23] including individual factors such as self-esteem [23-26] and problem solving ability,[27] and environmental factors such as connection to school,[23, 26, 28-33] family,[19, 23, 26, 28, 34] and pro-social peers.[34, 35]. Such factors have been considered to be factors protective of an adolescents' 'resilience',[25, 36-41] broadly described as a process, capacity or outcome of successfully adapting to challenging or threatening life circumstances.[42-44] As a consequence, enhancement of such protective factors is recommended as a strategy for reducing adolescent substance use.[15-17] The specific protective factors to be addressed by such interventions however are only broadly defined or are limited to a few examples in such recommendations. [15-17]

Although considerable research has been reported regarding the association between adolescent resilience protective factors and adolescent substance use,[23, 27-30, 32, 45-65] such research using multivariate analyses have only considered a limited number of resilience protective factors (six at

most [46]) or created aggregate scores of such factors[65], with the latter precluding assessment of

associations for particular factors. In such studies, inconsistency of findings is apparent in terms of

both the presence and direction of the associations between resilience protective factors and substance

use. For example, adolescents have been reported to be either less, more, or no more or less likely to

use a substance if they have low self-esteem,[23, 54, 63] low school connectedness,[23, 28, 29, 32] or

low academic aspirations.[28, 47, 50, 58, 61] Inconsistency is similarly evident between substances in

their reported association with specific protective factors. For example, in one study a significant

negative association was reported between educational aspirations and both alcohol and marijuana

use, but not tobacco use.[50] In other studies significant negative associations have been reported

between community involvement and both tobacco and marijuana use, but not alcohol use.[49]. Such

contrasting findings between studies may be attributable, in part, to the different measures of such

factors across studies, and to the inconsistent inclusion of protective factors.

To date, no peer-reviewed study has reported the associations between a comprehensive range of

adolescent individual and environmental resilience protective factors and multiple types of substance

use. To address this gap and provide information that may guide future development of interventions

targeting adolescent substance use, a study was conducted to determine the association between

fourteen adolescent individual and environmental resilience protective factors and seven measures of

tobacco, alcohol and illicit substance use in a population of Australian adolescents.

METHODS

STUDY DESIGN AND SETTING

A cross sectional study was conducted in one Health District of New South Wales, Australia. The

District encompasses metropolitan, regional, rural and remote areas with a population of

approximately 114,000 people aged 10 to 19 years.[66] The data were collected as baseline data for a

randomised controlled trial for which Human Research Ethics Committee (Hunter New England

Health Ref:09/11/18/4.01; University of Newcastle Ref:H-2010-0029) and other study approvals were

obtained. The methods of the larger study are described in detail elsewhere.[67]

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PARTICIPANTS AND RECRUITMENT

Secondary schools

Eligible schools were either Government or Catholic secondary schools located in a disadvantaged Local Government Area,[68] with enrolments in Grades 7 to 10 (typically aged 12 to 16 years) on one campus, and with more than 400 total student enrolments. Independent, special needs, selective, central (schools catering for children aged 4 to 18 years), boarding schools or schools that were not co-educational were ineligible.

Eligible schools were approached for study participation according to a randomly ordered list of schools. If a school declined, the next school was invited to participate until a quota of 32 schools was recruited.

Students

All students enrolled in Grade 7 (usually aged 12 to 13 years) to Grade 10 (usually aged 15 to 16 years) in the 32 selected schools were eligible to participate (n=18,310). Parents of students were mailed a study information sheet, a consent form and a reply paid envelope. Two weeks following, non-responding parents were telephoned by school-affiliated staff to prompt return of the consent form.

DATA COLLECTION PROCEDURES

Students with parental consent were invited to complete a self-report anonymous web-based survey in class time (August-November 2011).

MEASURES

Student and school characteristics

Student age, school grade, gender, Aboriginal and Torres Strait Islander status and residential postcode were collected via the student survey.

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Substance use

Students' reported tobacco, alcohol, marijuana and other illicit drug use (7 outcomes) via the web-based survey (Table 1). The substance use items were sourced from a national triennial survey of school students' health behaviours.[9]

Table 1. Student substance use and resilience protective factor items

	Indicator	Survey item	Response options
Substance use			
Tobacco	Ever use	Have you ever smoked even part of a cigarette? [9]	Yes/No
	Recent use	Have you smoked a cigarette in the last week?	Yes/No
Alcohol	Ever use	Have you ever had a drink of alcohol? E.g. beer, wine or alcopops/pre-mix drinks (do not count sips or tastes)	Yes/No
	Recent use	Have you had any alcoholic drinks, such as beer, wine or alcopops/pre-mix drinks in the last week? (do not count sips or tastes)	Yes/No
	'Risky' use	In the last 4 weeks, how many times have you had 5 or more alcoholic drinks in a row? [9]	None/Once/Twice/3-6 times/7 or more times
Marijuana	Recent use	How many times in the last four weeks have you smoked or used marijuana/cannabis (grass, hash, dope, weed, mull, yarndi, ganga, pot, a bong, a joint) [9]	None/Once or twice/3-5 times/6-9 times/10-19 times/20-39 times/40 or more times
Other illicit drugs	Recent use	How many times in the last four weeks have you used any other illegal drug or pill to get "high", such as inhalants, hallucinogens (eg LSD, acid, trips), amphetamines (eg. speed, ice), ecstasy, cocaine or heroin?	None/Once or twice/3-5 times/6-9 times/10-19 times/20-39 times/40 or more times
Resilience protective factors			
Individual	Cooperation and communication	2 items; e.g. "I enjoy working together with other students my age"	1: Never true, 2: True some of the time; 3: True most of the time; 4: True all of the time
	Self-efficacy	4 items; e.g. "I can do most things if I try"	As above
	Empathy	3 items; e.g. "I try to understand what other people feel and think"	As above
	Problem solving	3 items; e.g. "When I need help I find someone to talk with"	As above
	Self-awareness	3 items; e.g. "I understand why I do what I do"	As above
	Goals and aspirations	3 items; e.g. "I have goals and plans for the future"	As above
Environmental	School support	6 items; e.g. "At my school there is an adult who really cares about me"	As above

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School meaningful participation	3 items; e.g. "At my school, I help decide things like class activities or rules"	As above
Community support	6 items; e.g. "Outside of school and home, there is an adult whom I trust"	As above
Community meaningful participation	3 items; e.g. "I am part of clubs, sports teams, church/temple, or other groups"	As above
Home support	6 items; e.g. "At home, there is an adult who listens to me when I have something to say"	As above
Home meaningful participation	3 items; e.g. "I do fun things or go fun places with my parents or other adult from my home"	As above
Peer caring relationships	3 items; e.g. "I have a friend who helps me when I'm having a hard time"	As above
Pro-social peers	3 items; e.g. "My friends try to do what is right"	As above

Resilience protective factors

The Resilience and Youth Development module of the California Healthy Kids Survey, a measure of 14 adolescent individual and environmental resilience protective factors (termed internal and environmental assets), was used to measure protective factors (51 items: 4 point Likert scale –'1: Never true' to '4: True all of the time').[69] The survey incorporates items that addressed six individual factor subscales and eight environmental factor subscales (Table 1).[69] Two minor modifications were made to the survey for use in an Australian population. First, the survey item "I plan to go to college…" was modified to state "I plan to go to university or TAFE…". Second, the response options for all of the items from the survey were modified from "Not at all true, a little true, pretty much true, very much true" to "Never true, true some of the time, true most of the time, true all of the time". Consistent with reports from the tool developers,[69] the data from the current study confirms the survey tool is an internally consistent and valid measure (Cronbach alpha coefficients for individual factor subscales: 0.55-0.81; environmental factor subscales: 0.71-0.91). Additionally, confirmatory factor analysis using data from this study demonstrates the individual and environmental subscale factor structure to be a good model fit (Comparative fit index 0.92, Standardized Root Mean Square Residual 0.04, Root Mean Square Error of Approximation 0.04, Adjusted Goodness of Fit 0.90); with such results being similar to those reported by the tool developers.[69]

STATISTICAL ANALYSIS

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Student characteristics and substance use

Participants who did not answer any substance use items (that is, they started the online survey but dropped out of the survey before getting to the substance use items) were excluded from all analyses (n=16). Participants who did not answer items for a particular substance were excluded from analyses for that particular substance. Consent and participation rates, demographic and substance use data were examined using descriptive statistics. Socio-economic status and remoteness of residential location were calculated from student-reported residential postcode using the Australia Bureau of Statistics Socio-Economic Indexes for Areas[68] and the Accessibility/Remoteness Index of Australia [70] respectively.

The response options for 'risky' alcohol use were collapsed ('none' versus 'once'/'twice'/'3-6 times'/'7 or more times'), as were the response options for marijuana and other illicit drug use ('none' versus 'once or twice'/'3-5 times'/'6-9 times'/'10-19 times'/'20-39 times'/'40 or more times').

Differences by gender and grade for each of the seven substance use outcomes were assessed through logistic regression analysis via a Generalised Estimating Equation (GEE) framework [71, 72] to account for potential clustering of students within schools.

Resilience protective factors

Fourteen protective factor scores (six individual factor subscales, eight environmental factor subscales) were created. Protective factor subscale scores were calculated by averaging the responses to all items in a subscale for each student. All such scores ranged from 1 to 4.

Correlation between resilience protective factors

Correlation analysis was undertaken to determine the correlations between all individual and environmental resilience protective factors scores. Pearson correlation coefficients were calculated for each.

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Associations between resilience protective factors and substance use

To examine the univariate and multivariate associations between resilience protective factors and student substance use, logistic regression analyses were conducted within a Generalised Estimating Equation (GEE) framework [71, 72] to account for potential clustering of students within schools. Individual backward stepwise logistic regression models were conducted for each of the seven substance use outcomes (dependent variables) and each factor measure (independent variables: 14 protective factor subscales) to assess whether a decrease in each mean factor score was associated univariately with substance use (98 models). Multivariate logistic regression analyses explored the association between all individual and environmental protective factor subscales (14 in all, six individual, and eight environmental) and the seven substance use outcomes (7 models). In all models, factor score was used as a continuous variable (mean score). All models included potential demographic confounders of substance use, including: school size (400-800 medium/>800 large), school type (government/Catholic school) and student characteristics (gender, grade, remoteness of residential location, socio-economic and Aboriginal/Torres Strait Islander status). Odds ratios and 95% confidence levels were calculated for each model. In addition, the odds and probability of use of each substance was derived from the models for specific values of factors (factor score of 2 and 3), in order to calculate the difference in the probability of substance use for a one unit change in factor score.

Missing data from substance use items were imputed using the recommended method for cross sectional data in single item measures; 'hot deck' imputation.[73] Logistic regression analyses were repeated using the imputed dataset and any differential results reported.

To account for multiple testing a criterion for statistical significance of $p \leq 0.0005$ was used (Bonferroni-corrected).

RESULTS

SAMPLE

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Of the 172 eligible secondary schools in the study area 47 schools were eligible to participate. Across the 32 participating schools (73% school consent rate), parental consent was granted for 13,440 students (73.4%) of which 10,244 students completed at least part of the student survey (participation rate: 55.9% of total enrolled students; 76.2% of students with parental consent). Those students who completed at least one substance use item (n=10,092; 55.1%) are reported in the analysis, the demographic characteristics of whom are shown in Table 2.

Table 2. Description of participating students (N=10,092)

Student demographics	Student sample	State comparison data[a]
	N (%)	%
Gender		
Male	5066 (50.2)	51.4
Grade		
Year 7	3080 (30.5)	24.7
Year 8	2646 (26.2)	24.8
Year 9	2476 (24.5)	25.1
Year 10	1890 (18.7)	25.3
Age		
Younger than 12	11 (0.1)	0.4
12	1265 (12.5)	18.8
13	2926 (29.0)	24.9
14	2646 (26.2)	25.1
15	2215 (22.0)	24.4
16	1000 (9.9)	6.2
Older than 16	29 (0.3)	0.2
Aboriginality		
Aboriginal and/or Torres Strait Islander	1143 (11.3)	5.2
Socioeconomic status*		
Quintile 1 (most disadvantaged)	551 (5.5)	
Quintile 2	3000 (29.7)	
Quintile 3	5334 (52.9)	
Quintile 4	1124 (11.1)	
Quintile 5 (least disadvantaged)	68 (0.7)	
Remoteness (ARIA)*		
Major Cities	4246 (42.1)	
Inner Regional	2856 (28.3)	
Outer Regional/Remote	2975 (29.5)	

*Postcode missing for 15 students therefore SES and remoteness could not be calculated
[a] State comparison data for students in Years 7 to 10 attending government and Catholic schools in 2011[74]

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SUBSTANCE USE

Twenty-three per cent of students had ever used tobacco and 7% had recently used tobacco, with both

forms of use increasing by Grade (Table 3), with no difference by gender.

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Table 3. Proportion of students reporting substance use by grade and gender (n=10,092)

Substance use	All students % (n)	Grade 7 %	Grade 8 %	Grade 9 %	Grade 10 %	p value	Male %	Female %	p value	National comparison data[e] %
Ever used tobacco	22.5 (2272)	11.2	20.0	29.8	35.0	<0.0001	23.4	21.6	0.0920	23.3%
Recent tobacco use	6.9 (700)	2.3	6.1	9.7	12.2	<0.0001	7.3	6.6	0.2724	6.7%
Ever consumed alcohol[a]	50.5 (5080)	30.3	45.5	62.8	74.6	<0.0001	54.2	46.8	<0.0001	74.0%
Recent alcohol use[b]	13.6 (1367)	5.7	10.3	18.8	24.5	<0.0001	15.9	11.3	<0.0001	13.6%
Risk alcohol use[c]	14.8 (1488)	5.2	11.6	19.4	29.0	<0.0001	16.4	13.2	<0.0001	
Recent marijuana use[d]	6.3 (630)	1.5	4.7	9.4	12.2	<0.0001	7.9	4.7	<0.0001	6.8%
Recent other illicit drug use[d]	2.6 (259)	1.0	2.3	3.5	4.4	<0.0001	3.3	1.9	<0.0001	2.9%

[a] 35 missing (n=10,057); [b] 37 missing (n=10,055); [c] 40 missing (n=10,052); [d] 66 missing (n=10,026);

[e] Data from the 2011 Australian Secondary Students' Alcohol and Drug Survey (n= 26,194) [9]

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For alcohol use, 51%, 14% and 15% of students reported having ever used, recently used or 'risky' use of alcohol respectively. Alcohol use significantly increased by Grade across all three measures. A higher proportion of males reported use of each of the three alcohol measures.

Six percent of students reported recent marijuana use and 3% reported recent other illicit drug use. Both marijuana and other illicit drug use increased by Grade, with more males reporting use of marijuana and other illicit drugs.

RESILIENCE PROTECTIVE FACTORS

The mean scores for each measure of student resilience protective factors are shown in Table 4. The means varied from 2.36 (SD 0.74) to 3.42 (SD 0.75).

Table 4. Student mean resilience protective factor scores

Protective factor	Protective factor score	
	Mean	Std Dev
Individual protective factor subscales:		
Cooperation and communication	3.03	0.66
Empathy	2.98	0.71
Goals and aspirations	3.15	0.71
Problem solving	2.78	0.70
Self-awareness	3.07	0.70
Self-efficacy	3.03	0.53
Environmental protective factor subscales:		
School support	2.88	0.74
School meaningful participation	2.36	0.74
Community support	3.21	0.77
Community meaningful participation	3.02	0.85
Home support	3.38	0.61
Home meaningful participation	2.89	0.70
Pro-social peers	2.91	0.63
Peer caring relationships	3.42	0.75

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CORRELATION BETWEEN RESILIENCE PROTECTIVE FACTORS

Significant correlations were found between all resilience protective factor subscale scores. Little to

weak positive correlations between all individual (0.25-0.53) and environmental resilience protective

factor subscales were found (0.26-0.61) (see Appendix A).

ASSOCIATIONS BETWEEN RESILIENCE PROTECTIVE FACTOR SCORES AND

SUBSTANCE USE

Univariate associations

With four exceptions, all measures of substance use were inversely associated with all individual and

environmental resilience protective factor subscale scores (see Table 5).

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Table 5. Univariate associations between mean resilience protective factor scores and substance use[a,b]

Protective factor	Ever used tobacco		Recent tobacco use		Ever used alcohol[c]		Recent alcohol use[d]		Risk alcohol use[e]		Marijuana use[f]		Other illicit drug use[f]	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Individual protective factors: [f]														
Cooperation and communication	1.65*	1.50-1.81	1.81*	1.57-2.08	1.42*	1.32-1.52	1.48*	1.32-1.66	1.14*	1.29-1.55	1.79*	1.52-2.12	2.22*	1.78-2.77
Empathy	1.35*	1.23-1.49	1.47*	1.24-1.73	1.39*	1.29-1.50	1.38*	1.23-1.55	1.40*	1.26-1.54	1.53*	1.31-1.79	2.15*	1.68-2.75
Goals and aspirations	1.76*	1.64-1.90	2.23*	1.97-2.53	1.71*	1.56-1.87	1.73*	1.60-1.88	1.97*	1.82-2.15	1.93*	1.68-2.21	2.30*	1.89-2.79
Problem solving	1.66*	1.54-1.80	1.75*	1.49-2.05	1.53*	1.43-1.63	1.60*	1.45-1.76	1.54*	1.42-1.67	1.95*	1.69-2.26	2.50*	1.99-3.15
Self-awareness	1.84*	1.69-2.01	2.03*	1.77-2.32	1.58*	1.46-1.71	1.58*	1.42-1.74	1.58*	1.43-1.74	1.91*	1.65-2.20	2.18*	1.72-2.75
Self-efficacy	1.95*	1.77-2.15	2.21*	1.79-2.72	1.65*	1.50-1.81	1.59*	1.39-1.82	1.68*	1.50-1.89	1.84*	1.51-2.24	2.56*	1.93-3.41
Environmental protective factors:[f]														
School support	1.76*	1.63-1.89	1.80*	1.58-2.05	1.73*	1.61-1.85	1.60*	1.47-1.74	1.68*	1.53-1.86	1.86*	1.61-2.15	2.11*	1.68-2.67
School meaningful participation	1.66*	1.53-1.81	1.79*	1.54-2.08	1.45*	1.36-1.56	1.45*	1.28-1.64	1.46*	1.32-1.61	1.87*	1.63-2.16	1.98*	1.48-2.65
Community support	1.38*	1.30-1.46	1.39*	1.24-1.56	1.26*	1.20-1.33	1.27*	1.18-1.36	1.21*	1.11-1.32	1.43*	1.29-1.59	1.77*	1.49-2.10
Community meaningful participation	1.51*	1.42-1.63	1.69*	1.53-1.87	1.27*	1.20-1.35	1.26*	1.18-1.34	1.32*	1.23-1.42	1.48*	1.35-1.63	1.69*	1.51-1.90
Home support	2.25*	2.07-2.45	2.19*	1.89-2.52	2.21*	2.02-2.41	2.07*	1.88-2.29	2.07*	1.89-2.28	2.27*	1.96-2.63	2.63*	2.08-3.34
Home meaningful participation	1.71*	1.55-1.87	1.81*	1.55-2.11	1.49*	1.37-1.61	1.41*	1.27-1.58	1.46*	1.34-1.60	1.84*	1.61-2.10	2.02*	1.59-2.57
Peer caring relationships	1.14*	1.07-1.22	1.18	1.06-1.32	1.04	0.98-1.10	1.11	1.01-1.22	1.07	0.99-1.16	1.27*	1.13-1.43	1.53*	1.28-1.77
Pro-social peers	3.19*	2.85-3.58	3.82*	3.20-4.56	2.79*	2.51-3.10	2.92*	2.58-3.30	3.15*	2.76-3.59	3.75*	3.32-4.23	4.26*	3.41-5.31

[a] Models adjusted for school clustering, gender, grade, Aboriginal/Torres Strait Islander, socio-economic status, remoteness, school size, and school type;

[b] Reported data refer to association between substance use and a one unit decrease in each mean resilience protective factor score;

[c] 35 missing (n=10,057); [d] 37 missing (n=10,055); [e] 40 missing (n=10,052); [f] 66 missing (n=10,026);

* $p<0.0005$.

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Multivariate associations

The final multivariate model for each substance use measure contained between four and ten of the 14 resilience protective factor subscales (Table 6). Of the resilience protective factors that remained in each final model, the majority had an inverse association with substance use (Table 6).

Across all substance use models, two protective factors were found to have an inverse association with substance use ('goals and aspirations' and 'pro-social peers'). A one unit decrease in mean subscale score significantly increased the odds of smoking (both measures), having consumed alcohol (all three measures), having used marijuana or another illicit substance by between 1.20 and 1.65 times for 'goals and aspirations', and between 2.30 and 3.64 times for 'pro-social peers'.

Four resilience protective factors were inversely associated with a least one substance use measure ('home support' (5 of 7 substance use measures), 'school support' (3 of 7), 'self-awareness' (2 of 7), 'community meaningful participation' (2 of 7)). Two resilience protective factors were found to have a consistent positive association with at least one substance use measure ('community support' (3 of 7 substance use measures), 'peer caring relationships' (5 of 7)). The remaining six resilience protective factors were not associated with any substance use outcome.

Data for between 2 and 5 variables were missing for 81 of 10092 participants, with no identified pattern of missingness. Identical analyses using imputation for missing data did not show a differential pattern of results.

Table 6. Multivariate associations between mean resilience protective factor scores and substance use[a]

	Ever used tobacco		Recent tobacco use		Ever used alcohol[b]		Recent alcohol use[c]		Risk alcohol use[d]		Marijuana use[e]		Other illicit drug use[e]	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Resilience protective factors														
Individual														
Goals and aspirations	1.20*	(1.13-1.27)	1.54*	(1.39-1.70)	1.27*	(1.16-1.38)	1.29*	(1.18-1.40)	1.49*	(1.35-1.67)	1.31*	(1.14-1.51)	1.62*	(1.35-1.96)
Self-awareness	1.27*	(1.14-1.40)	1.42*	(1.23-1.64)	-	-	-	-	-	-	-			
Environmental									-	-				
School support	1.21*	(1.11-1.31)	-	-	1.38*	(1.26-1.51)	-	-	1.28*	(1.15-1.42)	-	-	-	-
Community support	0.82*	(1.76-0.89)	-	-	0.78*	(0.72-0.85)	-	-	0.74*	(0.67-0.82)	-	-	-	-
Community meaningful participation	1.17*	(1.09-1.24)	1.26*	(1.14-1.40)	-	-	-		-		-		-	-
Home support	1.53*	(1.39-1.69)	-	-	1.75*	(1.58-1.94)	1.60*	(1.44-1.79)	1.62*	(1.43-1.83)	1.43*	(1.22-1.69)	-	-
Peer caring relationships	0.71*	(0.65-0.77)	0.69*	(0.61-0.78)	0.69*	(0.65-0.74)	0.75*	(0.67-0.83)	0.71*	(0.66-0.77)	-	-	-	-
Pro-social peers	2.49*	(2.24-2.77)	3.10*	(2.63-3.65)	2.29*	(2.08-2.52)	2.46*	(2.14-2.81)	2.62*	(2.26-3.04)	2.96*	(2.60-3.36)	3.67*	(2.93-4.60)

[a] Models adjusted for school clustering, gender, grade, Aboriginal/Torres Strait Islander, socio-economic status, remoteness, school size, and school type;

[b] 35 missing (n=10,057); [c] 37 missing (n=10,055); [d] 40 missing (n=10,052); [e] 66 missing (n=10,026);

* $p<0.0005$.

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DISCUSSION

This study explored the associations between 14 adolescent individual and environmental resilience protective factors and seven measures of adolescent substance use. Of the 14 factors examined, six had an inverse and two had a positive association with at least one type of substance use. Of the resilience protective factors found to be inversely associated with substance use, only two were associated with all substance use measures. Such findings suggest that the protective benefit of resilience protective factors for adolescent substance use may be limited to only a small number of such factors and then, primarily, only for some substances.

No previous single peer reviewed study has reported the associations between a comprehensive range of individual and environmental protective factor measures and a broad range of adolescent substance use measures. Nonetheless, the inverse associations found between eight of the individual and environmental protective factor measures and substance use are generally consistent with the direction of previous studies of single or small numbers of factors and substance use.[23, 29, 30, 47-50, 58] Similarly, the findings of no association between six such factors and substance use are consistent with previous studies.[27, 48, 64] In contrast, the consistent positive association found between the protective factors of 'peer caring relationships' and use of some substances, differs from a previous study that have reported no evidence of an association.[30] Whilst the reason for such contrast is unknown, it may be at least partly attributable to the different measurement of resilience protective factors and substance use between studies.[30] No previous studies could be identified that examined the association between adolescent substance use and 'community support'. Further research is required to confirm the contrasting findings, and if confirmed, to understand the mechanisms for such an association such that interventions promoting these factors do not have an untoward effect.

The findings that six factors conferred a protective benefit for adolescent substance use appear to align with models of adolescent substance use prevention, such as the social development model (grounded in Bandura's social learning theory and control theory),[19] and models of resilience,[23, 25, 29, 36, 40-44, 75] which focus on individual capacities or assets, and bonding with family, school

and peers as protection against the risk factors for substance use. However despite the consistency in the direction of such associations, there was a lack of consistency of association across types of substances. For example lower 'community meaningful participation' was only associated with tobacco use (ever and recent) and lower 'school support' only associated with some measures of tobacco (ever) and alcohol use (ever and risk). Such findings suggest the protective benefit of such factors is variable across different types of substance use, rather than being generalised. The finding of no association or a positive association between a number of resilience protective factors and substance use however may challenge such models of substance use prevention, or at least the breadth of factors described by such models.

The finding of an inverse association between some resilience protective factors and different forms of adolescent substance use suggests that interventions and programs that seek to reduce such use by increasing resilience protective factors may be more likely to be effective if they target specific protective factors to address specific types of substance use. A number of studies have demonstrated that interventions can successfully increase resilience protective factors among young people, [76-79] including individual factors such as self-efficacy[80], and environmental factors related to family and community connection.[77] For example, a randomised controlled trial in Hong Kong examining the efficacy of a positive youth development intervention targeting a range of resilience protective factors (including self-efficacy, beliefs in the future, bonding, and prosocial involvement) to reduce adolescent substance use, reported an increase in some targeted protective factors (such as self-efficacy and bonding) and decreases in substance use.[80] Further research is required to determine whether intervention approaches focused on the enhancement of the specific resilience protective factors found to be associated with adolescent substance use in this study have a beneficial effect on such use.

As previous research has demonstrated that risk factors such as access to substances, substance use by parents, and by peers and siblings [18-22] are associated with adolescent substance use, further research exploring the association of resilience protective factors with adolescent substance use in the

context of such risk factors is warranted. Such research is needed to identify the specific set of individual and environmental resilience protective factors and risk factors that are associated with each type of adolescent substance use, the relative contribution of each factor, and to determine the consistency of association between such factors and different types of substances. Whilst some studies investigating both risk and protective factors generally have found risk factors to be stronger predictors of tobacco, alcohol and marijuana use, such studies have only examined a limited number of resilience protective factors and types of substance use.[49, 81] Additionally, future research investigating the potential of such factors for prevention should be theory driven in an effort to understand the aetiology of substance use, and whether this differs by substance use type.

The findings of this study should be viewed in light of a number of the study characteristics. First, the study included a number of design strengths, including: a large sample of adolescents; use of a tool validated in an Australian adolescent population; comprehensive measurement of both individual and environmental resilience protective factors; use of multiple accepted measures of substance use; and analyses that accounted for a range of known confounders and potential clustering effects within schools. Although the study was reliant upon adolescent self-report of substance use and subject to the known limitations of self-report in this population,[81] self-report is an accepted method of measuring substance use by adolescents. To optimise validity of report, a web-based survey was utilised [82] as was confidential participation by students, strategies that have been found to increase the validity of adolescent report of sensitive questions, such as substance use.[83]

Although a non-response bias may exist, the demographic characteristics and prevalence of adolescent substance use found in this study are consistent with those reported in Australian triennial nation-wide surveys,[9] and suggests that the likelihood of bias may be limited. The conduct of the study in one local health district of New South Wales Australia may limit the generalisability of the results to other adolescent populations, and whilst the imbalance in the proportion of Aboriginal and Torres Strait Islander and Year 10 student may be indicative of this, the impact is not known. Finally, the study is limited by its cross sectional design which does not allow for investigation of the causal pathways of

the association findings. Further longitudinal and intervention-based research is required to address these questions.

AUTHORS' CONTRIBUTIONS

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FUNDING STATEMENT

COMPETING INTERESTS STATEMENT

We have read and understood BMJ policy on declaration of interests and declare that we have no competing interests.

DATA SHARING STATEMENT

Requests for additional unpublished data should be forwarded to

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Appendix A. Correlation between individual and environmental resilience protective factor subscales

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Cooperation and communication (1)	1.00													
Empathy (2)	0.48*	1.00												
Goals and aspirations (3)	0.30*	0.39*	1.00											
Problem solving (4)	0.43*	0.38*	0.31*	1.00										
Self-awareness (5)	0.45*	0.25*	0.30*	0.44*	1.00									
Self-efficacy (6)	0.48*	0.32*	0.37*	0.42*	0.53*	1.00								
School support (7)							1.00							
School meaningful participation (8)							0.58*	1.00						
Community support (9)							0.53*	0.42*	1.00					
Community meaningful participation (10)							0.36*	0.41*	0.42*	1.00				
Home support (11)							0.50*	0.38*	0.52*	0.38*	1.00			
Home meaningful participation (12)							0.48*	0.53*	0.50*	0.41*	0.61*	1.00		
Pro-social peers (13)							0.35*	0.30*	0.29*	0.26*	0.38*	0.32*	1.00	
Peer caring relationships (14)							0.33*	0.26*	0.40*	0.26*	0.36*	0.34*	0.30*	1.00

* *p*<0.0001

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-9
Bias	9	Describe any efforts to address potential sources of bias	8-9
Study size	10	Explain how the study size was arrived at	9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-9
		(*b*) Describe any methods used to examine subgroups and interactions	n/a
		(*c*) Explain how missing data were addressed	7-9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	8-9
		(*e*) Describe any sensitivity analyses	9

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9-10
		(b) Give reasons for non-participation at each stage	9-10
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	24
		(b) Indicate number of participants with missing data for each variable of interest	24-26
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	24
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	25-26
		(*b*) Report category boundaries when continuous variables were categorized	24-26
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	na
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	25
Discussion			
Key results	18	Summarise key results with reference to study objectives	12-13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14-15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Cover page

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.