

Is use of smokeless tobacco a risk factor for cigarette smoking? The U.S. experience

Scott L. Tomar

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Some researchers are promoting the use of smokeless tobacco as safer than cigarette smoking and as a possible method for quitting smoking, but smokeless tobacco might be a gateway drug that leads to smoking, and the availability and marketing of smokeless tobacco may keep smokers from quitting. This study assessed 4-year initiation rates of smokeless tobacco use and cigarette smoking in relation to each other and examined switching between the products. Data were from the 1989 Teenage Attitudes and Practices Survey and its 1993 follow-up study, comprising a nationally representative U.S. cohort of 7,960 people aged 11–19 years at baseline. Analyses were limited to males with complete data on smoking and smokeless tobacco use at both interviews ($n=3,996$). Young males who were not smokers in 1989 but regularly used smokeless tobacco were more than three times as likely as never users to be current smokers 4 years later (23.9% vs. 7.6%), adjusted $OR=3.45$ (95% $CI=1.84-6.47$). In contrast, 2.4% of current smokers and 1.5% of never smokers at baseline became current regular smokeless tobacco users by follow-up. More than 80% of baseline current smokers were still smokers 4 years later, and more than 40% of baseline current regular smokeless tobacco users became smokers either in addition to or in place of smokeless tobacco use. It appears that smokeless tobacco may be a starter product for subsequent smoking among young U.S. males but may have little effect on quitting smoking.

Introduction

Smokeless tobacco products in the United States are classified into two broad categories: Snuff and chewing tobacco. Snuff includes both dry snuff and moist snuff varieties. Chewing tobacco includes loose leaf, plug, and twist varieties. Sales of moist snuff grew by 62% between 1986 and 1999, from 36.1 million pounds (US\$438 million) to 58.5 million pounds (US\$1.6 billion) (Federal Trade Commission, 2001). The growth in sales in moist snuff was paralleled by tobacco industry expenditures for advertising and promotion of these products during this period, which rose from US\$43.3 million in 1986 to US\$147.3 million in 1999 (Federal Trade Commission, 2001). In contrast, sales of chewing tobacco and

dry snuff have been declining in recent years. For example, sales of loose leaf chewing tobacco in the United States declined from 65.7 million pounds in 1986 to 44.5 million pounds in 1999 (Federal Trade Commission, 2001). That pattern followed the trend in advertising and promotional expenditures for loose leaf chewing tobacco, which declined during that period from US\$32.2 million to US\$28.8 million.

Oral use of smokeless tobacco, particularly moist snuff, is capable of delivering rapid, high dosages of nicotine (Benowitz, Porchet, Sheiner, & Jacob, 1988; Fant, Henningfield, Nelson, & Pickworth, 1999a). Levels of nicotine dependence in smokeless tobacco users are often comparable to those seen in smokers (Hatsukami & Severson, 1999).

Several expert panels have concluded that use of smokeless tobacco is a cause of cancer in humans (International Agency for Research on Cancer, 1985; National Institutes of Health, 1986; U.S. Department of Health and Human Services [USDHHS], 1986). This conclusion has been questioned recently, at least concerning Swedish brands of moist snuff, or *snus* (Nilsson, 1998). There have been recent calls for a lifting of the ban on sales of oral snuff products in

Scott L. Tomar, D.M.D., Dr.P.H., University of Florida College of Dentistry, Division of Public Health Services and Research, Gainesville, FL.

Correspondence: Scott L. Tomar, D.M.D., Dr.P.H., University of Florida College of Dentistry, Division of Public Health Services and Research, 1600 SW Archer Road, P. O. Box 100404, Room D8-38, Gainesville, FL 32610, USA. Tel: +1 (352)-846-1860; Fax: +1 (352)-392-2672; E-mail: stomar@dental.ufl.edu

European Union countries (Sweden was exempt when it joined the European Union in 1995) (Nilsson, 1998), and some researchers have attributed Sweden's decline in cigarette smoking to a switch to use of *snus* (Ramstrom, 2000; Schildt, Eriksson, Hardell, & Magnuson, 1998). Other researchers acknowledge that smokeless tobacco is a risk factor for cancers of the oral cavity and pharynx but claim that switching from smoking to use of smokeless tobacco would save thousands of lives because of a reduction in risk for other smoking-associated diseases such as lung cancer and emphysema (Rodu, 1994; Rodu & Cole, 1994). On that basis, the use of smokeless tobacco has been advocated as a method for quitting smoking in both professional and lay publications (Rodu, 1994, 1998). The only evidence supporting the efficacy of smokeless tobacco as a method for quitting smoking comes from one uncontrolled pilot study (Tilashalski, Rodu, & Cole, 1998), the methodology and approach of which have been criticized (Fagerström & Ramstrom, 1998; Fant, Henningfield, & Tomar, 1999b; Jorenby, Fiore, Smith, & Baker, 1998; Pfister, 1999).

The widespread availability of smokeless tobacco products, aggressive marketing of entry-level products by their manufacturers, increased prevalence of clean indoor air policies in the United States, and advocacy by health professionals of switching to smokeless tobacco raises three questions of public health relevance: (a) Does smokeless tobacco act as a gateway drug for nicotine addiction and subsequent smoking? (b) Do young smokers switch to smokeless tobacco and quit smoking? (c) Do young smokers initiate smokeless tobacco use but still keep smoking? The present study examined the empirical evidence in the United States on the use of smokeless tobacco in relation to cigarette smoking in a cohort of young people. The study sought to test the following specific hypotheses: (a) The rate of smoking initiation is higher among males who use smokeless tobacco than among nonusers, (b) the rate of smokeless tobacco initiation is higher among smokers than among non-smokers, and (c) smoking quit rates are no higher for males who begin using smokeless tobacco than for those who do not. To my knowledge, this study is the first longitudinal study to test these hypotheses in a nationally representative cohort of young males.

Method

Subjects

The data for this study were derived from the 1989 Teenage Attitudes and Practices Survey (TAPS-I) and its 1993 follow-up (TAPS-II). These U.S. national surveys were sponsored primarily by the Office on Smoking and Health, Centers for Disease Control and Prevention (CDC), and were conducted by the CDC's

National Center for Health Statistics. The TAPS-I sampling frame consisted of all teenagers aged 12–18 years on November 1, 1989, who resided in households interviewed for the National Health Interview Survey (Massey, Moore, Parsons, & Tadros, 1989) during the last two quarters of 1988 and the first two quarters of 1989 (Moss, Allen, Giovino, & Mills, 1992). The eligible sample for TAPS-I was 12,097 persons. In TAPS-I, interviewers collected data on knowledge, attitudes, and practices regarding tobacco use by using computer-assisted telephone interviews ($n=9,135$; response rate=75%). Persons who could not be contacted by telephone were sent self-administered questionnaires by mail. Of the 9,135 respondents to the 1989 TAPS-I telephone interview, 7,960 (87.1%) participated in TAPS-II. The primary method of data collection in TAPS-II was computer-assisted telephone interviewing; persons who could not be contacted by telephone were contacted in person. The overall response rate for the follow-up was 62% (95% National Health Interview Survey completion rate \times 75% TAPS-I completion rate \times 87% TAPS-II follow-up completion rate). Data were ratio-adjusted for nonresponse by sex, age, and race and weighted to provide U.S. national estimates. Analysis was limited to males because they comprised nearly all users of smokeless tobacco ($n=4,039$). Of these male respondents, 3,996 (98.9%) had complete data on baseline and follow-up status of smokeless tobacco use and cigarette smoking.

Definitions of tobacco use

Survey participants in TAPS-I and TAPS-II were asked whether they had ever tried chewing tobacco or snuff, whether they ever considered themselves regular users of these products, and whether they currently were regular users of smokeless tobacco. Based on responses to these questions, persons were categorized at baseline and follow-up as never having used smokeless tobacco, having used smokeless tobacco but never regularly, having used smokeless tobacco regularly at some time but not currently, or being a current regular user. Because these questions were not asked separately for chewing tobacco and snuff, it was not possible to individually analyze initiation rates for these forms of smokeless tobacco. In addition, a problem with the skip pattern in the computer-assisted telephone interviewing setup resulted in only self-defined regular smokeless tobacco users being asked the number of days on which they used these products out of the preceding 30 days. Therefore, current use was based strictly on the respondents' self-classification as regular users. For that reason, past-month use of smokeless tobacco could not be used as a valid baseline predictor for initiation of smoking, because it would omit past-month smokeless tobacco users who did not perceive themselves as regular users. This

coding problem was corrected in TAPS-II, in which all respondents who reported ever having used smokeless tobacco were asked the number of days on which they used smokeless tobacco out of the preceding 30 days. It was therefore possible to categorize respondents at follow-up based on their past-month smokeless tobacco use, but for purposes of consistency, the same case definition was generally applied at both baseline and follow-up.

In the present study, current smokers were those who reported smoking at least 100 cigarettes in their lifetime and who smoked on at least 1 day in the 30 days preceding the interview, former smokers had smoked at least 100 cigarettes but reported that they did not smoke in the past 30 days, and never smokers had not smoked 100 cigarettes. This case definition is in contrast to the ones used to estimate the prevalence of smoking in most U.S. national surveys of young people, including the Youth Risk Behavior Survey (Kann et al., 2000), the Monitoring the Future Study (Johnston, O'Malley, & Bachman, 2001), the National Youth Tobacco Survey (Office on Smoking and Health, 2000), and the National Household Survey on Drug Abuse (Substance Abuse and Mental Health Services Administration, 2000). Those surveys, with some minor differences in wording, generally defined current smoking as having smoked on at least one of the 30 days preceding the interview, without the qualifier of having smoked at least 100 cigarettes. The definition of smoking used in the present study is consistent with definitions used for adults (CDC, 2000) but may tend to underestimate current smoking in younger age groups because adolescents are frequently in the early stages of smoking behavior (USDHHS, 1994). The more stringent definition was used in the present study specifically to identify more established smokers.

The 4-year smoking initiation rate was defined as the percentage of baseline never-smokers who were current smokers at the follow-up interview. Similarly, the 4-year initiation rate for smokeless tobacco use was defined as the percentage of baseline never-users who reported current use of smokeless tobacco at follow-up. The 4-year smoking quit rate was the percentage of baseline current smokers who were no longer current smokers at follow-up.

Data analysis

The primary analyses in this study included: (a) Estimation of the 4-year smoking initiation rate among young males between baseline and follow-up, by respondents' baseline smokeless tobacco use status, (b) estimation of their 4-year smokeless tobacco initiation rate between baseline and follow-up, by baseline smoking status, and (c) smoking quit rates over the 4-year period, by status of smokeless tobacco use at follow-up. To estimate the initiation rate of

smoking by baseline smokeless tobacco use status, analysis was limited to males who had never smoked at the time of the baseline interview. Similarly, the analysis of smokeless tobacco initiation by baseline smoking status excluded males who had ever used snuff or chewing tobacco before the baseline interview. Estimates of prevalence and initiation rates included 95% confidence intervals (*CI*). Estimates whose 95% *CI*s did not overlap were interpreted as being statistically significantly different from each other, at the 95% level of confidence.

Multiple logistic regression modeling was used to adjust for age and race/ethnicity. An odds ratio (*OR*) estimate was interpreted as significantly different from the reference group, at the 95% level of confidence, if its 95% *CI* excluded 1.0. All analyses of TAPS data were conducted using sampling weights developed by the National Center for Health Statistics. Data management and preliminary analyses were conducted using the SAS statistical software package. Because of the complex survey design, SUDAAN statistical software was used to estimate all standard errors and to conduct multivariable modeling.

Because household income may be a correlate of rates of smoking initiation (USDHHS, 1994) and a possible confounder of the association between smokeless tobacco use and smoking, an attempt was made to adjust for income in estimating initiation rates. However, data on household income were missing for 509 study participants (13%). Adjusting for household income in multivariate modeling did not appreciably change the parameter estimates for smoking or smokeless tobacco use but resulted in many excluded records and larger variances for parameter estimates. Therefore, the *OR* estimates were not adjusted for household income.

Results

Prevalence of tobacco use

At the time of the baseline interview, 9.0% of males met the case definition for current smoking and 1.6% were former smokers (Table 1). At baseline, 6.1% reportedly had been regular users of smokeless tobacco at some time, and 2.7% were current regular users. At the 4-year follow-up interview, 21.2% of male respondents were current smokers, 11.9% had been regular users of smokeless tobacco at some time, and 5.7% were current regular smokeless tobacco users.

Initiation of smoking

Among males who reported at baseline that they had never smoked a cigarette, 9.0% were current smokers at the 4-year follow-up interview (Table 2). Rates of smoking initiation differed significantly by baseline

Table 1. Prevalence of cigarette smoking or smokeless tobacco use at baseline (1989) and follow-up (1993) interviews among males aged 11–19 years^a

Cigarette smoking or smokeless tobacco use status	Baseline		4-year follow-up	
	Percentage	95% <i>CI</i>	Percentage	95% <i>CI</i>
Cigarette smoking				
Current ^b	9.0	8.0–10.0	21.2	19.6–22.7
Former ^c	1.6	1.2–2.0	4.2	3.6–4.8
Never ^d	89.4	88.3–90.5	74.6	72.9–76.4
Smokeless tobacco use				
Used regularly ^e	6.1	5.0–7.1	11.9	10.4–13.4
Current	2.7	2.0–3.4	5.7	4.7–6.8
Former	3.3	2.7–3.9	6.1	5.2–7.1
Used, but never regularly	23.9	22.0–25.8	30.4	28.5–32.3
Never used	70.0	67.7–72.4	57.7	55.1–60.3

^aData derived from the Teenage Attitudes and Practices Surveys (*n*=3,996).
^bSmoked 100 or more cigarettes in their lifetime and smoked on one or more of the 30 days preceding the interview.
^cSmoked 100 or more cigarettes in their lifetime but did not smoke during the 30 days preceding the interview.
^dNever smoked a cigarette or smoked fewer than 100 cigarettes in their lifetime.
^eRespondents were asked if they had ever used chewing tobacco or snuff and if they considered themselves to be regular users now (current regular users) or at some time (former regular users).

Table 2. Four-year rates of initiation of cigarette smoking among males aged 11–19 years at baseline, by baseline smokeless tobacco use status^a

Baseline smokeless tobacco use status	Sample size	Rates of initiation of cigarette smoking	
		Percentage (95% <i>CI</i>)	<i>OR</i> ^b (95% <i>CI</i>)
Used regularly	60	23.9 (13.4–34.3)	3.45 (1.84–6.47)
Used, but never regularly	373	14.8 (11.1–18.6)	2.01 (1.38–2.93)
Never used	2,232	7.6 (6.5–8.7)	1.00 (referent)
Total	2,665	9.0 (7.9–10.1)	–

^aData derived from Teenage Attitudes and Practices Surveys, 1989–1993. Current cigarette smoking defined as smoking 100 or more cigarettes in lifetime and smoking on one or more of the 30 days preceding the interview. Analysis limited to persons who had never smoked at baseline.
^bAdjusted for age and race/ethnicity.

smokeless tobacco use status: 23.9% of males who had ever been regular users of smokeless tobacco and 14.8% of those who used smokeless tobacco but never regularly became smokers, compared with 7.6% of males who had never used smokeless tobacco. After adjusting for age and race/ethnicity, it was found that males who had been regular users of smokeless tobacco were more than three times as likely as those who had never used smokeless tobacco to become smokers, *OR*=3.45 (95% *CI*=1.84–6.47). A

similar pattern was found when current smoking was defined as smoking within the preceding 30 days (data not shown).

Initiation of smokeless tobacco use

Among males who reported at baseline that they had never used smokeless tobacco, 1.5% became current regular users (Table 3). After adjusting for age and race/ethnicity, it was found that current smokers were

Table 3. Four-year rates of initiation of smokeless tobacco use among males aged 11–19 years at baseline, by baseline cigarette smoking status^a

Baseline cigarette smoking status	Sample size	Rates of initiation of smokeless tobacco use			
		Current regular use		Use within preceding 30 days	
		Percentage (95% <i>CI</i>)	<i>OR</i> ^b (95% <i>CI</i>)	Percentage (95% <i>CI</i>)	<i>OR</i> ^b (95% <i>CI</i>)
Current	107	2.4 (.0–6.0)	1.65 (.32–8.52)	5.1 (.4–9.8)	1.45 (.50–4.22)
Former ^c	13	–	–	–	–
Never	2,682	1.5 (1.0–1.9)	1.0 (referent)	3.9 (3.2–4.6)	1.0 (referent)
Total	2,802	1.5 (1.1–1.9)	–	4.0 (3.3–4.7)	–

^aData derived from Teenage Attitudes and Practices Surveys, 1989–1993. Analysis limited to persons who had never used smokeless tobacco at baseline.
^bAdjusted for age and race/ethnicity.
^cThe number of former smokers who had never used chewing tobacco or snuff was too small to allow meaningful analysis.

not significantly different from never smokers in the rate of initiating current regular smokeless tobacco use, $OR=1.65$ (95% $CI=.32-8.52$). A similar pattern was found when current use of smokeless tobacco was defined at follow-up as any use within the preceding 30 days, $OR=1.45$ (95% $CI=.50-4.22$).

Smoking quit rates

Overall, 19.2% of current smokers at baseline were no longer smoking at the 4-year follow-up (Table 4). The 4-year prevalence of smoking cessation did not differ significantly between male smokers who reported at follow-up that they had ever been regular users of smokeless tobacco (20.5%) and those who had never used smokeless tobacco (26.3%). Similarly, no significant difference in the prevalence of smoking cessation was found between respondents who reported using smokeless tobacco within the 30 days preceding the follow-up interview (23.1%) and those who did not (18.6%).

Switching between products

Figure 1 shows the distribution of the study cohort at baseline and follow-up, by current smoking and smokeless tobacco use status. The arrows depict the change in classification between baseline and follow-up. Among males who were regular smokeless tobacco users but were not smokers at baseline, 44.8% were still exclusively using smokeless tobacco at the 4-year follow-up, 25.5% had switched to smoking, 14.3% continued using smokeless tobacco but also became smokers, and 15.2% were no longer using tobacco. In contrast, most males (78.7%) who smoked at baseline but did not use smokeless tobacco were still smokers 4 years later, just .8% switched to smokeless tobacco, 3.6% continued to smoke but became smokeless tobacco users as well, and 16.9% quit using tobacco. The number of males who smoked and regularly used smokeless tobacco at baseline was too small for meaningful analysis ($n=17$) but was included in Figure 1 to show the complete distribution of subjects by tobacco use status.

Discussion

This nationally representative cohort study of adolescent and young adult males found that: (a) Substantial initiation of cigarette smoking occurred during the 4-year period of follow-up, (b) males who were smokeless tobacco users at baseline were significantly more likely than those who had never used these products to become cigarette smokers during the 4-year period, (c) initiation rates for current regular smokeless tobacco use did not differ significantly between those who were current smokers and those who had never smoked at baseline, and (d) the prevalence of smoking cessation did not differ significantly between males who were smokeless tobacco users at follow-up and those who were not.

These findings suggest that use of smokeless tobacco may increase the likelihood of subsequent cigarette smoking among young males. The highest rate of smoking initiation was among regular smokeless tobacco users (Table 2), which was more than three times higher than among males who had never used smokeless tobacco. More than 25% of current regular smokeless tobacco users switched to cigarettes, and an additional 14.3% became smokers in addition to maintaining regular use of smokeless tobacco (Figure 1). Smokeless tobacco may indeed be a gateway drug for cigarette smoking.

In contrast, 4-year initiation rates for regular use of smokeless tobacco did not differ by baseline smoking status, and smoking cessation rates did not differ by smokeless tobacco use status at follow-up (Table 4). Less than 1% of smokers who were not regular smokeless tobacco users at baseline switched completely to regular smokeless tobacco use by the 4-year follow-up and 3.6% of smokers were using smokeless tobacco in addition to cigarettes 4 years later (Figure 1). These patterns suggest that relatively few young male smokers switch completely to smokeless tobacco. Smokeless tobacco may not be widely used as a method for smoking cessation among young males but perhaps serves as a supplementary source of nicotine dosing for some smokers.

Table 4. Prevalence of smoking cessation among baseline smokers at 4-year follow-up, by smokeless tobacco use status^a

Smokeless tobacco use status	Prevalence of smoking cessation	
	Percentage	95% <i>CI</i>
Use at follow-up		
Used regularly	20.5	11.6–29.4
Used, but never regularly	14.2	8.5–20.0
Never used	26.3	17.3–35.4
Use in past 30 days		
Yes	23.1	10.6–35.6
No	18.6	13.4–23.9
Total	19.2	14.3–24.0

^aData derived from Teenage Attitudes and Practices Surveys, 1989–1993.

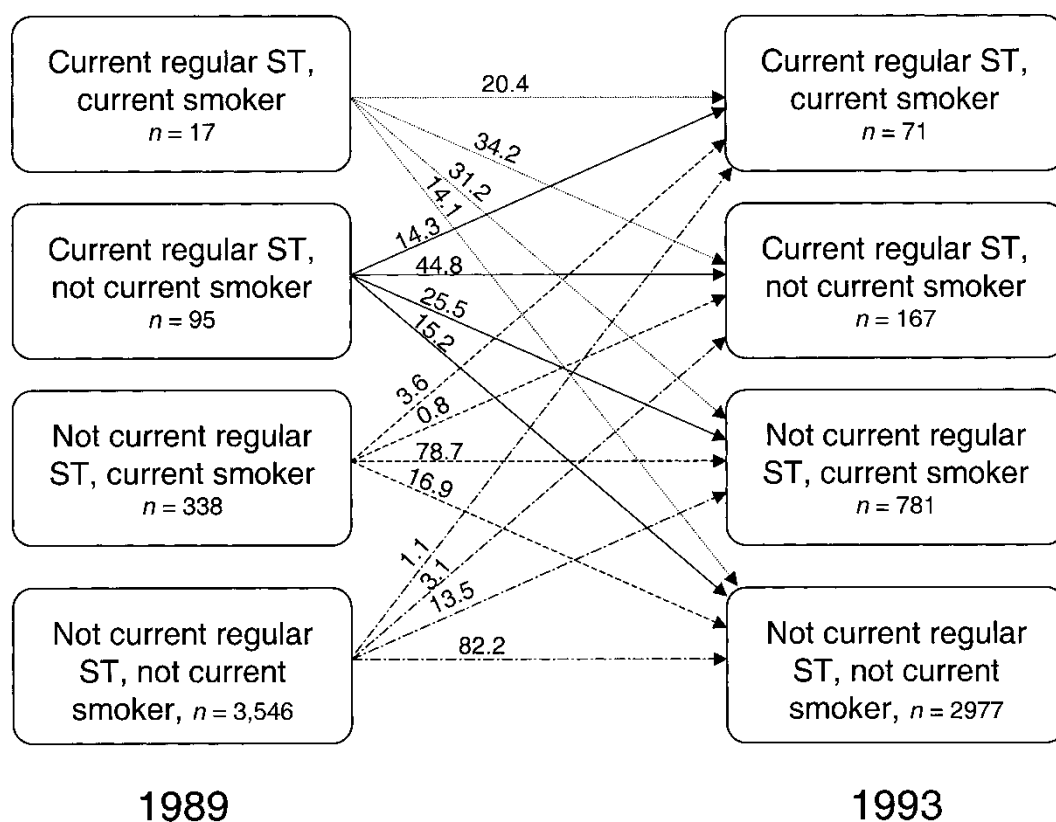


Figure 1. Change in tobacco use status between baseline and follow-up interviews among male respondents aged 11–19 years at baseline. Numbers in boxes are unweighted sample sizes (total $n=3,996$), and numbers next to arrows are weighted percentages. ST, smokeless tobacco.

Findings from this study generally are consistent with other investigations. Many cross-sectional studies reported moderate to strong degrees of association between concurrent smoking and use of smokeless tobacco (Ary, Lichtenstein, & Severson, 1987; Ary, Lichtenstein, Severson, Weissman, & Seeley, 1989; Colborn, Cummings, & Michalek, 1989; Coogan, Geller, & Adams, 2000; Glover, Laflin, & Edwards, 1989; Hatsukami, Jensen, Boyle, Grillo, & Bliss, 1999; Jones & Moberg, 1988; Lee, Raker, & Chisick, 1994; Lichtenstein, Severson, Friedman, & Ary, 1984; Murray, Roche, Goldman, & Whitbeck, 1988; Olds, 1988; Peterson, Marek, & Mann, 1989; Riley, Barenie, & Myers, 1989; Ringel, Pacula, & Wasserman, 2000; Severson, 1990; Sussman et al., 1989). Those studies, however, used a wide range of definitions of tobacco use and often were unable to establish the temporal relationship between initiation of use of each tobacco product. Relatively few reports have been published on longitudinal investigations into the relationship between smoking and smokeless tobacco. Some longitudinal studies found that use of smokeless tobacco was predictive of onset or increased cigarette smoking (Ary et al., 1987, 1989; Dent, Sussman, Johnson, Hansen, & Flay, 1987; Haddock et al., 2001), and some studies reported that smoking was predictive of

initiation of smokeless tobacco experimentation or regular use (Ary, 1989; Ary et al., 1987; Dent et al., 1987; Sussman et al., 1989; Tomar & Giovino, 1998).

It is difficult to directly compare the findings of this study with the results of other longitudinal investigations. First, most of the other studies used school-based samples limited to specific geographic region of the United States (Ary, 1989; Ary et al., 1987; Dent et al., 1987) or were conducted among groups such as military recruits (Haddock et al., 2001), whereas this study used a nationally representative sample of adolescents and young adults. In addition, those studies used different case definitions of tobacco use. For example, Ary et al. (1987) categorized study participants by the number of times they had used smokeless tobacco in the preceding 6 months, Ary (1989) categorized respondents based on daily use, and Dent et al. considered “new users” of smokeless tobacco to be respondents in the 9th grade who reported trying smokeless tobacco but had reported never using it at the baseline survey administered 1 year earlier. In a cohort study of Air Force recruits with a mean age of 19 years at baseline, Haddock et al. considered regular smokeless tobacco use to be use of these products at least once per day; the 1-year outcome measure of smoking was defined as any smoking within the preceding 7 days. Despite the

differences in age range, target population, operational definitions of tobacco use, and length of follow-up, the present study and other longitudinal investigations consistently found that use of smokeless tobacco was a predictor of subsequent smoking. For example, Haddock et al. reported that, among recruits who never had been daily smokers, current smokeless tobacco users were significantly more likely than nonusers to have initiated smoking at the 1-year follow-up, $OR=2.33$ (95% $CI=1.84-2.94$).

The present study did not find that smoking was a significant predictor of current smokeless tobacco use, but in an earlier study of initiation of smokeless tobacco use among this cohort (Tomar & Giovino, 1998) we found that current smokers were more likely than never smokers to become experimenters or regular users at some time during the follow-up period. Other studies reported that smokers were more likely than nonsmokers to become smokeless tobacco users, but, again, the wide range of definitions of tobacco use makes comparisons difficult. Dent et al. (1987) reported the highest probabilities (range .22–.36) for onset of smokeless tobacco use among students in the 8th grade who transitioned from never smoking, trying smoking (smoked one cigarette), or experimenting with smoking (smoked >1 cigarette but currently smoked less than once per month) at baseline to regular smoking (smoked at least once per month) 1 year later. Those findings do not contradict the present study's results, because they consistently suggest that smokeless tobacco may foster progression from early stages of smoking initiation to more established smoking. Dent et al. found that males who were regular smokers at baseline did not have a significant probability of beginning smokeless tobacco use, unless they had quit smoking at follow-up ($p=.05$).

Several possible explanations exist for the association between use of smokeless tobacco and smoking observed in the present study and many others. First, there may be common psychosocial risk factors for experimentation and initiation of using either of these forms of tobacco, such as peer use, normative expectations, risk-taking orientation, and functional utility. Some evidence supports that hypothesis, although other evidence suggests that differences may exist in the psychosocial risk factors for the initiation of each of these products (USDHHS, 1994). If psychosocial factors were the only predictors for initiating use of these products, it might be expected that comparable proportions of smokers and smokeless tobacco users would switch between the products. It was found that a very small proportion of male smokers switched to smokeless tobacco completely, whereas a substantial proportion of smokeless tobacco users switched to cigarettes.

Perhaps one explanation for the longitudinal patterns of switching is the nicotine dosing characteristics of these products and the development of nicotine dependence. It has been well documented that the major manufacturers of smokeless tobacco products have developed a product line and marketing strategy that have been effective in recruiting new users and fostering their development of nicotine addiction (U.S. Food and Drug Administration, 1996). Specifically, the manufacturers can manipulate the nicotine dosing characteristics of their products (Tomar & Henningfield, 1997) and have developed moist snuff products that deliver relatively low levels of nicotine at slow rates of absorption (Djordjevic, Hoffmann, Glynn, & Connolly, 1995; Fant et al., 1999a; Henningfield, Radzius, & Cone, 1995). These products often incorporate flavorings that mask the tobacco taste and may appeal to young, novice users. As users develop greater tolerance to nicotine and progress in their level of addiction, they are likely to "graduate" to brands engineered to deliver much higher levels of nicotine with more rapid rates of absorption (Connolly, 1995; Tomar, Giovino, & Eriksen, 1995). Smokeless tobacco products may also serve as starter products for subsequent cigarette smoking. Although brands of moist snuff with high pH levels can deliver high levels of nicotine (Fant et al., 1999a) and peak levels of nicotine concentration may be comparable for smokers and smokeless tobacco users (Benowitz et al., 1988), cigarette smoking results in a much faster rise in serum nicotine levels (Benowitz et al., 1988). The speed of delivery of nicotine is one factor in its behavioral effects (Henningfield & Heishman, 1998), and smokeless tobacco users may switch to smoking as their degree of tolerance to nicotine develops and the nicotine dependence process progresses.

Although smokeless tobacco manufacturers and some health professionals have promoted smokeless tobacco as a possible supplement or substitute for smoking, the empirical evidence from the present study suggests that few young smokers in the United States switch completely to smokeless tobacco. Among males who were smokers at baseline, those who reported using smokeless tobacco at the follow-up interview were about as likely as nonusers to still be smokers 4 years later. It is not possible to conclude that smokeless tobacco kept these smokers in the cigarette market, but neither is there evidence that these products helped many young smokers to quit.

Several limitations in this study should be considered when interpreting its findings. First, all data on smoking and use of smokeless tobacco were based on self-reports from respondents collected by using an interviewer-administered telephone-based survey. Telephone-based surveys and face-to-face household interviews may compromise respondents' sense of privacy and thus produce lower estimates of current

prevalence of some substance use, including tobacco use, among young people than do household or school-based self-administered questionnaires (Gfroerer & Hughes, 1992; Turner, Lessler, & Devore, 1992). In addition, young people may significantly underreport smokeless tobacco use (Bauman, Koch, Bryan, Haley, Downton, & Orlandi, 1989). The net result of these factors may have been an underestimate of the prevalence or initiation rates of smoking or smokeless tobacco use. Indeed, baseline prevalence estimates for these substances were slightly lower than were estimates from contemporary surveys that used anonymous, self-administered school-based questionnaires (USDHHS, 1994).

Second, the present study used a definition of smokeless tobacco use that relied on respondents' self-characterization of regular use. It is unknown how respondents may have interpreted the term *regular* or how their interpretation may have affected estimates of prevalence or initiation rates.

Third, bias may have been introduced because of the differential response rates between tobacco users and nonusers, which undermines the assumption of random nonresponse with respect to analytic variables. Analysis of the original TAPS-I sample by status of smokeless tobacco use or smoking at the time of the 1989 interview revealed that youths who were successfully followed up in TAPS-II were less likely to have reported using those tobacco products than were those who could not be reinterviewed (CDC, unpublished data). Persons who progressed to current smoking or regular use of smokeless tobacco may have been more likely to be lost to follow-up than those successfully recontacted, which may have led to an underestimation of initiation rates.

In summary, findings from this nationally representative cohort study suggest that smokeless tobacco may have been a starter product for cigarette smoking and that its availability had little effect on smoking quit rates among young U.S. males in the early 1990s. Future studies should investigate the effects of smokeless tobacco use on quitting behavior of adult smokers, particularly in relation to clean indoor air policies.

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