

Original Investigation

Suicidal Behavior, Smoking, and Familial Vulnerability

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Abstract

Introduction: Smoking is a well-established correlate of suicidal behavior. It is not known if familial risk factors contribute to this association.

Methods: Data were obtained via semistructured interviews with 1,107 twin fathers, 1,919 offspring between ages 12–32 years, and 1,023 mothers. Familial vulnerability to nicotine dependence and suicidal behavior was modeled via father and maternal self-report of these behaviors. Multinomial logistic regression models were computed with and without familial risk factors to estimate the association between offspring ever smoking, regular smoking, nicotine dependence, and a 4-level offspring suicide variable: (a) none, (b) ideation, (c) ideation + plan, and (d) ideation + plan + attempt or ideation + attempt. All models were stratified by gender and adjusted for sociodemographics, familial risk factors including parental suicidal behavior, nicotine dependence, and conduct disorder, and offspring conduct disorder, depression, alcohol abuse/dependence, and illicit drug abuse/dependence.

Results: After adjusting for covariates and familial risk factors, ever smoking was not significantly associated with suicidal behavior in males and females. In males, regular smoking was associated with ideation + plan (odds ratio [OR] = 5.47; 95% CI: 1.05–28.60), and in females, regular smoking was associated with ideation + plan + attempt or ideation + attempt. In both genders, nicotine-dependent smoking was associated with ideation + plan + attempt or ideation + attempt (males: OR = 6.59; 95% CI: 1.91–22.70, females: OR = 3.37; 95% CI: 1.25–9.04). Comparison of models with and without familial risk factors indicated that there is no mediation of smoking status and suicidal behavior by familial risk.

Conclusions: Smoking and nicotine dependence are correlated with suicidal behaviour. Contributions from familial risk factors did not significantly alter this association.

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Introduction

Smoking is a well-established correlate of suicidal behavior in adolescents and young adults. Compared with never-smokers, both former and current smokers are more likely to report suicidal ideation (Clarke et al., 2010). The severity of smoking is associated with suicidal behavior. Regular smoking is associated with a greater risk of suicide attempt than smoking experimentation (Riala et al., 2007), and the association is still stronger in current smokers than in ever-smokers (Breslau, Schultz, Johnson, Peterson, & Davis, 2005; Clarke et al., 2010). Kessler et al. (2009) suggest that only nicotine dependence and not less severe smoking phenotypes remains significantly associated with suicide plans after adjusting for potential confounders. In addition to diagnostic criteria for smoking, heaviness of smoking is associated with suicide with evidence of a dose–response relationship between cigarettes smoked per day and risk for suicide attempt and completed suicide (Beratis, Lekka, & Gabriel, 1997; Hemenway, Solnick, & Colditz, 1993; Hemmingsson & Kriebel, 2003; Iwasaki, Akechi, Uchitomi, & Tsugane, 2005).

Multiple explanations for this association have been posited including lower serotonergic functioning and low monoamine oxidase activity (Malone et al., 2003; Whitfield et al., 2000). In a review of the literature, Hughes (2008) presents both causal (smoking as a physiological/psychological toxin or that smokers self-medicate for depression) and noncausal (via a third correlated measure) hypotheses linking current smoking and smoking cessation to suicide. A potential noncausal influence is common familial vulnerability.

Though we are not aware of twin studies that have estimated the common genetic contribution to smoking and suicide, we know that both behaviors are heritable. The estimates of the genetic contribution to regular smoking range between 58% and 74% (Heath & Martin, 1993; Madden, Pedersen, Kaprio, Koskenvuo, & Martin, 2006; Pergadia, Heath, Agrawal, et al., 2006; Pergadia, Heath, Martin, et al., 2006; True et al., 1997,

1999). Genetic factors have been found to account for 33%–70% of the variance in risk for developing nicotine dependence (Heath & Madden, 1995; Heath & Martin, 1993; Kendler et al., 1999; Lessov et al., 2004; Maes et al., 2004; True et al., 1999). The genetic contributions to suicidal ideation and suicide attempt range from 36% to 43% and from 30% to 55%, respectively (Glowinski et al., 2001; Fu et al., 2002; Statham et al., 1998). Furthermore, the risk of ideation and attempt is significantly higher in family members of patients who have committed suicide as compared with those who have not (Brent & Mann, 2005). In addition, given evidence that suicide and smoking “run in families,” it is possible that familial risk factors may partially account for the observation that smoking is a risk factor for suicide (Qin, Agerbo, & Mortensen, 2003). However, evidence that parental smoking is associated with offspring suicidal behavior is inconclusive (Hockenberry, Timmons, & Vander Weg, 2010).

To our knowledge, no studies have simultaneously controlled for familial risk from parental suicidal behavior and parental smoking while estimating the relationship between suicide and smoking in the offspring generation. We sought to clarify the mechanisms for the lifetime co-occurrence of smoking and suicide by testing if familial vulnerability may account for this association. Specifically we sought not to confirm the association between smoking and suicide but to test the hypothesis that familial factors mediate the association between offspring ever smoking, regular smoking, and nicotine dependence and suicidal ideation, suicide plan, and suicide attempt.

Methods

Participants were offspring of male twins from the Vietnam Era Twin Registry, which is a national registry of monozygotic (MZ) and dizygotic (DZ) twin pairs who served in the military during the Vietnam Era (1965–1975). Construction of the registry and method of determining zygosity have been previously reported (Eisen, Neuman, Goldberg, Rice, & True, 1989; Eisen, True, Goldberg, Henderson, & Robinette, 1987; Henderson et al., 1990).

The present study involved analyses of data collected during a 1992 administration of the Diagnostic Interview Schedule to twin fathers and from diagnostic telephone interviews in two complementary offspring-of-twins (OOT) projects. Both OOT projects used an adaptation of the Semi-Structured Assessment for the Genetics of Alcoholism (SSAGA; Bucholz et al., 1994) to collect data from OOT concordant or discordant for alcohol dependence (AD; Project 1) and from the OOT concordant or discordant for illicit drug dependence (DD; Project 2). Both studies included offspring of unaffected twin pairs as controls. Data collection for Project 1 and Project 2 began in 2001 and 2004, respectively. For both projects, biological mothers or custodial mothers (e.g., step mothers) were eligible to participate if twins provided permission to contact them. Offspring were eligible to participate if the twin and biological and/or custodial mothers gave permission to contact them (In Project 2, permission was granted by twin and/or mother). If a subject participated in the AD study, he or she was not asked duplicate questions in the DD study. Project data were merged by taking all data from all subjects in the DD study (the more recent data source) and adding subjects from the AD study who did not

participate in the DD study. Thus, if a subject participated in both studies, only the responses provided in the most recent assessment were used in the present analysis. The sample available for the present study included 1,107 fathers, 1,919 offspring between ages 12–32 years, and 1,023 biological mothers (2.9% rearing only/nonbiological).

Descriptions of survey contents and response rates have been previously published for those subjects eligible to participate. Eligible subjects were those able to participate, that is, not incarcerated, deceased, or too ill to participate (Duncan et al., 2008; Jacob et al., 2003; Scherrer et al., 2004, 2008). Briefly, Project 1 resulted in the following response rates: Of the 1,464 targeted twin fathers, 1,213 (83%) participated in the study as did 862 participating mothers (67% of 1,282 eligible) and 1,270 offspring 12–25 years of age (85.4% of 1,487 eligible) participated in the 2001 survey. In Project 2, of eligible twin fathers, 725 (81% of the 895 eligible) were interviewed, 427 (72.8% of the 601 eligible) mothers were interviewed, and 839 offspring aged 12–32 years (88% of the 950 eligible) participated in the 2003–2004 interviews.

Experienced staff from the Institute for Survey Research at Temple University conducted data collection. All participants gave verbal consent prior to being interviewed as approved by the Institutional Review Board at the participating institutions. Parents provided written consent for their minor aged offspring to be interviewed.

Measures

Parental Suicidal Behavior

Fathers were queried about ever thinking about, planning, and attempting suicide as part of an assessment for major depression. Mothers were asked about ever thinking about, planning, and making a suicide attempt independently of depression assessments. A positive response to any of the questions was considered suicidal behavior.

Parental Nicotine Dependence

Father's nicotine dependence was defined according to *DSM-III-R* lifetime criteria. Maternal nicotine dependence was defined according to the Heaviness of Smoking Index (HSI) because *DSM* symptoms were not available on mothers. The HSI consists of the time to first cigarette upon waking and number of cigarettes smoked per day when smoking the most (Heatherton, Kozlowski, Frecker, Rickert, & Robinson, 1989). Based on evidence that HSI scores of 4 or greater indicate high nicotine dependence (ND) (Diaz et al., 2005; Heatherton et al., 1989) and consideration of the distribution of HSI scores, we created a dichotomized HSI score so that values of 1–2 defined low and values ≥ 3 defined medium to severe ND mothers. Lifetime never-smokers were the reference group.

Parental Conduct Disorder

Father's conduct disorder was defined according to *DSM-III-R* lifetime criteria, while maternal conduct disorder was computed according to *DSM-IV* criteria based on a screening for symptoms developed for the SSAGA interview.

Offspring Suicidal Behavior

Independent of the assessment of major depression, offspring were asked if they ever thought about suicide, planned suicide, or made a suicide attempt. Following the method of Conner

et al. (2007), an ordinal level, offspring suicidal behavior variable was created as follows: (a) nonsuicidal, (b) ideation, (c) ideation plus plan, and (d) ideation, plus plan and attempt or ideation plus attempt.

Offspring Ever Smoking, Regular Smoking, and Nicotine Dependence

Ever smoking cigarettes was defined by a positive response to the question, "Did you ever try smoking cigarettes." Regular smoking was defined as having smoked 21 or more cigarettes over the lifetime and smoking 3 or more times per week for a minimum of 3 weeks. Our definition of regular smoking was selected because this intensity of smoking is associated with loss of control over cigarettes, ND, and withdrawal in young smokers (DiFranza et al., 2007) and was deemed an appropriate definition of regular smoking in this adolescent and young adult cohort where 22% were under age 18 years. Fagerström Test for Nicotine Dependence (FTND) scores (Fagerstrom, 1978; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991) were obtained for all offspring who were regular smokers. Nicotine dependence was defined by an FTND of 4 or more.

Offspring Conduct Disorder, Depression, Alcohol Abuse/Dependence, and Illicit Drug Abuse/Dependence

DSM-IV criteria were used to make diagnosis of offspring level psychiatric disorders using data derived from the telephone administration of the adapted SSAGA interview.

Sampling Design Variable

Because the samples for the current project were from two separate OOT designs for AD and DD in data collection Projects 1 and 2, respectively; the sampling design variables for these projects were included in all analyses to adjust for sampling bias. Adjustment for sampling design was done by combining AD and DD cohorts using a seven-Level design based on father and co-twins AD and DD status and zygosity. This adjusts for the sampling strategy used in deriving the AD and DD samples. Level 1 consisted of offspring born to fathers with DD with and without AD. Father DD was highly comorbid with AD and therefore considered together in DD fathers. Level 2 offspring were born to unaffected MZ twins whose co-twin had DD with and without AD. Level 3 offspring were born to unaffected DZ twin fathers whose co-twin had DD with and without AD. Level 4 offspring were born to fathers with AD. Level 5 offspring had unaffected MZ twin fathers whose co-twin had AD. Level 6 offspring had unaffected DZ twin fathers whose co-twin had AD, and Level 7 offspring were born to MZ and DZ twins without DD and AD.

Analysis

Analysis began by computing univariate models with chi-square tests to describe the association between the four-level suicidal behavior and offspring smoking and other covariates. Multinomial logistic regression models were then computed, adjusting for age and the sampling design variable, to estimate the association between offspring ever smoking, regular smoking, nicotine dependence, and suicidal behavior with and without familial risk factors. Because father nicotine dependence was measured using DSM-III-R criteria and mother's by HSI (measures that do not overlap), we computed analysis separately for father and mother risk variables. Because of the strong associa-

tion between gender and suicide, analyses were also computed separately by gender. Since the data were structured into clusters of individual offspring (Level 1), offspring born to the same twin father (i.e., siblings, Level 2), and offspring born to twin pairs of fathers (i.e., cousins, Level 3), hierarchical multinomial logistic regression models were applied using Mplus v6.1 (Muthén & Muthén, 1998–2010), which accommodated the OOT design with the multilevel analytic feature that accounted for the fixed and random effects and the "cluster" option (twin family clustering and extended twin pair family clustering) that accounted for the clustered nature of the observations. Mplus also provides the opportunity to model a two-group design. We used Wald chi-square tests to determine if models were significantly different with and without familial risk factors. Differences between genders were made by observing the CIs for each parameter estimate.

Results

Shown in Table 1 are the means for continuous variables and percentages for binary and ordinal variables by level of suicidal behavior. The mean age of offspring was not significantly different across levels of suicidal behavior. Gender was significantly associated with degree of suicidal behavior with female offspring more likely to endorse all levels of suicidal behavior ($p < .001$). Paternal nicotine dependence but not maternal nicotine dependence was associated with offspring suicidal behavior. Offspring who had a father with DSM-III-R nicotine dependence were more likely to report ideation + plan + attempt or ideation + attempt ($p < .05$). Offspring conduct disorder, major depression, alcohol, and illicit drug/abuse dependence were significantly associated with levels of suicidal behavior ($p < .0001$). Lastly, offspring degree of smoking was associated with increasing suicidal behavior in a stepwise fashion ($p < .0001$).

The associations between offspring smoking and degree of suicidal behavior are shown separately for males and females in Table 2, respectively. In males, regular smoking (odds ratio [OR] = 9.86; 95% CI: 2.04–47.59) and nicotine dependence (OR = 8.47; 95% CI: 1.95–36.83) were significantly associated with ideation + plan. In males, nicotine dependence was significantly associated with ideation + plan + attempt or ideation + attempt (OR = 9.74; 95% CI: 2.42–39.23). Among females, nicotine dependence was significantly associated with ideation (OR = 2.41; 95% CI: 1.33–4.37) and with ideation + plan (OR = 3.49; 95% CI: 1.41–8.61). In females, both regular smoking (OR = 4.71; 95% CI: 1.88–11.79) and ND (OR = 8.43; 95% CI: 3.43–20.74) were significantly associated with ideation + plan + attempt or ideation + attempt.

The associations between offspring smoking and degree of suicidal behavior are shown separately for males and females in Table 3 after adjusting for offspring covariates. Among males, after adjusting for offspring level covariates, smoking status was not significantly associated with ideation and ideation + plan. In males, after adjustment for offspring level covariates, nicotine dependence remained significantly associated with ideation + plan + attempt or ideation + attempt (OR = 7.31; 95% CI: 1.95–27.49). Similarly for females, smoking status was not significantly associated with ideation and ideation + plan. After adjusting for offspring level covariates, regular smoking (OR = 3.06; 95% CI: 1.16–8.12) and nicotine dependence (OR = 3.27;

Table 1. Characteristics of Sample by Level of Suicidal Behavior

	Nonsuicidal (n = 1,456)	Ideation (n = 280)	Ideation + plan (n = 62)	Ideation + plan + attempt or ideation + attempt (n = 91)	Chi-square p value
Age (M, [SD])	21.2 (4.4)	22.1 (4.0)	22.0 (4.0)	22.1 (4.1)	
Male (n = 949)	81.6	13.9	2.8	1.6	.0003
Female (n = 970)	75.3	16.2	3.9	4.6	
Paternal race					
White (n = 1,794)	78.2	15.1	3.4	3.2	
Non-White (n = 125)	81.5	14.3	2.5	1.7	.730
Paternal suicide ^a					
No (n = 967)	78.8	14.8	3.4	3.1	
Yes (n = 139)	76.0	17.3	3.1	3.6	.749
Maternal suicide ^a					
No (n = 800)	79.8	14.9	2.6	2.7	
Yes (n = 166)	74.8	16.0	4.6	4.6	.069
Parental nicotine dependence ^b					
No (n = 516)	79.3	15.9	2.6	2.2	
Yes (n = 591)	77.6	14.3	4.1	4.0	.033
Maternal nicotine dependence ^c					
None (n = 640)	78.3	15.1	3.4	3.3	
Low (n = 204)	78.4	16.4	2.0	3.2	
High (n = 252)	78.7	14.1	4.4	2.8	.652
Paternal conduct disorder					
No (n = 984)	77.3	14.8	3.1	4.8	
Yes (n = 122)	74.9	15.5	4.8	4.8	.597
Maternal conduct disorder					
No (n = 806)	78.6	14.5	3.0	4.0	
Yes (n = 268)	73.8	15.7	3.8	6.7	.059
Offspring conduct disorder					
No (n = 1786)	78.9	14.3	2.6	4.2	
Yes (n = 132)	53.0	22.0	12.1	12.9	<.0001
Offspring major depression					
No (n = 1698)	82.9	12.7	2.4	2.0	
Yes (n = 220)	42.9	34.1	10.7	12.2	<.0001
Offspring alcohol/abuse dependence					
No (n = 1293)	82.4	13.0	2.5	2.2	
Yes (n = 562)	69.4	19.9	5.3	5.3	<.0001
Offspring illicit drug abuse/dependence					
No (n = 1560)	81.9	13.4	2.4	2.3	
Yes (n = 295)	60.3	24.1	8.1	7.5	<.0001
Offspring smoking					
Never (n = 628)	84.8	12.1	2.1	1.0	
Ever (n = 667)	80.1	15.8	2.3	1.8	
Regular smoker (n = 310)	71.6	18.2	5.1	5.1	
Nicotine dependent (n = 314)	68.4	16.7	6.5	8.5	<.0001

Note. ^aEver thinking about, planning, and making a suicide attempt.

^bDSM-III-R criteria.

^cGreater than four Heaviness of Smoking Index.

95% CI: 1.22–8.78) were significantly associated with ideation + plan + attempt or ideation + attempt.

The associations between offspring smoking and degree of suicide are shown separately for males and females in Table 4 after adjusting for paternal risk variables including father suicide, father nicotine dependence, and father conduct disorder. For both males and females, the ORs were nearly identical to those reported in Table 2. Among males, regular smoking

(OR = 10.10; 95% CI: 2.08–48.92) and nicotine dependence (OR = 8.32; 95% CI: 1.84–37.61) were significantly associated with ideation + plan. Nicotine dependence was significantly associated with ideation + plan + attempt or ideation + attempt (OR = 8.49; 95% CI: 2.29–31.48). Among females, nicotine dependence was significantly associated with ideation (OR = 2.32; 95% CI: 1.27–4.24) and with ideation + plan (OR = 3.16; 95% CI: 1.23–8.11). Among females, regular smoking (OR = 4.76; 95% CI: 1.93–11.74) and nicotine dependence (OR = 8.61; 95%

Table 2. Association Between Offspring Regular Smoking, Nicotine Dependence, and Suicidal Behavior in Males and Females^a

	Ideation	Ideation + plan	Ideation + plan + attempt or ideation + attempt
Males			
Age	1.06 (1.01–1.11)	1.01 (0.93–1.09)	1.0 (0.90–1.11)
Offspring smoking			
Never	1.0	1.0	1.0
Ever	1.12 (0.69–1.82)	3.65 (0.82–16.29)	1.49 (0.34–6.65)
Regular smoking	1.72 (0.93–3.20)	9.86 (2.04–47.59)	3.69 (0.70–19.57)
Nicotine dependence	1.06 (0.57–1.98)	8.47 (1.95–36.83)	9.74 (2.42–39.23)
Females			
Age	1.02 (0.98–1.05)	1.00 (0.94–1.07)	1.0 (0.94–1.07)
Offspring smoking			
Never	1.0	1.0	1.0
Ever	1.46 (0.94–2.26)	0.71 (0.27–1.88)	1.80 (0.72–4.49)
Regular smoking	1.50 (0.87–2.61)	1.58 (0.60–1.15)	4.71 (1.88–11.79)
Nicotine dependence	2.41 (1.33–4.37)	3.49 (1.41–8.61)	8.43 (3.43–20.74)

Note. ^aAdjusted for seven-level sampling design variable and missing maternal data variable. Bold text indicates significant odds ratio.

CI: 3.59–20.69) were significantly associated with ideation + plan + attempt or ideation + attempt.

The associations between offspring smoking and degree of suicide are shown separately for males and females in Table 5 after adjusting for maternal risk variables including mother suicide, mother nicotine dependence, and mother conduct disorder. Similar to adjustment for paternal variables, ORs remained

nearly identical to those reported in Table 2. Among males, regular smoking (OR = 10.06; 95% CI: 2.05–49.34) and nicotine dependence (OR = 8.54; 95% CI: 1.90–38.31) were significantly associated with ideation + plan. Nicotine dependence was significantly associated with ideation + plan + attempt or ideation + attempt (OR = 11.10; 95% CI: 2.64–46.62). Among females, nicotine dependence was significantly associated with ideation (OR = 2.32; 95% CI: 1.27–4.23) and with ideation + plan

Table 3. Association Between Offspring Regular Smoking, Nicotine Dependence, and Suicidal Behavior in Males and Females Adjusted for Offspring Covariates^a

	Ideation	Ideation + plan	Ideation + plan + attempt or ideation + attempt
Males			
Age	1.04 (0.99–1.08)	0.99 (0.90–1.08)	0.97 (0.85–1.10)
Offspring conduct disorder	1.47 (0.75–2.90)	5.86 (2.43–14.13)	1.17 (0.39–3.51)
Offspring major depression	4.79 (2.74–8.35)	4.13 (1.46–11.66)	8.41 (3.51–20.12)
Offspring alcohol abuse/dependence	1.06 (0.61–1.83)	1.35 (0.50–1.09)	1.30 (0.45–3.76)
Offspring illicit drug abuse/dependence	2.16 (1.26–3.71)	1.78 (0.66–4.77)	1.55 (0.55–4.37)
Offspring smoking			
Never	1.0	1.0	1.0
Ever	1.09 (0.65–1.81)	3.15 (0.67–14.88)	1.60 (0.35–7.30)
Regular smoking	1.22 (0.63–2.39)	4.83 (0.94–24.88)	2.63 (0.53–12.98)
Nicotine dependence	0.93 (0.47–1.85)	3.40 (0.71–19.31)	7.31 (1.95–27.49)
Females			
Age	1.0 (0.97–1.05)	0.99 (0.91–1.07)	1.0 (0.93–1.08)
Offspring conduct disorder	2.33 (0.90–6.07)	1.91 (0.51–7.12)	5.74 (1.96–16.85)
Offspring major depression	5.01 (3.11–8.07)	10.79 (5.05–23.06)	9.28 (5.05–17.05)
Offspring alcohol abuse/dependence	2.12 (1.20–3.74)	3.20 (1.15–8.93)	1.82 (0.75–4.44)
Offspring illicit drug abuse/dependence	1.93 (1.14–3.27)	3.15 (1.18–8.40)	1.99 (0.95–4.14)
Offspring smoking			
Never	1.0	1.0	1.0
Ever	1.32 (0.83–2.10)	0.56 (0.20–1.52)	1.64 (0.67–4.03)
Regular smoking	1.06 (0.59–1.90)	0.77 (0.25–2.37)	3.06 (1.16–8.12)
Nicotine dependence	1.20 (0.60–2.39)	1.09 (0.36–3.30)	3.27 (1.22–8.78)

Note. ^aAdjusted for seven-level sampling design variable and missing maternal data variable. Bold text indicates significant odds ratio.

Table 4. Association Between Offspring Regular Smoking, Nicotine Dependence, and Suicidal Behavior in Males and Females Adjusted for Father Suicide^a, Father Nicotine Dependence^b, and Father Conduct Disorder^c

	Ideation	Ideation + plan	Ideation + plan + attempt or ideation + attempt
Males			
Age	1.06 (1.02–1.11)	1.01 (0.92–1.11)	1.0 (0.89–1.12)
Offspring smoking			
Never	1.0	1.0	1.0
Ever	1.17 (0.72–1.91)	3.56 (0.78–16.27)	1.40 (0.33–6.01)
Regular smoking	1.78 (0.96–3.32)	10.10 (2.08–48.92)	3.37 (0.67–16.93)
Nicotine dependence	1.14 (0.61–1.92)	8.32 (1.84–37.61)	8.49 (2.29–31.48)
Females			
Age	1.02 (0.98–1.06)	1.01 (0.95–1.08)	1.00 (0.93–1.08)
Offspring smoking			
Never	1.0	1.0	1.0
Ever	1.46 (0.94–2.27)	0.70 (0.26–1.87)	1.79 (0.72–4.44)
Regular smoking	1.49 (0.86–2.58)	1.49 (0.57–3.89)	4.76 (1.93–11.74)
Nicotine dependence	2.32 (1.27–4.24)	3.16 (1.23–8.11)	8.61 (3.59–20.69)

Note. ^aEver thought, planned, or attempted suicide.

^bDSM-III-R criteria.

^cAdjusted for seven-level sampling design variable and missing maternal data variable. Bold text indicates significant odds ratio.

(OR = 3.21; 95% CI: 1.26–8.20). Regular smoking (OR = 4.95; 95% CI: 1.92–12.76) and nicotine dependence (OR = 8.62; 95% CI: 3.33–22.32) were significantly associated with ideation + plan + attempt or ideation + attempt.

Models adjusted for all offspring level and maternal and paternal level variables are shown in Tables 6 and 7. Comparison of significance and point estimates with Table 3 in which models are shown adjusted for only offspring level variables indicates that results are similar with and without the addition of maternal and paternal risk variables. There were no significant

differences between models in Table 3 (offspring level covariates) and their respective models (offspring level and parental level covariates) in Tables 6 and 7 (Wald chi-square = 42.6, *p* = .21).

Discussion

In unadjusted analysis, in a cohort of 1,919 male and female offspring, we observed that increasing involvement in smoking was associated with increasing suicidal behavior such that ever

Table 5. Association Between Offspring Regular Smoking, Nicotine Dependence, and Suicidal Behavior in Males and Females Adjusted for Mother Suicide^a, Mother Nicotine Dependence^b, and Mother Conduct Disorder^c

	Ideation	Ideation + plan	Ideation + plan + attempt or ideation + attempt
Males			
Age	1.06 (1.01–1.11)	1.01 (0.92–1.11)	1.00 (0.88–1.12)
Offspring smoking			
Never	1.0	1.0	1.0
Ever	1.13 (0.70–1.84)	3.66 (0.82–16.32)	1.49 (0.34–6.60)
Regular smoking	1.76 (0.95–3.28)	10.06 (2.05–49.34)	3.54 (0.74–16.98)
Nicotine dependence	1.10 (0.58–2.07)	8.54 (1.90–38.31)	11.10 (2.64–46.62)
Females			
Age	1.02 (0.98–1.06)	1.01 (0.93–1.09)	1.0 (0.93–1.08)
Offspring smoking			
Never	1.0	1.0	1.0
Ever	1.45 (0.94–2.24)	0.71 (0.26–1.89)	1.85 (0.73–4.68)
Regular smoking	1.50 (0.87–2.60)	1.61 (0.60–4.29)	4.95 (1.92–12.76)
Nicotine dependence	2.32 (1.27–4.23)	3.21 (1.26–8.20)	8.62 (3.33–22.32)

Note. ^aEver thought, planned, or attempted suicide.

^bHeavy Smoking Index.

^cAdjusted for seven-level sampling design variable and missing maternal data variable. Bold text indicates significant odds ratio.

Table 6. Association Between Male Offspring Regular Smoking, Nicotine Dependence, and Suicidal Behavior in Males Adjusted for Father and Mother Suicide^a, Father^b and Mother Nicotine Dependence^{c,d}, and Father and Mother Conduct Disorder and Adjusted for Offspring Conduct Disorder, Depression, Alcohol, and Illicit Drug Abuse/Dependence

	Ideation	Ideation + plan	Ideation + plan + attempt or ideation + attempt
Age	1.04 (0.99–1.10)	0.98 (0.89–1.08)	0.97 (0.87–1.10)
Offspring conduct disorder	1.50 (0.75–2.99)	5.81 (2.33–14.51)	1.16 (0.37–3.64)
Offspring major depression	4.55 (2.59–7.99)	4.76 (1.62–13.97)	6.48 (2.53–16.61)
Offspring alcohol abuse/dependence	1.10 (0.64–1.89)	1.32 (0.45–3.85)	1.35 (0.46–3.92)
Offspring illicit drug abuse/dependence	2.27 (1.31–3.94)	1.84 (0.67–5.03)	1.42 (0.52–3.90)
Offspring smoking			
Never	1.0	1.0	1.0
Ever	1.27 (0.64–2.52)	3.14 (0.65–15.19)	1.49 (0.35–6.28)
Regular smoking	1.27 (0.64–2.52)	5.47 (1.05–28.60)	2.17 (0.49–9.54)
Nicotine dependence	0.74 (0.35–1.57)	4.03 (0.75–21.66)	6.59 (1.91–22.70)

Note. ^aEver thought, planned, or attempted suicide.

^bDSM-III-R criteria.

^cHeavy Smoking Index.

^dAdjusted for seven-level sampling design variable and missing maternal data variable. Bold text indicates significant odds ratio.

smoking was associated with ideation among females and with ideation + plan among males. Regular smoking was more strongly associated with this measure of suicidal behavior and was significantly associated with ideation + plan among males and with ideation + plan + attempt or ideation + attempt in females. Last, nicotine dependence increased in strength of association from ideation through ideation + plan + attempt or ideation + attempt. Adjustment for offspring covariates attenuated the association between smoking status and levels of suicidal behavior; however, adjustment for paternal and maternal familial vulnerability did not mediate the effect between smoking status and levels of suicidal behaviors.

The familial contributions to suicidal behavior as well as the familial contribution to smoking were controlled in the present study. Though we are unable to determine the temporal direction of effect in the present design, we can conclude that the association exists above and beyond familial contributions to smoking and suicidal behavior. We also found the association remained after controlling for offspring conduct disorder, major depression, alcohol abuse/dependence, and illicit drug abuse/dependence but were attenuated, suggesting partial mediation by these offspring level variables. The present design provides some of the strongest evidence to date that ever smoking, regular smoking, and nicotine dependence are all

Table 7. Association Between Female Offspring Regular Smoking, Nicotine Dependence, and Suicidal Behavior in Females Adjusted for Father and Mother Suicide^a, Father^b and Mother Nicotine Dependence^{c,d}, and Father and Mother Conduct Disorder and Adjusted for Offspring Conduct Disorder, Depression, Alcohol, and Illicit Drug Abuse/Dependence

	Ideation	Ideation + plan	Ideation + plan + attempt or ideation + attempt
Age	1.01 (0.97–1.05)	1.0 (0.92–1.08)	1.0 (0.93–1.09)
Offspring conduct disorder	2.36 (0.89–6.25)	2.82 (0.77–10.37)	6.23 (2.0–19.40)
Offspring major depression	5.08 (3.14–8.22)	11.44 (5.31–24.65)	10.0 (5.37–18.62)
Offspring alcohol abuse/dependence	2.13 (1.21–3.75)	3.37 (1.17–9.67)	1.94 (0.80–4.71)
Offspring illicit drug abuse/dependence	1.87 (1.10–3.18)	2.96 (1.05–8.37)	1.74 (0.82–3.70)
Offspring smoking			
Never	1.0	1.0	1.0
Ever	1.34 (0.85–2.13)	0.51 (0.18–1.47)	1.68 (0.67–4.18)
Regular smoking	1.08 (0.60–1.93)	0.71 (0.22–2.30)	3.30 (1.23–8.88)
Nicotine dependence	1.14 (0.56–2.31)	0.88 (0.27–2.89)	3.37 (1.25–9.04)

Note. ^aEver thought, planned, or attempted suicide.

^bDSM-III-R criteria.

^cHeavy Smoking Index.

^dAdjusted for seven-level sampling design variable and missing maternal data variable. Bold text indicates significant odds ratio.

independent correlates of suicidal behavior above the influence of familial vulnerability.

Our results extend the growing literature that establishes the association between smoking and suicidal behaviors (Breslau et al., 2005; Clarke et al., 2010; Kessler et al., 2009). Our results are consistent with previous research, which found that more severe smoking phenotypes, such as nicotine dependence, have a stronger association with suicidal behavior than less severe phenotypes such as ever smoking (Beratis et al., 1997; Hemenway et al., 1993; Hemmingsson & Kriebel, 2003; Iwasaki et al., 2005; Kessler et al., 2009).

Though not modeled, we note that another common mechanism underlying the co-occurrence of smoking and suicidality may be exposure to trauma. Evidence suggests that traumatic events in adolescence increase both risk of suicidal behavior as well as smoking (Berenson, Wiemann, & McCombs, 2001). Further research in this area is warranted.

Strengths

Strengths include the large sample size and nonclinical sample that enhance generalizability to other community-based adolescent and young adult populations. In fact, the prevalence of nicotine dependence in the current cohort of regular smokers (50%) is consistent with findings from similarly aged respondents to the National Epidemiologic Survey of Alcoholism and Related Conditions in which 53% of smokers 18–25 years of age were nicotine dependent (Dierker & Donny, 2008). The structured method of data collection reduced chance for interviewer bias, which is especially important when assessing sensitive topics such as suicidal behavior. The rich data resource permitted modeling not only familial vulnerability but also several key offspring level risk factors.

Limitations

Because we lacked DSM nicotine dependence criteria on mothers, we had to analyze paternal and maternal risk factors separately; however, neither paternal or maternal familial risk factors mediated the association between offspring smoking status and suicidal behavior. Because of inaccurate self-reported race evident in the offspring data, we were limited to utilizing paternal race, which is overwhelmingly White. Conclusions regarding the association between smoking and suicide are limited by the fact that not all offspring have passed through the age of risk for regular smoking and nicotine dependence. Likewise not all offspring have passed the peak risk for suicide (Tsuang, Simpson, & Fleming, 1992). While we did not tease apart all the levels of suicidal behavior, in subanalysis limited to those who have had ideation, we can conclude that nicotine dependence is significantly associated with risk of suicide attempt. Future analyses of longitudinal data will determine if our current observations hold as offspring age and more offspring experience ideation and attempt. Self-reported suicidal behavior may overestimate the prevalence of thinking of suicide. Lastly, the cross-sectional design does not permit conclusions regarding causation. However some evidence suggests that smoking onset precedes suicidal behavior. We observed that 62% of offspring were ever-smokers before onset of ideation, 63% before making a plan, and 72% before making an attempt.

Public health attempts to reduce suicidal behavior should target high-risk populations that includes smokers. Additional

messages to smokers for reasons to quit smoking may include evidence that smoking may not assuage depression and may worsen suicidal ideation.

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Declaration of Interests

None declared.

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