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Increased burden of cardiovascular risk among youth suicide attempters

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Abstract

Background. Suicide and cardiovascular disease rank among the leading causes of disability and premature mortality worldwide. Young adult suicide attempters are at increased risk of mortality from cardiovascular disease even compared to those with major depressive disorder suggesting an increased burden of cardiovascular risk factors. We compared the cardiovascular risk burden between *youth* attempters and other high-risk individuals.

Methods. Participants were from the Collaborative Psychiatric Epidemiology Surveys (CPES), a U.S. population-based study, aged 18–30 years [suicide attempt (SA): $n = 303$; suicidal ideation (SI): $n = 451$; controls: $n = 3671$]; and psychiatric inpatients admitted for a SA ($n = 38$) or SI ($n = 40$) and healthy controls ($n = 37$) aged 15–30 years. We computed a cardiovascular risk score and high- and low-risk latent classes based on risk factors of high blood pressure, obesity, and smoking.

Results. Suicide attempters showed an increased cardiovascular risk score (CPES: $B = 0.43$, 95% confidence interval (CI) 0.31–0.54, $p < 0.001$; inpatient sample: $B = 1.61$, 95% CI 0.53–2.68, $p = 0.004$) compared to controls. They were also more likely to be classified in the high cardiovascular risk group (CPES: odds ratio (OR) 3.36, 95% CI 1.67–6.78, $p = 0.001$; inpatient sample: OR 9.89, 95% CI 1.38–85.39, $p = 0.03$) compared to those with SI (CPES: OR 1.15, 95% CI 0.55–2.39, $p = 0.71$; inpatient sample: OR 1.91, 95% CI 0.25–15.00, $p = 0.53$).

Conclusions. Youth attempters show an increased burden for cardiovascular risk compared to other high-risk individuals in inpatient and population-based samples. Clinicians should pay particular attention to cardiovascular risk factors among suicide attempters in order to reduce their risk for cardiovascular events.

Introduction

Suicide and cardiovascular disease rank among the leading causes of disability and premature mortality worldwide (Abubakar, Tillmann, & Banerjee, 2015; Mokdad et al., 2018). In 2017, 10.7% of U.S. young adults aged 18–25 years have seriously thought about suicide and 1.9% attempted suicide in the past year (Bose, 2017). The relationship between depression and cardiovascular disease is well established. Two recent scientific statements from the American Heart Association (AHA) suggest that depression and childhood adversities – two well-established predictors for suicidal behavior (Bridge, Goldstein, & Brent, 2006) – are also risk factors for cardiovascular disease (Goldstein et al., 2015; Suglia et al., 2018). However, in a population sample of young adults, a history of suicide attempt (SA) was associated with a higher risk of mortality from cardiovascular disease even compared to the risk associated with major depressive disorder (MDD) (Shah, Veledar, Hong, Bremner, & Vaccarino, 2011). Longitudinal studies also show that individuals with suicidal ideation (SI) and behavior have poor health outcomes decades later and are at increased risk of death from natural causes including cardiovascular disease (Bergen et al., 2012; Hawton, Harriss, & Zahl, 2006). These results suggest that suicide attempters may have an increased burden of cardiovascular risk factors, which could explain their increased risk for cardiovascular disease and mortality (Greenland et al., 2003).

Studies report that early smoking initiation is associated with suicidal behavior (Swahn et al., 2012), and smoking is associated with obesity and high blood pressure (BP) (Goldstein et al., 2015; Williams et al., 2002), hence increasing the risk for cardiovascular disease (Williams et al., 2002). In a population-based study in New Zealand, SA prior to age 24 was associated with a higher composite risk score for cardiovascular disease and metabolic syndrome later in adulthood or midlife (Goldman-Mellor et al., 2014). There are no studies examining the burden of cardiovascular risk in young adult suicide attempters (SA) and whether this burden is different than those with a high-risk population, those with SI who

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never attempted suicide, which will help us better understand whether the increased cardiovascular risk is unique to the subset of psychiatric patients with suicidal behavior. In this study, we compare the burden of cardiovascular risk factors between youth SA and SI in a population-based sample and replicate these findings in a more severely ill sample of psychiatric inpatients admitted for SI and SA. We hypothesize that attempters will show an increased burden of cardiovascular risk in the two samples.

Methods

Sample

The Collaborative Psychiatric Epidemiology Surveys (CPES)

CPES is a U.S. population-representative study that aimed to report the prevalence of psychiatric disorders and related conditions. Details about the sampling strategies and sample characteristics were reported elsewhere (Alegria, Jackson, Kessler, & Takeuchi, 2007). The CPES sample consisted of 16 423 respondents aged 18 and older who were interviewed from 2001 to 2003 and had an assessment of chronic health conditions including cardiovascular disease. Since we are interested in youth, we restricted our analyses to the 4425 CPES participants aged 18–30 (online eFig. 1 in Supplement). There were 303 attempters (SA, 6.1%, standard error (S.E.) = 0.5%), 451 with SI only (SI, 10.2%, S.E. = 0.8%), and 3671 controls with no history of ideation or attempt (83.8%, S.E. = 1.0%).

Inpatient sample

This sample consisted of psychiatric inpatients, aged 15–30 years, admitted for SA ($n = 38$) or SI with no history of attempt (SI, $n = 40$); and healthy controls with no history of psychiatric disorders and suicidal and/or self-injurious behaviors ($n = 37$). We recruited inpatients from Western Psychiatric Hospital of the University of Pittsburgh Medical Center, and healthy controls from the University of Pittsburgh's Clinical and Translational Science Institute participant registry which recruits participants at points of routine clinical care, through MyChart, and other community outreach events. Psychiatric inpatients were recruited on average 3 days after admission (standard deviation (S.D.) = 1.6, range 1–8), and attempters were medically stabilized prior to participation in the study. Detailed sample characteristics were previously reported (Chang et al., 2019; Melhem et al., 2017). SA and SI groups had similar psychiatric and comorbidity profiles (Table 1). Participant recruitment followed the Institutional Review Board guidelines at the University of Pittsburgh and provided informed consent/assent.

Assessments

The CPES

The World Mental Health Survey Initiative's version of the Composite International Diagnostic Interview (WMH-CIDI) was used to assess psychiatric disorders using the Diagnostic and Statistical Manual for Mental Disorders-IV (DSM-IV). The WMH-CIDI is a fully structured diagnostic interview administered by trained lay interviewers (Kessler & Üstün, 2004). *SI and SA*. Suicide attempters were identified as participants endorsing ever attempted suicide on the WMH-CIDI; youth with SI only were those who endorsed ever seriously thinking about attempting suicide but have no history of attempt (Kessler, Borges, & Walters, 1999).

Cardiovascular risk factors and disease: Participants who endorsed 'a doctor or other health professional ever told you that you had high BP' were classified as having high BP. Self-reported height and weight were collected and used to calculate body mass index (BMI). For adults aged 18 or over, BMI < 25.0 kg/m^2 was classified as underweight/normal, ⩾25.0 kg/m^2 and <30 kg/m^2 as overweight, and ⩾30 kg/m^2 as obese (Jensen et al., 2014). For youth under age 18 years, we used the extended International Obesity Task Force BMI cut-offs for classification (Cole & Lobstein, 2012). We conducted sensitivity analyses excluding individuals who were underweight (prevalence: 3.7%, S.E. = 0.005). Lifetime smoking was determined by self-report. Finally, cardiovascular disease status was defined using a positive response to 'ever had heart disease, heart attack, or stroke in your lifetime.'

Covariates: We controlled in our analyses for age, sex, race, and income to need ratio in 2003 as a proxy of socioeconomic status (SES). Controls with a history of psychiatric disorders were included. Thus, we controlled for lifetime DSM-IV MDD and Generalized Anxiety Disorders (GADs), which were the most common psychiatric disorders in this sample (Kessler et al., 2005). We also controlled for alcohol drinking, defined as ⩾1–2 days per week over the past year, and conducted sensitivity analyses additionally controlling for DSM-IV bipolar disorder (Naiberg et al., 2016a; Naiberg, Newton, Collins, Bowie, & Goldstein, 2016b) because these are associated with increased risk for cardiovascular disease (Flegal & Williamson, 2010; Park, Lee, & Han, 2017; Wu et al., 2008). Childhood abuse was not publicly available in CPES data and as such, we did not include it as a covariate; however, we included posttraumatic stress disorder (PTSD). We controlled for the use of psychiatric medications (yes/no) in the past year in sensitivity analyses (Casey, 2005; Hamer, Batty, Seldenrijk, & Kivimaki, 2011).

Inpatient sample

We used the Family History-Research Diagnostic Criteria to assess DSM-IV psychiatric disorders (Andreasen, 1986). *SI and SA* were assessed using the Columbia Suicide Severity Rating Scale (Posner et al., 2011) administered by master-level clinical interviewers. We previously reported SA and SI to be similar on primary and comorbid diagnoses and mood disorders to be the most common primary psychiatric diagnosis (MDD: 50% in SA *v.* 62.5% in SI; bipolar disorder: 42.1% in SA *v.* 32.5% in SI, Fisher's exact test, $p = 0.58$) (Melhem et al., 2017).

Cardiovascular risk factors: We collected three consecutive readings of systolic and diastolic BP at rest when seated with 3–5 min intervals between readings. The correlation among three readings was >0.7 and the average of the three readings was used in our analyses [mean (S.D.): systolic = 120.5 (14.2), diastolic = 78.2 (9.3)]. We then classified BP using the latest American College of Cardiology (ACC) and AHA criteria for high BP (Armstrong, 2018; Flynn et al., 2017) for adults into three categories: normal defined as systolic <120 mmHg and diastolic <80mmHg; elevated defined as systolic 120–129 mmHg and diastolic <80 mmHg; and high BP defined as systolic ⩾130 mmHg or diastolic ⩾80 mmHg. We used the same classification for elevated/high BP for adolescents' participants as those of adults (Flynn et al., 2017). We measured height and weight and computed BMI and used the same guidelines for classification into underweight/normal, overweight, and obese as for the CPES

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Table 1. Characteristics of the inpatient sample and the CPES sample by group

	CPES sample[1]							Inpatient sample						
	SA		SI		Control			SA		SI		Control		
	n = 303		*n* = 451		*n* = 3671			*n* = 38		*n* = 40		*n* = 37		
	6.1% (S.E. = 0.5%)		10.2% (S.E. = 0.8%)		83.8% (S.E. = 1.0%)		p^3	33%		34.80%		32.20%		p^2
Female, % (*n*/S.E.)	61.7[a]	4.6	53[a]	2.9	50[a]	1.6	**0.04**	54.1	20	44.7	17	27.5	11	0.06
Age in years, mean (S.D./S.E.)	23.5	0.3	23.1	0.4	23.8	0.1	0.22	22.8	3.8	23.6	3.9	22.1	2.2	0.18
Caucasian, % (*n*/S.E.)	63.4[a,b]	4.2	70.4[a]	3.3	61.1[b]	2.6	**0.008**	90	34	75	30	84	31	0.24
SES														
Hollingshead Index, mean (S.D.)	–	–	–	–	–	–		4.8[a]	2.6	5.9[b]	3.1	8.1[c]	1.8	**<0.001**
Income Need Ratio, mean (S.E.)	3.5	0.4	3.1	0.2	3.5	0.1	0.52	–	–	–	–	–	–	–
Self-report Cardiovascular Diseases, % (S.E.)	3.6[a]	1.4	1.4[b]	0.6	0.6[b]	0.2	**0.001**	–	–	–	–	–	–	–
Cardiovascular risk factors														
Blood pressure, % (*n*/S.E.)														
Normal	Ref							21[a]	8	50[a,b]	20	57[b]	21	**0.02**
Elevated	–	–	–	–	–	–	–	8	3	8	3	8	3	
High	17.5[a]	3.1	8[b]	2.1	4.5[b]	0.5	**<0.001**	71	27	42	17	35	13	
Weight status (BMI), % (*n*/S.E.)														
Normal/underweight	50.7	4.5	53.4	2.9	53.4	1.6	0.86	63	24	62	25	81	30	0.27
Overweight	29	5	25.6	3	27.9	1.3		26	10	22	9	16	6	
Obese	20.4	2.6	21	3	18.7	1.2		10	4	15	6	3	1	
Smoking[4], % (*n*/S.E.)	65.8[a]	3.6	54.8[b]	3.6	35.8[c]	1.7	**<0.001**	84[a]	32	70[a]	28	8.1[b]	3	**<0.001**
Risk score, mean (S.D./S.E.)[5]	1.5[a]	0.1	1.3[b]	0.1	1.1[c]	0.04	**<0.001**	2.8[a]	1.3	2.2[b]	1.5	1.1[c]	1.2	**<0.001**
Psychiatric risk factors for cardiovascular disease														
Depression														
PHQ9, mean (S.D.)	–	–	–	–	–	–		18.1[a]	7	18.3[a]	6.6	1.1[b]	11.6	**<0.001**
DSM-IV MDD, % (S.E.)	43.2	4[a]	33	2.8[b]	11.6	0.7[c]	**<0.001**	50	19	62.5	25	–	–	0.58
Anxiety														
GAD7, mean (S.D.)	–	–	–	–	–	–		14.3[a]	5.3	14.3[a]	5.8	1.2[b]	1.6	**<0.001**
DSM-IV GAD, % (S.E.)	26.5[a]	4	6.0[b]	1.4	3.6[b]	0.4	**<0.001**	71	27	60	24	–	–	0.31
DSM-IV bipolar, % (S.E.)	13.4[a]	2.9	5.1[b]	1.2	0.9[c]	0.2	**<0.001**	42.1	16	32.5	13	–	–	0.38
DSM-IV PTSD, % (S.E.)	26.6[a]	3.9	9.5[b]	1.7	4.2[c]	0.4	**<0.001**	37	14	40	16	–	–	0.77

(*Continued*)

Table 1. (*Continued.*)

	CPES sample[1]							Inpatient sample						
	SA		SI		Control			SA		SI		Control		
	n = 303		*n* = 451		*n* = 3671			*n* = 38		*n* = 40		*n* = 37		
	6.1% (s.e. = 0.5%)		10.2% (s.e. = 0.8%)		83.8% (s.e. = 1.0%)		*p*[3]	33%		34.80%		32.20%		*p*[2]
Childhood abuse, % (*n*)	–	–	–	–	–	–	–	74[a]	28	52[a]	21	8[b]	3	**<0.001**
Alcohol drinking, % (s.d./s.e.)	34.8	6.1	33.9	3.7	28.4	1.6	0.22	68.4[a,b]	26	45[a]	18	73[b]	27	**0.02**
Psychotropic medications, % (*n*/s.e.)	24.9[a]	3.3	14.0[b]	2.5	6.1[c]	0.5	**<0.001**	52.6	20	47.5	19	–	–	0.82

SA, suicide attempt; SI, suicidal ideation; PHQ9, Patient Health Questionnaire 9-item; GAD7, Generalized Anxiety Disorder 7-item; DSM-IV MDD, DSM-IV major depressive disorder; DSM-IV GAD, DSM-IV Generalized Anxiety Disorder; DSM-IV PTSD, DSM-IV post-traumatic stress disorder; DSM-IV bipolar, DSM-IV bipolar disorder; ref, reference group.
Bolded values represents significant differences.
[1]Weighted prevalence and means (aged 18–30 years).
[2]Chi-squared/Fisher's exact test for frequency difference, one-way ANOVA for the mean difference
[3]Weighted χ^2 for frequency difference, Wald's test for the mean difference
[4]Current smoking for psychiatric inpatient and life-time smoking status for a population-based sample.
[5]Risk score for psychiatric inpatient sample (range 0–5): BP (normal = 0, elevated = 1, high = 2) + BMI (normal/underweight = 0, overweight = 1, obese = 2) + smoking (no = 0, yes = 1); for the population-based sample (range 0–4): high BP (no = 0, yes = 1) + BMI (normal/underweight = 0, overweight = 1, obese = 2) + smoking (no = 0, yes = 1).
a–c: different letters represent significant post hoc differences and similar letters represent no post hoc differences (Bonferroni's method).

sample. Similar to the CPES samples, we conducted sensitivity analyses excluding individuals who were underweight (3%, n = 3). Finally, we measured the number of cigarettes currently smoked per day and classified those smoking at least one cigarette/day as current smokers.

Covariates: We controlled for the effects of age, sex, race, and the Hollingshead index of SES (Hollingshead, 1975). Since our controls have no history of psychiatric disorders and suicidal and/or self-injurious behaviors, we controlled for the severity of depression and anxiety symptoms (Goldstein et al., 2015), assessed by the Patient Health Questionnaire 9-item (PHQ9; Kroenke and Spitzer, 2002) and GAD 7-item (GAD7; Spitzer, Kroenke, Williams, and Löwe, 2006), respectively. We also controlled for childhood abuse because it is associated with cardiometabolic outcomes (Suglia et al., 2018), assessed using the Child Trauma Questionnaire (CTQ; Bernstein et al., 1994) and used the CTQ cutoffs for moderate and severe childhood physical and sexual abuse to compute a binary variable. We also controlled for alcohol drinking in the past year, which was assessed using the revised Drug Use Screening Inventory (Kirisci, Mezzich, & Tarter, 1995) and defined as 3–9 times or more per month over the past year. We also conducted sensitivity analyses comparing SA and SI in this sample controlling for MDD, GAD, PTSD, bipolar disorder, current use of psychiatric medications (yes/no), similar to the CPES sample.

Statistical analyses

We compared the groups on demographic and clinical characteristics using χ^2 tests and analysis of variance (ANOVA), followed by Bonferroni's post-hoc comparisons for significant results. We also examined differences between groups on individual cardiovascular risk factors (elevated/high BP, overweight/obesity, and smoking status) and used a Bonferroni correction with $\alpha = 0.05/3 = 0.017$. We then computed a cardiovascular risk score adding the number and the magnitude of individual risk factors, ranging from 0 to 4 in CPES and from 0 to 5 in the inpatient sample. Linear regression was used to examine the association of SI and SA with the risk score in each sample: *Model 1*, unadjusted model; *Model 2*, adjusting for age, sex, race, SES, depressive and anxiety symptoms (MDD and GAD in CPES sample); *Model 3*, adjusting in addition for alcohol drinking, childhood abuse (inpatient sample), and PTSD (CPES). A dummy coded variable for SI and SA was used as the independent variable with controls as the reference group. When dummy variables for SA and SI showed significant differences, we compared the coefficients resulting from the models post-hoc. Similar models were conducted for the individual cardiovascular risk factors with $\alpha = 0.05/3 = 0.017$; results are included in the supplementary materials. Analyses were conducted in R (3.5.1) and sampling weights of CPES were accounted for using survey package (3.33-2).

The latent class analysis was used to identify the unobserved (latent) clusters based on observed variables using Mplus (Version 8). We entered the three cardiovascular risk factors to classify participants into high- and low-risk groups for both samples. Similar logistic regression models were conducted to examine the associations of cardiovascular risk groups with SI and SA. In CPES, we also tested the association between a history of cardiovascular disease and SI and SA by weighted logistic regressions: Model 1, an unadjusted model; Model 2, adjusted for age, sex, race, SES, DSM-IV MDD, GAD, and PTSD diagnoses; and we additionally adjusted for self-reported BP, BMI, and smoking in Model 3.

Because of the different nature of controls in the two samples, we conducted sensitivity analyses for all regression models where we repeated them excluding controls. In these models, we also controlled for MDD, GAD, PTSD, and bipolar disorder diagnoses in the inpatient sample, comparable to covariates included in CPES. Additional sensitivity analyses were conducted excluding underweight individuals because the number in the two samples was too small to analyze as a separate category. In addition, we conducted Tobit and logistic regressions to examine the relationship of the cardiovascular risk score with SI and SA given its distribution with left-censored observations towards 0 or low-risk scores. In logistic regression, we combined risk scores of 0 and 1 in one category as the reference category and 2 or more as the risk category.

Results

Cardiovascular risk score

Table 1 shows the sociodemographic and cardiovascular risk factors characteristics by the group for the two samples. There were no differences between SA, SI, and controls on demographic characteristics except that SI was more likely to be Caucasians compared to controls in the CPES sample. In the inpatient sample, SA and SI showed lower SES than controls and SA showed lower SES than SI.

SA and SI showed significantly higher cardiovascular risk scores than controls in unadjusted models in the two samples (Tables 1 and 2). Controlling for covariates, SA ($B = 0.43$, 95% confidence interval (CI) 0.31–0.54, Cohen's $d = 0.11$, $p < 0.001$) and SI ($B = 0.24$, 95% CI 0.11–0.38, Cohen's $d = 0.05$, $p < 0.001$) had significantly increased risk scores in the CPES sample and the coefficients for SA were significantly larger than coefficients for SI in post-hoc comparisons. In the inpatient sample, only SA showed increased risk score ($B = 1.61$, 95% CI 0.53–2.68, Cohen's $d = 0.28$, $p = 0.004$) (Table 2). There were no differences in our cardiovascular risk score between individuals using psychiatric medications (excluding controls) and those who did not, respectively (CPES: 1.42 ± 0.07 *v.* 1.38 ± 0.14, $t = 0.26$, df = 98, $p = 0.80$; inpatient: 2.21 ± 1.49 *v.* 2.74 ± 1.31, $t = 1.69$, df = 74.8, $p = 0.09$). Sensitivity analyses showed similar results in the two samples, when we excluded controls, controlled for diagnoses in the inpatient sample similar to the CPES sample, and controlled for bipolar disorder and psychotropic medications in the two samples (online supplementary eTable S1); and when using Tobit and logistic regression methods (online eFig. S2; eTable S2). Similar findings of sensitivity analyses were observed when underweight subjects were excluded (results are available upon request).

Examining individual risk factors, BP and current smoking status were significantly higher in SA than SI and controls in the two samples; however, there were no significant differences in BMI (Table 1). When controlling for covariates, only SA was significantly more likely to be current smokers (online supplementary e Tables S3–S8). The prevalence of high BP and lifetime smoking differed significantly between the three groups but there were no differences in BMI. Controlling for covariates, SA were more likely to have high BP and to be lifetime smokers. SI was also more likely to be smokers compared to controls.

Clustering of cardiovascular risk factors

Latent class modeling resulted in two classes with 4.7% (S.E. = 0.4, $n = 282$) of the CPES sample classified in the high cardiovascular risk group and 44.3% ($n = 51$) of the inpatient sample. Latent class model indices and class characteristics are presented in online supplementary eTables S9 and S10. Only SA was significantly more likely to be classified in the high-risk group (CPES: OR 3.36, 95% CI 1.67–6.78, $p = 0.001$; inpatient sample: OR 9.89, 95% CI 1.38–85.39, $p = 0.03$) after adjusting for covariates (Table 3). Sensitivity analyses excluding controls and controlling for the same covariates in the two samples showed similar results (online supplementary eTable 11).

In CEPS, SA was also significantly more likely to report having been diagnosed with cardiovascular disease (OR 4.28, 95% CI 1.18–15.49, $p = 0.03$) adjusting for demographic, and psychiatric and cardiovascular risk factors (online supplementary eTable 12).

Discussion

Youth SA showed an increased burden of cardiovascular risk compared to other high-risk youth with SI and was also more likely to report a history of established cardiovascular disease.

This is the first study to examine differences in cardiovascular risk between *youth* SA and SI. A major strength of our study is including two independent samples: a population-based sample and a severely ill psychiatric inpatient sample. However, there were several limitations. The two samples were cross-sectional and do not include a detailed assessment of cholesterol, blood glucose, physical activity (Goldstein et al., 2015), heart rate (Chang et al., 2016; Lemogne et al., 2011; Tadic, Cuspidi, & Grassi, 2018), use of medication for non-psychiatric purposes and cardiovascular risk factors, and family history of cardiovascular disease (Casey, 2005; Hamer et al., 2011; McCusker et al., 2004). The two samples differed in their measures of SI and SA, cardiovascular risk factors (measured *v.* self-report), and in the type of control participants included. However, sensitivity analyses comparing SA and SI while excluding controls and controlling for the same covariates in the two samples showed similar results. In addition, the rates of high BP were high in our sample of psychiatric patients recruited during their hospitalization, which may or may not reflect their BP in a naturalistic setting. We also used the latest ACC/AHA criteria for high BP (Armstrong, 2018; Flynn et al., 2017), which are conservative and may have contributed to these high rates (Doran, McChargue, & Spring, 2008). The sample size for the inpatient sample is relatively small; however, we only included attempters who were admitted to the hospital and thus required medical attention. Suicidal behavior is a rare event and as such, our sample size of SA is not small for such a rare outcome. In addition, our sample size is powered to detect medium effect sizes in the order of 0.65 or higher, which we are interested in detecting for effect sizes to be clinically significant. Despite these methodological differences, the results were consistent across the two samples.

We found that SA has an increased burden of cardiovascular risk and are already more likely to report a history of cardiovascular disease, despite being young adults and even after controlling for well-established risk factors. These results are consistent with Shah et al.'s findings showing increased risk for cardiovascular disease mortality in young adult attempters, a risk higher than those with a history of major depression (Shah et al., 2011). Our results are cross-sectional and cannot address the temporality between suicidal behavior and the onset of cardiovascular risk factors or disease. However, longitudinal studies suggest patients with self-harm have higher mortalities of both suicide and

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Table 2. Relationships of cardiovascular risk score with SI and SA

	Model 1				Model 2				Model 3			
	B	95% CI		*p*	*B*	95% CI		*p*	*B*	95% CI		*p*
CPES sample[1]												
Group (Ref = controls)												
SA	0.47[a]	0.35	0.60	**<0.001**	0.47[a]	0.35	0.60	**<0.001**	0.43[a]	0.31	0.54	**<0.001**
SI	0.25[b]	0.12	0.38	**<0.001**	0.26[b]	0.12	0.40	**<0.001**	0.24[b]	0.11	0.38	**0.001**
Age in years	–	–	–	–	0.05	0.04	0.06	**<0.001**	0.05	0.04	0.06	**<0.001**
Female	–	–	–	–	−0.25	−0.34	−0.15	**<0.001**	−0.23	−0.32	−0.13	**<0.001**
Caucasian	–	–	–	–	−0.05	−0.18	0.08	0.44	−0.06	−0.19	0.07	0.46
SES	–	–	–	–	−0.02	−0.03	−0.003	**0.02**	−0.02	−0.03	−0.003	**0.02**
DSM-IV MDD	–	–	–	–	0.11	−0.01	0.24	0.07	0.10	−0.03	0.22	0.13
DSM-IV GAD	–	–	–	–	0.06	−0.15	0.22	0.71	0.003	−0.18	0.19	0.82
DSM-IV PTSD	–	–	–	–	–	–	–	–	0.22	0.08	0.36	**0.003**
Alcohol drinking	–	–	–	–	–	–	–	–	0.14	0.03	0.25	**0.02**
Inpatient sample												
Group (Ref = controls)												
SA	1.74[a]	1.12	2.35	**<0.001**	1.71	0.63	2.79	**0.002**	1.61[a]	0.53	2.68	**0.004**
SI	1.07[a]	0.47	1.67	**<0.001**	0.97	−0.10	2.04	0.08	1.09[a]	0.02	2.16	**0.05**
Age in years	–	–	–	–	0.07	−0.01	0.15	0.09	0.06	−0.02	0.14	0.16
Female	–	–	–	–	−0.47	−1.01	0.07	0.09	−0.41	−0.95	0.13	0.14
Caucasian	–	–	–	–	−0.19	−0.88	0.51	0.59	−0.10	−0.80	0.59	0.77
SES	–	–	–	–	−0.03	−0.14	0.08	0.57	−0.03	−0.14	0.08	0.60
PHQ9	–	–	–	–	0.01	−0.05	0.08	0.70	0.01	−0.06	0.07	0.87
GAD7	–	–	–	–	−0.03	−0.11	0.05	0.45	−0.03	−0.11	0.05	0.44
Childhood abuse	–	–	–	–	–	–	–	–	0.42	−0.22	1.06	0.20
Alcohol drinking	–	–	–	–	–	–	–	–	0.48	−0.06	1.02	0.08

SA, suicide attempt; SI, suicidal ideation; Controls is the reference group; SES, socioeconomic status; PHQ9, Patient Health Questionnaire 9-item; GAD7, Generalized Anxiety Disorder 7-item; DSM-IV MDD, DSM-IV major depressive disorder; DSM-IV GAD, DSM-IV generalized anxiety disorder; DSM-IV PTSD, DSM-IV post-traumatic stress disorder; ref, reference group.
Bolded values represents significant differences.
[1]Weights linear regression models were used; letters represent Bonferroni post-hoc comparison for the coefficients between SA and SI.

Table 3. Logistic regression models for cardiovascular risk latent class by group

	Model 1				Model 2				Model 3			
	OR	95% CI		*p*	OR	95% CI		*p*	OR	95% CI		*p*
CPES sample[a]												
Group (Ref = controls)												
SA	4.53	2.40	8.53	**<0.001**	3.68	1.84	7.34	**<0.001**	3.36	1.67	6.78	**0.001**
SI	1.21	0.63	2.34	0.56	1.20	0.59	2.45	0.61	1.15	0.55	2.39	0.71
Age in years	–	–	–	–	1.10	1.05	1.14	**<0.001**	1.10	1.05	1.14	**<0.001**
Female	–	–	–	–	1.23	0.80	1.87	0.34	0.82	0.53	1.28	0.39
Caucasian	–	–	–	–	0.57	0.41	0.80	**0.001**	0.57	0.41	0.79	**0.001**
SES	–	–	–	–	0.98	0.91	1.05	0.54	0.98	0.91	1.05	0.56
DSM-IV MDD	–	–	–	–	1.50	0.91	2.47	0.11	1.47	0.90	2.40	0.12
DSM-IV GAD	–	–	–	–	1.89	1.16	3.07	**0.01**	1.74	1.05	2.90	**0.03**
DSM-IV PTSD	–	–	–	–	–	–	–	–	1.55	0.87	2.76	0.14
Alcohol drinking	–	–	–	–	–	–	–	–	1.20	0.78	1.84	0.40
Inpatient sample												
Group (Ref = controls)												
SA	17.92	5.87	64.89	**<0.001**	11.3	1.63	94.54	**0.02**	9.89	1.38	85.39	**0.03**
SI	5.24	1.79	17.8	**0.004**	1.84	0.25	13.35	0.54	1.91	0.25	15	0.53
Age in years	–	–	–	–	0.31	0.10	0.90	**0.04**	0.32	0.1	0.94	**0.05**
Female	–	–	–	–	0.33	0.08	1.23	0.10	0.35	0.09	1.32	0.13
Caucasian	–	–	–	–	1.17	1.01	1.38	**0.04**	1.17	1.01	1.38	0.05
SES	–	–	–	–	0.93	0.77	1.12	0.44	0.94	0.78	1.14	0.54
PHQ9	–	–	–	–	1.09	0.97	1.23	0.15	1.08	0.95	1.22	0.26
GAD7	–	–	–	–	0.92	0.79	1.07	0.29	0.92	0.78	1.07	0.28
Childhood abuse	–	–	–	–	–	–	–	–	2.37	0.79	7.19	0.12
Alcohol drinking	–	–	–	–	–	–	–	–	1.27	0.46	3.60	0.65

SA, suicide attempt; SI, suicidal ideation; Controls is the reference group; PHQ9, Patient Health Questionnaire 9-item; GAD7, Generalized Anxiety Disorder 7-item; DSM-IV MDD, DSM-IV major depressive disorder; DSM-IV GAD, DSM-IV generalized anxiety disorder; DSM-IV PTSD, DSM-IV post-traumatic stress disorder; ref, reference group.
Bolded values represents significant differences.
[a]Weighted logistic regression models were used.

cardiovascular disease compared to patients without self-harm (Bergen et al., 2012; Hawton et al., 2006). It is also important to note that our samples are youth aged under 30 years. The mean age of onset of a heart attack is 65.6 years in males and 72 years in females (Benjamin et al., 2018). The mean age of onset of SA was 19.9 (S.D. = 5.1) in the inpatient sample and 15.6 (S.D. = 0.54) in the CPES. The two samples may be different in the severity of SAs, which could explain the younger age of onset in the CPES since our sample only included those who required medical attention. These results suggest that suicide attempters may be a more severely ill population among psychiatric patients and are at risk for cardiovascular disease and other chronic diseases. They also suggest that there might be a common etiology between suicidal behavior and cardiovascular disease. Indeed, there are several potential mechanistic pathways between suicidal behavior and cardiovascular risk, including increased impulsivity (Naiberg et al., 2016b), impaired cognitive function (Naiberg et al., 2016a), reduced brain volume (Islam, Metcalfe, MacIntosh, Korczak, & Goldstein, 2018), and inflammation (Melhem et al., 2016; 2017). Future longitudinal studies are needed in order to interrogate biological pathways for these diseases that can be targeted for early prevention and intervention.

SA was more likely to smoke and have high BP, consistent with current literature on the association between smoking and severe mental illness and suicide (Li et al., 2012). Smoking is also a common behavioral risk factor for high BP and obesity (Chang et al., 2019; Goldstein et al., 2015; Lee, Taneja, & Vassallo, 2012). In the inpatient sample, the rate of high BP based on BP readings was higher in each of the SA, SI, and control groups compared to the CPES groups. We used the latest ACC/AHA criteria for high BP (Armstrong, 2018; Flynn et al., 2017), which are more conservative compared to those used at the time of CPES data collection. However, the severity of psychiatric illness in our inpatient sample and the often-comorbid medical illness in

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these patients may explain the higher rates of high BP. Although obesity is a major cardiovascular risk factor, SA and SI were not different than controls on obesity. Smoking has been reported to be associated with lower BMI (Piirtola et al., 2018). In the inpatient sample, the high cardiovascular risk group showed a higher number of cigarettes per day compared to the low cardiovascular risk group (12.8 ± 12.0 *v.* 4.4 ± 8.9, $p < 0.001$). As such, smoking is a potential risk factor that needs to be targeted for interventions.

In conclusion, youth suicide attempters showed an increased burden of cardiovascular risk compared to other high-risk youth with SI. Future studies are needed to further characterize cardiovascular risk in suicide attempters using longitudinal study designs and to examine the biological pathways that are common between suicidal behavior and cardiovascular disease. In the meantime, clinicians should pay particular attention to suicide attempters among psychiatric patients in terms of cardiovascular risk factors in order to reduce their risk for cardiovascular events. In addition, reducing cardiovascular risk factors, especially smoking, could potentially reduce the risk of SAs among high-risk youth.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0033291720003736

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