Original investigation

Nicotine Dependence in Adolescence and Physical Health Symptoms in Early Adulthood

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Abstract

Introduction: To examine the prospective associations of Diagnostic and Statistical Manual of Mental Disorders nicotine dependence (ND) and other individual and parental factors in adolescence on self-reported health symptoms in early adulthood.

Methods: Multiethnic prospective longitudinal cohort of adolescents from grades 6–10 and a parent ($N = 908$) from the Chicago Public Schools. Adolescents were interviewed five times at 6-month intervals (Waves 1–5) and once 4.5 years later (Wave 6). Parents were interviewed annually three times (W1, W3, W5). Multivariate regressions estimated prospective associations of Diagnostic and Statistical Manual of Mental Disorders ND, other individual and familial risk factors in adolescence (mean age 16.6) on physical health symptoms in early adulthood (mean age 21.3), controlling for health symptoms in adolescence.

Results: Levels of health symptoms declined from adolescence to early adulthood, except among dependent smokers. Nicotine dependent adolescents reported more health symptoms as young adults than nonsmokers and nondependent smokers, especially if depressed. ND and health symptoms in adolescence were the strongest predictors of health in early adulthood. These two adolescent factors, depression, and the familial factors of parental ND, depression and health conditions, each independently predicted health symptoms in young adulthood. Females reported more symptoms than males.

Conclusions: There is continuity of health status over time. ND, depression, and parental factors in adolescence contribute to poor health in early adulthood. The findings highlight not only the role of adolescent behavior, but the importance of the family in the development of young adult health. Reducing smoking, particularly ND, and depression among adolescents and parents will decrease physical health burden.

Introduction

Smoking is a leading cause of preventable morbidity and mortality in the US population.^{1,2} While the long-term consequences of smoking on health in adulthood have been well-documented, less is known about the short-term consequences in adolescence or young adulthood, when these effects first manifest themselves.³ Furthermore, while adult studies have examined the effects of smoking, and to a lesser extent nicotine dependence (ND),^{4–7} adolescent studies have only examined the effects of smoking whether in adolescence or

subsequently in adulthood.³ The impact of ND in adolescence on young adult health has not been examined. In a cross-sectional sample of young adults aged 21–30, Andreski and Breslau,⁸ found poor self-reported physical health (chronic illness, physical limitations, lower self-reported health) to be associated only with ND and not with non-nicotine dependent smoking. Other health effects of adult ND include cardiovascular and respiratory diseases, diabetes and increased health care utilization.^{4–7}

Smoking initiation occurs in adolescence and is mostly completed by the late teens.³ Thus, in 2013, 90% of adult smokers in the United

States first tried a cigarette by age 20 (unpublished analyses, NSDUH 2014).⁹ Similarly, ND has its onset in adolescence, with 22%–40% of smokers meeting criteria for ND.^{10–12} Adolescence and the transition to young adulthood are important developmental periods in which to investigate the impact of early smoking and ND on health symptoms that predate and may predict smoking-related diseases of later adulthood.

We investigate the effect of adolescent ND on health symptoms in early adulthood within a social ecological framework based on Bronfenbrenner's Model of Human Development,¹³ in which we examine together individual and familial risk factors. ND in adolescence may have negative effects on health because of its direct physiological effects as well as its association with individual and familial factors that impact negatively on health.^{13,14–24} Factors comorbid with adolescent smoking and ND, including substance use (alcohol, marijuana) and mental health problems (depression, anxiety, disruptive disorders), predict poor health in young adulthood.^{15–18,20,25–29}

Parents can affect offspring health through genetic factors, physical and mental health, health behaviors, and socioeconomic status.^{18,30–35} Studies have found that parental health conditions directly predict poorer self-rated health in young adult offspring, and indirectly through offspring's health behaviors.¹⁸ Parental depression is associated with offspring health problems, such as respiratory illness in childhood,³¹ physical symptoms in adolescence,³² and chronic physical conditions, particularly cardiovascular illness, in mid-adulthood.³³ Similarly, parental smoking is a risk factor for offspring respiratory problems, other health problems, and lower self-rated health in young adulthood.^{18,34} Parental smoking and ND predict youth smoking and ND.^{14,35}

In addition, there are well-known gender differences in health status. Females report more health symptoms and poorer general health than males in adolescence and early adulthood.^{18,22,26,36,37} The nature of gender differences in the associations of health symptoms with smoking and ND as well as other predictors of health symptoms in early adulthood remains to be established.

This study investigates the prospective impact of adolescent Diagnostic and Statistical Manual of Mental Disorders (*DSM-IV*) ND, and other adolescent and familial risk factors, at mean age 16.6 years, on young adult self-reported physical health 4.5 years later, at mean age 21.3 years. Identical health symptoms were ascertained in adolescence and early adulthood. Familial factors were based on independent assessments of one parent. We examine (1) associations of adolescent smoking and ND with health symptoms in adolescence and early adulthood; (2) the unique impact of adolescent smoking and ND, other adolescent and familial risk factors on early adult health; (3) potential interactive effects of adolescent smoking/ND with adolescent substance use and psychiatric disorders on subsequent health; and (4) potential gender differences in the predictors of early adult health.

To our knowledge, no study has considered simultaneously the prospective effects of adolescent ND, other adolescent risk factors, and the broader context of familial risk on young adult health, while taking parental ND into account.

Methods

Study Sample

The data are from the Transition to Nicotine Dependence study, a prospective six-wave longitudinal study of a multiethnic cohort of

1039 6th–10th graders selected from the Chicago Public Schools and one parent, mostly mothers. A two-stage design was implemented to select the follow-up household sample ([Supplementary Figure 1](#)) and to provide approximately equal numbers of youths from the three major ethnic groups: non-Hispanic white, non-Hispanic black, and Hispanic. In Phase I (1/03–5/03), 15 763 students from 43 schools were surveyed (completion rate 83.1%). Survey responses were used to select a target sample of 1236 youths: 1106 tobacco users who reported having initiated tobacco use within 12 months of the school survey and 130 nontobacco users susceptible of starting to smoke, per Pierce et al.³⁸ Nontobacco users were only included so as not to divulge to parents that the study focused on smokers. All whites and blacks who started using tobacco 0–12 months earlier and Hispanics who started 0–6 months earlier were selected at 100%; 25% of Hispanics who started 7–12 months earlier were selected because of the larger number of Hispanics than other racial/ethnic groups in the schools.

In Phase II (2/03–10/05, Waves 1–5), 9 weeks after each school survey, 1039 (84.1% of the 1236 target) youths and one parent were interviewed (Wave 1). Three annual computerized household interviews (Waves 1,3,5; 90 minutes) were conducted with youths and parents (87% biological mother, 5% biological father, 8% other parental figure), and two bi-annual interviews (20 minutes) were conducted with youths 6 months after W1 and W3 (Waves 2 and 4). The average interval between waves was 6.0–6.3 months. Wave 1 participants were targeted for reinterviewing at each subsequent wave. The W2–W5 completion rates were 96% of the W1 sample.

In Phase III (11/09–08/10, Wave 6), 4.5 years after W5, 934 (90.6%) of 1031 W1 youths (eight had died) were reinterviewed (80 minutes). Parents were not reinterviewed. The National Opinion Research Center conducted the fieldwork.

The analytical sample included 908 (90.7%) of W5 adolescents reinterviewed at W6 as young adults (232 white, 306 black, 370 Hispanic; 54.9% female). The mean age was 16.6 years ($SD = 1.3$, range = 13–19) at W5, 21.3 years ($SD = 1.3$, range = 18–24) at W6.

The Institutional Review Boards of the New York State Psychiatric Institute, Columbia University, and the National Opinion Research Center approved the study.

Measures

Measures were based on youths' and parents' self-reports, except adolescent psychiatric disorders, which combined youth and parental reports about youths, as per the Diagnostic Interview Schedule for Children-IV-Youth and Parent.³⁹

Early Adult Outcome

Physical Health Symptoms (W6)

From the National Longitudinal Study of Adolescent to Adult Health,²⁶ Assessed frequency of six physical health symptoms experienced the last 12 months at W6: headache, stomach ache, sore throat or cough, muscle or joint pain, chest pain, dizziness. The seven categorical responses were recoded into frequency values corresponding to the actual annual frequencies of the category or the midpoint values between prior and succeeding categories: never = 0 times; once or twice = 2; several times = 7; about once month = 12; 2 to 3 times a month = 30; once a week = 52; more than once a week = 104 times. Factor analysis, using a robust weighted least squares estimator for ordered categorical data estimated in Mplus V7.2,⁴⁰ indicated that the items formed a single factor (eigenvalue = 3.15;

loadings = 0.54–0.74). Individual symptom values were averaged to create an overall score (mean = 4.0, *SD* = 7.4, range 0–59; α = 0.74).

Adolescent Predictors

Measured at W5, except as noted.

Demographics.

Age (in years).

Gender (male; female).

Race/ethnicity (non-Hispanic white; non-Hispanic black; Hispanic).

Nicotine Dependence

Measured per the *DSM-IV*,⁴¹ with an instrument for adolescents and young adults.⁴² The 11-item scale⁴³ assessed the seven *DSM-IV* dependence criteria: tolerance, withdrawal, impaired control, unsuccessful quit attempts, great deal of time spent using tobacco, neglect important activities, use despite physical or psychological problems (α = 0.85).¹² Dependence = 3+ criteria within a 12-month period. W4 and W5 symptoms were aggregated to construct a last 12-month measure. Adolescents were classified into three groups: did not smoke in the last 12 months; smoked, not dependent; smoked, dependent.

Cigarette Consumption

Prior 12 months at W5. Frequency and quantity were each measured for the 6-month period prior W4 and prior W5. Consumption was calculated as the log-transformed [$\log(\text{product}+1)$] sum of W4 and W5 products: the recoded midpoint values of days smoked (frequency) multiplied by cigarettes smoked per day on the days used the past 30 days/most recent month used (quantity) during the prior 6 months at W4 and at W5. Frequency recodes: 0 days = 0; 1–2 days = 1.5; 3–5 days = 4; 6–9 days = 7.5; 10–39 = 25; 40–99 = 70; 100–199 = 150; 200–299 = 250; ≥ 300 days = 333. Quantity recodes: one or two puffs = 0.5; 1 = 1; 2–5 = 3; 6–15 = 10; 16–25 = 20; 26–35 = 30; ≥ 35 = 40 cigarettes (unlogged range 0–6660).

Alcohol Consumption

Asked about the prior 12 months at W5. Log-transformed [$\log(\text{product}+1)$] product of the recoded midpoint values of days drank (frequency) and drinks per day on the days used the past 30 days/most recent month used (quantity) the last 12 months. Frequency recode values were identical to those for cigarettes. Quantity recodes: <1 drink = 0.5; 1 = 1; 2 = 2; ...5 = 5; 6–8 = 7; 9–11 = 10; 12 = 12 drinks (unlogged range 0–1800).

Marijuana Consumption

Asked about the prior 12 months at W5. Log-transformed [$\log(\text{product}+1)$] product of the recoded midpoint values of days used (frequency) and joints smoked per day on days used the past 30 days/most recent month used (quantity) the last 12 months. Frequency recode values were identical to those for cigarettes and alcohol. Quantity recodes: <1 joint = 0.5; 1 = 1; 2–3 = 2.5; 4–6 = 5; ≥ 7 = 7 joints (unlogged range 0–2331).

Physical Health Symptoms (W5)

Same measure as W6 outcome above. As at W6, the items formed a single factor. The eigenvalue was 3.13, factor loadings = 0.61–0.70. The average overall symptom score (mean = 5.1, *SD* = 8.3, range = 0–63; α = 0.72) was log-transformed [$\log(\text{var}+1)$] when entered as a predictor in the longitudinal analysis.

Body Mass Index

Ratio of current weight to height squared.

Psychiatric Disorders

Assessed by Diagnostic Interview Schedule for Children-IV-Youth and Parent.³⁹ Any *DSM-IV* depressive (major depression/dysthymia), anxiety (social phobia, panic, generalized anxiety, posttraumatic stress), or disruptive (attention deficit/hyperactivity, oppositional defiant, conduct) disorder last 12 months, ascertained from parents and youths. Youths were assigned a diagnosis if met criteria on the parent, youth, or combined informant scores without impairment.

Parental Predictors

W1, W3, W5.

Education

Highest level parent or spouse/partner by W1: <high school; high school; some college or more.

Lifetime Smoking (Ever a Puff of a Cigarette)

Yes; no.

ND

Same assessment as youths. ND = 3+ criteria within a 12-month period.

A trichotomous variable was defined: never smoked; smoked, but never dependent; lifetime dependent by W5.

Health Conditions

Count of 14 conditions experienced the last 12 months either at W1, W3 or W5: anemia, asthma, chronic bronchitis or emphysema, ulcer, heart trouble, high blood pressure, arthritis or rheumatism, diabetes, epilepsy, hernia or rupture, back or spine trouble, chronic headaches or migraines, irritable bowel syndrome, cancer (range 0–10).

Depressive Disorder

Lifetime *DSM-IV*, as per the Composite International Diagnostic Interview 2.1 by W5.

Nonparticipation at Wave 6

W5 youths reinterviewed at W6 (*N* = 908) were compared with those not reinterviewed (*N* = 93) on W5 characteristics. Nonparticipants were slightly older (mean = 17.0, *SD* = 1.4 vs. mean = 16.6, *SD* = 1.3, P < .05) and reported fewer health symptoms (mean = 3.0, *SD* = 4.7 vs. mean = 5.1, *SD* = 8.3, P < .01) than participants. The nonparticipation rate was higher among last year nondependent (13.7%, P < .01) or dependent smokers (11%, *ns*) than nonsmokers (8%).

Statistical Analysis

Because the health symptoms were non-normal quantitative count data, all analyses were estimated using generalized linear models with a negative binomial link. Differences in levels of individual health symptoms and overall symptom scores by smoking/ND status in adolescence (W5) were examined in adolescence and in early adulthood (W6). Likelihood ratio tests were used to determine if the model including smoking/ND significantly improved fit over the model without smoking/ND. In a second step, differences in overall symptoms scores between W5 and W6 in the total sample, and separately among nonsmokers, nondependent smokers and dependent smokers, were tested.

Prospective effects of adolescent ND and other adolescent and familial risk factors on early adulthood physical health symptoms were examined without and with control for other covariates. As noted above, generalized linear models with a negative binomial link were estimated because the health outcome was a count and the variance of the variable ($=55.1$) exceeded the mean ($=4.0$). Although the distribution was skewed, there was not an excess of 0 values: 23.7% of young adults reported no symptoms, 26.5% reported one symptom, 39.4% 2–9 symptoms, and 10.4% 10–59 symptoms. Effects of predictors were interpreted as incidence rate ratios (IRRs). Adolescent health symptoms at W5 controlled for the autoregressive effects of symptoms over time. Number of cigarettes smoked controlled for the potential independent effect of consumption over that of ND. Other risk factors included in the models were adolescent age, gender, race/ethnicity, alcohol and marijuana consumption, body mass index, depressive, anxiety and disruptive disorder; parental education, smoking/ND, health conditions, and depressive disorder. Interactions of (1) adolescent smoking/ND status by adolescent other substance use (alcohol, marijuana) and psychiatric disorders (depressive, anxiety, disruptive), and of (2) each adolescent and parental factor by child gender were tested. Each interaction was estimated in a separate multivariate model, controlling for all other factors. Statistically significant interaction effects were then estimated simultaneously in the same multivariate model; only significant interaction effects were retained in the final model.

The effect of persistent ND on young adult health symptoms was examined by reestimating the multivariate model in which a variable indexing persistent ND was substituted for adolescent ND.

The sampling weights adjusted for (1) the 25% selection rate of Hispanics who started to use tobacco 7 to 12 months before the school survey (assigned a weight of 4) and (2) the higher nonresponse in Wave 1 of all youths reporting in the school survey having smoked in the last year and being a heavy smoker.

Results

Characteristics of Adolescents and Parents

At W5, 57.6% of adolescents did not smoke in the last 12 months, 29% smoked but were not nicotine dependent, 13.4% were dependent (31.5% among smokers; Table 1). Dependent smokers consumed more cigarettes during the prior 12 months than nondependent smokers (mean = 1319, SD = 1659 vs. mean = 304, SD = 860). Females reported more health symptoms than males (mean = 5.7, SD = 9.0 vs. mean = 4.4, SD = 7.4, P < .01). Adolescent and parent characteristics are presented in Table 1.

Associations of Smoking and ND in Adolescence with Health Symptoms in Adolescence and Early Adulthood

Overall, youths reported fewer health symptoms at W6 than W5 (means = 4.0 and 5.1, respectively, IRR = 0.78, 95% confidence interval [CI] = 0.69 to 0.90, P < .001). However, levels of health symptoms decreased between adolescence and early adulthood only among those who, in adolescence, had not smoked in the prior 12 months (IRR = 0.68, 95% CI = 0.58 to 0.80, P < .001) and were nondependent smokers (IRR = 0.78, 95% CI = 0.62 to 1.0, P < .05). Symptoms remained at the same level among those nicotine dependent as adolescents (IRR = 1.2, 95% CI = 0.82 to 1.66, ns ; Table 2). Adolescent smoking/ND was associated with overall levels

Table 1. Means or Percentages of Predictor Variables Among Adolescents and Parents (N = 908)

Predictors	Mean (SD)	%
Adolescent factors (W5)		
Demographics		
Age (in years)	16.6 (1.3)	
Female		54.9
Race/ethnicity		
White		25.5
Black		33.6
Hispanic		40.9
Smoking/DSM-IV nicotine dependence last 12 months		
Did not smoke		57.6
Smoked, not nicotine dependent		29.0
Smoked, nicotine dependent		13.4
Number of cigarettes smoked last 12 months (among users) ^a	3.9 (2.7)	
Other substance use		
Alcohol use last 12 months		49.8
Number of alcohol drinks consumed last 12 months (among users) ^a	2.5 (1.7)	
Marijuana use last 12 months		31.0
Number of marijuana joints smoked last 12 months (among users) ^a	2.9 (2.3)	
Physical health		
Frequency physical health symptoms last 12 months	5.1 (8.3)	
Body mass index	23.8 (4.9)	
Mental Health		
Depressive disorder last 12 months		3.5
Anxiety disorder last 12 months		6.3
Disruptive disorder last 12 months		13.1
Parental factors (W1–W5)		
Education—highest level lifetime (by W1)		
Less than high school		22.0
High school		22.7
Some college or more		55.3
Smoking/DSM-IV nicotine dependence lifetime (by W5)		
Never smoked		29.8
Smoked, never nicotine dependent		42.0
Smoked, nicotine dependent		28.2
Number of health conditions last 12 months (W1–W5)	1.6 (1.6)	
Depressive disorder lifetime (by W5)		15.8

DSM-IV = Diagnostic and Statistical Manual of Mental Disorders. Weighted estimates, unweighted N .

^aLog-transformed values.

of physical health symptoms only in early adulthood but not in adolescence.

Effects of Smoking and ND in Adolescence on Health Symptoms in Early Adulthood: Multivariate Analyses

Controlling for health symptoms in adolescence and adolescent and parental risk factors, ND and health symptoms in adolescence were the two strongest predictors of health symptoms in early adulthood. Nicotine dependent adolescents reported 1.7 times (95% CI = 1.25 to 2.42) more health symptoms in early adulthood than nondependent adolescent smokers, and 2.3 times (95% CI = 1.51 to 3.60) more symptoms than nonsmokers (Table 3; Supplementary Table 1 presents the correlations among covariates). Depressed adolescents experienced more health symptoms in young adulthood

Table 2. Frequency of Self-Reported Physical Health Symptoms in the Last 12 Months in Adolescence (Wave 5) and in Early Adulthood (Wave 6) by Smoking and DSM-IV Nicotine Dependence at Wave 5 (*N* = 908)

Health symptoms	Wave 5 health symptoms					Wave 6 health symptoms				
	Smoking and nicotine dependence at wave 5					Smoking and nicotine dependence at wave 5				
	Total (<i>N</i> = 908)	Did not smoke (<i>N</i> = 530)	Smoked not ND (<i>N</i> = 259)	Smoked ND (<i>N</i> = 119)	Likelihood ratio test $\chi^2(2)$	Total (<i>N</i> = 908)	Did not smoke (<i>N</i> = 530)	Smoked not ND (<i>N</i> = 259)	Smoked ND (<i>N</i> = 119)	Likelihood ratio test $\chi^2(2)$
Headache	Mean (SD) 8.9 (19.5)	8.9 (18.8)	8.9 (21.0)	9.3 (18.9)	0.0	5.2 (15.8)	3.8 ^a (12.1)	6.1 ^b (18.2)	9.0 ^b (22.9)	16.0***
Stomach ache	Mean (SD) 6.2 (13.0)	5.7 ^a (12.3)	6.3 (13.1)	8.0 ^b (15.6)	6.0*	5.4 (14.2)	4.6 ^a (12.6)	4.6 ^a (9.9)	10.5 ^b (24.2)	26.0***
Sore throat or cough	Mean (SD) 4.6 (10.7)	4.6 (10.9)	3.9 ^a (7.2)	6.0 ^b (15.1)	8.0*	3.3 (7.4)	3.3 (7.6)	3.1 (7.4)	3.6 (6.9)	0.0
Muscle or joint pain	Mean (SD) 7.0 (20.5)	7.8 (22.1)	5.7 (17.2)	6.5 (19.6)	4.0	6.7 (17.8)	6.3 ^a (16.9)	5.5 ^a (14.2)	11.0 ^b (26.3)	10.0**
Chest pain	Mean (SD) 2.2 (11.2)	1.4 ^a (7.2)	2.6 (13.1)	4.6 ^b (18.6)	9.32**	1.8 (9.2)	1.0 ^a (7.0)	1.8 ^a (7.8)	4.8 ^b (17.0)	21.36***
Dizziness	Mean (SD) 1.7 (9.5)	1.7 (8.7)	1.4 (9.1)	2.4 (13.0)	1.44	1.8 (9.0)	1.4 ^a (8.0)	1.6 ^a (5.7)	3.7 ^b (16.1)	7.4*
Overall	Mean (SD) 5.1 (8.3)	5.0 (8.0)	4.8 (8.0)	6.1 (9.9)	4.0	4.0 (7.4)	3.4 ^a (6.5)	3.8 ^a (5.9)	7.1 ^b (12.1)	32.0***

DSM-IV = Diagnostic and Statistical Manual of Mental Disorders. Weighted estimates, unweighted *N*s. Within a row, means with different superscript letters are statistically significantly different from each other at $P < .05$ within each wave.

* $P < .05$; ** $P < .01$; *** $P < .001$.

than those not depressed. Females also experienced more health symptoms than males. Parental ND, health conditions and depression each had unique adjusted effects on health symptoms in young adult offspring. Adolescent anxiety and disruptive disorder, alcohol consumption, and body mass index each had significant univariate effects on young adult health symptoms, which did not persist with control for other risk factors.

The pattern regarding cigarette consumption and ND is of particular interest. The two variables are highly correlated ($r = 0.64$, $P < .001$ at W5). Collinearity diagnostics indicated that the correlation between cigarette consumption and ND did not appear to affect the stability of their individual estimates in the regression analysis. The variance inflation factors were under 10 for both consumption = 3.5 and ND = 3.2 (estimated in SAS PROC REG). Each was a significant univariate predictor of subsequent health symptoms, and each had significant effects on health in multivariate models that excluded the other variable (ND IRR = 1.99, 95% CI = 1.47 to 2.70, $P < .001$; consumption IRR = 1.06, 95% CI = 1.01 to 1.11, $P < .05$). However, when both variables were included, adolescent ND, but not consumption level, predicted early adult health symptoms. Nicotine dependent adolescents who smoked at low levels reported as many health symptoms in young adulthood as those who smoked heavily. The average number of health symptoms was 8.6 ($SD = 8.7$, $N = 21$) among dependent youths who smoked 1–24 cigarettes in the prior 12 months, 8.2 ($SD = 13.2$, $N = 15$) among those who smoked 25–99 cigarettes, 6.8 ($SD = 13.1$, $N = 19$) among those who smoked 100–499 cigarettes, 3.5 ($SD = 5.6$, $N = 20$) among those who smoked 500–999 cigarettes, and 7.9 ($SD = 14.6$, $N = 44$) among those who smoked 1000 or more cigarettes.

Two statistically significant interactions emerged. The effect of adolescent ND on health symptoms in early adulthood was moderated by adolescent depression [Interaction = $\chi^2(2) = 10.00$, $P < .01$]: health symptoms were greatly elevated only among those who were both nicotine dependent and depressed in adolescence compared with those who were nicotine dependent but not depressed (IRR = 3.84, 95% CI = 1.71 to 8.62; Figure 1). The effect of parental ND on health symptoms in early adulthood was moderated by child gender [Interaction = $\chi^2(2) = 6.00$, $P < .05$]. Males with a nicotine dependent parent had more health symptoms (mean = 4.9, $SD = 9.1$) than males with a nondependent smoking parent (mean = 2.9, $SD = 5.0$, IRR = 1.71, 95% CI = 1.22% to 2.38%) or never smoking parent (mean = 2.7, $SD = 3.9$, IRR = 1.76, 95% CI = 1.22 to 2.55). Among females, the levels of health symptoms did not vary by parental smoking/ND and were the same as for males with a nicotine dependent parent. Symptom means for females means were 4.6, $SD = 8.4$, when the parent was nicotine dependent; 4.7, $SD = 8.6$, when the parent was a nondependent smoker; and 4.1, $SD = 7.5$, when the parent never smoked.

Effects of ND Persistence on Health Symptoms

To examine the effect of chronic ND on health symptoms in early adulthood, the model was reestimated in which persistent ND between W5 and the 12 months preceding W6 was substituted for W5 dependence. Five groups were identified: (1) persistent dependent (dependent at W5 and the 3.5 year interval up to the 12 months preceding W6; $N = 53$); (2) remitting dependent (dependent at W5 but not the interval; $N = 66$); (3) newly dependent (not dependent at W5 but dependent in the interval; $N = 118$); (4) intermittent nondependent smokers ($N = 373$); (5) persistent nonsmokers ($N = 298$). Persistent dependent youths had the highest levels of health

Table 3. Adolescent and Parental Predictors of Self-Reported Physical Health Symptoms in the Last 12 Months in Early Adulthood at Wave 6 (*N* = 908)

Predictors	Health symptoms at W6	
	Univariate IRR (95% CI) (unadjusted)	Multivariate IRR (95% CI) (adjusted) ^a
Adolescent factors (W5)		
Demographics		
Age (in years)	1.00 (0.92 to 1.07)	0.95 (0.88 to 1.02)
Female (vs. male)	1.31 (1.09 to 1.59)**	1.21 (1.00 to 1.45)*
Race/ethnicity (vs. white)		
Black	0.87 (0.68 to 1.11)	0.98 (0.72 to 1.32)
Hispanic	0.73 (0.57 to 0.92)**	0.82 (0.64 to 1.05)
Smoking/DSM-IV nicotine dependence last 12 months (vs. did not smoke)		
Smoked, not nicotine dependent	1.11 (0.90 to 1.36)	1.34 (1.02 to 1.76)*
Smoked, nicotine dependent	2.09 (1.59 to 2.74)***	2.33 (1.51 to 3.60)***
Number of cigarettes smoked last 12 months	1.06 (1.02 to 1.10)**	0.97 (0.91 to 1.03)
Other substance use		
Number of alcohol drinks consumed last 12 months	1.07 (1.02 to 1.14)*	1.02 (0.96 to 1.09)
Number of marijuana joints smoked last 12 months	1.03 (0.98 to 1.09)	0.95 (0.89 to 1.01)
Physical health		
Frequency physical health symptoms last 12 months	1.49 (1.37 to 1.63)***	1.50 (1.37 to 1.64)***
Body mass index	1.02 (1.00 to 1.04)*	1.01 (0.99 to 1.03)
Mental health		
Depressive disorder last 12 months (vs. no)	2.16 (1.32 to 3.52)**	1.72 (1.05 to 2.84)*
Anxiety disorder last 12 months (vs. no)	1.64 (1.13 to 2.38)**	1.09 (0.76 to 1.57)
Disruptive disorder last 12 months (vs. no)	1.32 (1.01 to 1.74)*	0.90 (0.68 to 1.19)
Parental factors (W1–W5)		
Education—highest level (vs. less than high school) (by W1)		
High school	1.03 (0.78 to 1.36)	1.10 (0.83 to 1.47)
Some college or more	1.04 (0.82 to 1.31)	1.04 (0.81 to 1.37)
Smoking/DSM-IV nicotine dependence lifetime (vs. never smoked) (by W5)		
Smoked, never nicotine dependent	1.14 (0.91 to 1.42)	0.99 (0.79 to 1.23)
Smoked, nicotine dependent	1.38 (1.08 to 1.77)**	1.32 (1.02 to 1.70)*
Number of health conditions last 12 months (W1–W5)	1.08 (1.02 to 1.15)**	1.07 (1.01 to 1.14)*
Depressive disorder lifetime (vs. never) (by W5)	1.47 (1.14 to 1.89)**	1.28 (1.00 to 1.64)*

CI = confidence interval; DSM-IV = Diagnostic and Statistical Manual of Mental Disorders; IRR = incidence rate ratio. Weighted estimates, unweighted *N*.

^aControlling for adolescent and parental factors listed under Predictors.

P* < .05; *P* < .01; ****P* < .001.

symptoms in early adulthood (mean = 10.0, *SD* = 14.8), persistent nonsmokers the lowest (mean = 3.0, *SD* = 6.0; IRR of the two groups = 4.04, 95% CI = 2.38 to 6.83, *P* < .001). Youths whose dependence remitted (mean = 4.9, *SD* = 8.9), those who became dependent (mean = 5.0, *SD* = 7.0), and intermittent nondependent smokers (mean = 3.5, *SD* = 6.2) had intermediate levels of health symptoms that were significantly lower than those of youths who remained dependent (IRR = 0.52, 95% CI = 0.32 to 0.84, *P* < .01; IRR = 0.46, 95% CI = 0.27 to 0.77, *P* < .01; IRR = 0.36, 95% CI = 0.23 to 0.57, *P* < .001, respectively), and higher than those who remained nonsmokers (IRR = 2.09, 95% CI = 1.38 to 3.16; *P* < .001; IRR = 1.85, 95% CI = 1.37 to 2.50, *P* < .001; IRR = 1.45, 95% CI = 1.14 to 1.83, *P* < .01, respectively).

Discussion

In adolescence, those who had not smoked in the prior 12 months, nondependent smokers, and dependent smokers experienced similar levels of health symptoms. By early adulthood, however, health had improved among most youths, except those nicotine dependent in adolescence. Controlling for the strong continuity of health symptoms between adolescence and young adulthood, and adolescent and

parental risk factors, youths dependent in adolescence reported more health symptoms in early adulthood than nondependent smokers or nonsmokers. The unique negative effect of ND on health in young adulthood was similarly emphasized by Andreski and Breslau⁸ in their cross-sectional study of young adults drawn from a health maintenance organization. In the current study, the impact of ND was amplified among those who were depressed in adolescence. There appears to be a cumulative effect of ND on health. Youths who remained chronically dependent had the highest levels of health symptoms in young adulthood of any group. Adolescents whose dependence remitted still experienced significantly more health symptoms as young adults than those who never smoked, as has been shown for daily smoking.²⁰ Cigarette and alcohol consumption predicted increases in health symptoms in young adulthood at the univariate level, but not with control for other factors. Contrary to other reports,^{15,16} marijuana consumption did not increase health symptoms.

The effect of cigarette consumption did not persist in models where both consumption levels and ND were included. While consumption and dependence are highly correlated, and each were significant univariate predictors of health symptoms, the lack of unique effects of smoking level, when ND is controlled, suggests

Figure 1. Frequency of physical health symptoms in early adulthood (Wave 6) by smoking/nicotine dependence and depressive disorder in adolescence (Wave 5) (N = 908).

that aspects of addiction other than consumption may have adverse effects on health. This result is not confounded by the fact that criteria of *DSM-IV* dependence include continued use despite physical problems, a consequence of tobacco use. Removal of cases classified as dependent by this criterion did not change the results (data not presented), a strategy also used by Andreski and Breslau⁸ with similar results. The lack of effect of cigarette consumption (controlling for other factors) illustrates that the same level of smoking may lead to different degrees of dependence and may have varying consequences for smokers in different subgroups of the population.⁴⁴ Indeed, among adolescents, ND occurs at lower consumption levels than among adults, suggesting that adolescents have an increased physiological sensitivity to nicotine.⁴⁵

Adolescent depression had a negative effect on health symptoms in early adulthood only among those who were nicotine dependent. Effects of adolescent depression on young adult health outcomes have been reported previously.^{18,25-29} To our knowledge, this is the first study to report that youths who were both nicotine dependent and depressed in adolescence experienced the poorest health in young adulthood, underscoring the particularly deleterious effect of depression.

Females reported more health symptoms than males. The associations between adolescent characteristics and health symptoms in early adulthood did not differ by gender.

Three self-reported parental characteristics negatively affected offspring health in young adulthood, and these characteristics paralleled the predictors identified among offspring in adolescence: ND, health conditions, and depression. However, only male offspring

appear to be adversely affected by parental ND. When parents were nicotine dependent, males' health symptom levels matched those of females, whose health symptom levels were unaffected by patterns of parental smoking/ND. The reasons underlying the gender differences in offspring health symptoms in relationship to parental ND remain to be determined. This is an unexplored area of research. Effects of parental health conditions on self-rated health in young adult offspring have been previously reported.¹⁸ Parental depression has also been linked with health problems in offspring.³¹⁻³³ The current findings corroborate the long-term effects of parental depression on offspring, effects that extend to physical health in early adulthood.

Genetic and environmental factors not measured in this study may also account for parental effects on offspring health.¹⁸ Heritability (genetic and epigenetic factors), and not only role modeling, may account for the fact that nicotine dependent parents have offspring who smoke and are nicotine dependent.³⁵ Parents and children are also exposed to community-wide and period-specific levels of smoking.

The number of health symptoms decreased from adolescence to early adulthood in the overall sample, specifically among nonsmokers and nondependent smokers. Similarly, a longitudinal Finnish study reported a decrease in general health symptoms over this age period.⁴⁶ By contrast, no difference or increased number of health conditions (self-rated health, injury, obesity) among young adults than adolescents have been reported in cross-sectional national samples.⁴⁷ Differences in health status in the transitional period from adolescence to young adulthood need to be examined further by type of condition and subgroups.

Limitations of the study include the fact that the sample is not nationally representative. Although sample weights corrected for the higher non-participation of heavier smoking youths, the sample is biased toward light smokers. Physical health was based on self-reports of general symptoms frequency, and did not ascertain severity or duration. The high correlation between self-reported symptom checklist and neuroticism^{48,49} may have inflated the observed relationship between depression and health symptoms. Reflecting the standard psychiatric nosology at the time the study was implemented, ND was measured by the *DSM-IV*. Parental respondents included primarily mothers. Contributions of factors, such as diet and exercise, or stress could not be determined.

Strengths of this investigation include its prospective design, the identical ascertainment of health symptoms in adolescence and early adulthood, control for adolescent health symptoms when predicting early adulthood symptoms, and examination of individual and independently reported familial factors on young adult health in a community sample.

The study highlights the contributions of adolescent ND, mental health, and familial factors to young adult physical health. Smoking is the major cause of mortality in the United States, and ND has particularly deleterious effects.⁵⁰ Unipolar depressive disorders are a major contributor to years lost to disability worldwide.⁵¹ Our findings suggest that the co-occurrence of ND and depression greatly exacerbates the negative consequences of each condition alone. Further examination of these effects is of public health importance. Reducing smoking, particularly ND, and depression among adolescents and family members will improve physical health.

Supplementary Material

Supplementary Figure 1 and Table 1 can be found online at <http://www.ntr.oxfordjournals.org>.

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Declaration of Interests

None declared.

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