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Concomitant Use of Cigarettes and Smokeless Tobacco: Prevalence, Correlates, and Predictors of Tobacco Cessation[1]

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Background. **This study examined the characteristics, tobacco use patterns over time, and predictors of tobacco cessation among concomitant users of cigarettes and smokeless tobacco.**

Methods. **Participants were employed adults residing in the southeastern United States who participated in the Working Well cancer prevention trial. Participants were assessed at baseline and followed-up 4 years later.**

Results and Conclusions. **The study yielded several key findings: (a) the prevalence of concomitant smoking and smokeless tobacco use was high among males and nonexistent among females, (b) the characteristics of concomitant users were relatively distinct from those of both smokers and smokeless tobacco users, (c) concomitant users exhibited substantial variability in their tobacco use patterns and were less likely to stop using tobacco than were smokers or smokeless tobacco users, (d) indicators of nicotine dependence predicted tobacco cessation for both smokers and smokeless tobacco users, but were largely unrelated to tobacco cessation among concomitant users, and (e) demographics, environmental variables, and measures derived from the transtheoretical model were not consistent predictors of tobacco cessation after controlling for nicotine dependence.**

INTRODUCTION

The two most pervasive forms of regular tobacco use are cigarette smoking and smokeless tobacco (ST) (dip, snuff, chewing tobacco). Recent data from the National Health Interview Survey (NHIS) and the National Household Survey on Drug Abuse (NHSDA) show adult smoking rates in the United States of approximately 25% and ST use rates of approximately 3.5% [*1–3*]. Unfortunately, there are few representative national data on the prevalence of concomitant smoking and ST use (i.e., regular use of both cigarettes and ST), even though concomitant use of two tobacco products may increase the risk of adverse health consequences relative to use of a single tobacco product. Data from the 1991 NHIS supplement indicated that among ST users, 23% currently smoked cigarettes, compared to only 2.6% of current smokers who also used ST [*1*]. Lando and colleagues [*4*] found that the prevalence of concomitant smoking and ST use was 1.3%, ST use was 4.9%, and smoking was 25% among 28,747 Air Force recruits. Among current ST users, 29% smoked, whereas 4.9% of current smokers also used ST [*4*]. Most recently, a small study among Native Americans indicated that 4.8% were concomitant users [*5*]. Much of the other data on concomitant smoking and ST use has come from studies examining only ST users. For example, Riley *et al.* [*6*] found that 37% of ST users currently smoked and studies of ST users seeking treatment reveal rates of concomitant ST and cigarette use of up to 30% [*7*]. Research with adolescents and college students is congruent with the high rate of concomitant smoking among adult ST users [*8–11*].

In sum, approximately 25% or more of current adult ST users also smoke cigarettes, whereas 2.5–5% of current adult smokers use ST. Using data from national surveys such as the NHIS and NHSDA [*1–3*], the population of concomitant users of cigarettes and tobacco is estimated to encompass approximately 0.6–0.8% of the U.S. adult population (e.g., 25% smoking rate × 2.6% ST use rate among smokers; 3.5% ST use rate × 23% smoking rate among ST users). Nevertheless, there is a paucity of data on the correlates, patterns of use over time, and predictors of tobacco cessation in this population. The latter may be particularly

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important as some data suggest that concomitant users may experience more difficulty giving up tobacco than do users of ST only [*12*,*13*].

Correlates of Concomitant Smoking and ST Use

Although representative data on the correlates of concomitant use have not been reported, both smoking and ST prevalence rates tend to be higher among males, younger age groups, Native Americans and Whites, and individuals with lower educational and income levels [*1*,*2*]. Therefore, concomitant use is also likely to be high among these groups. In addition, the prevalence of ST use is higher among residents of rural areas and the southern portions of the United States [*1*], and both cross-sectional and longitudinal data indicate that concomitant use of ST and cigarettes is associated with higher levels of alcohol use [*4*,*14*,*15*]. Thus, heavy alcohol users and individuals from rural areas and the South are also likely to have elevated rates of concomitant smoking and ST use.

Natural History and Predictors of Tobacco Cessation among Concomitant Users

As with the correlates of concomitant use, representative data on the natural history and predictors of tobacco cessation among concomitant users have not been reported. A voluminous literature on smoking cessation has identified a broad spectrum of factors that predict cessation. Consistent predictors of successful smoking cessation include higher levels of motivation, readiness to change, self-efficacy, and supportive social networks; and lower levels of nicotine dependence, stress, and psychiatric comorbidity (see [*16*,*17*]). Factors associated with successful quitting among ST users include lower nicotine dependence [*18*,*19*] and older age [*18*,*20*,*21*]. Smokers and ST users appear similar on a number of key constructs associated with cessation. They report essentially equivalent levels of nicotine exposure, nicotine dependence, craving, and difficulty in stopping tobacco use (see [*12*,*22*]). Recent evidence also suggests that ST users and smokers may experience similar levels of withdrawal severity upon quitting [*23*], and like smokers, the majority of ST users want to quit but are generally unsuccessful in their attempts to do so [*12*]. Therefore, many of the factors identified as predictors of cessation for smoking and ST use (e.g., nicotine dependence, stage of change, confidence in quitting) are hypothesized to predict tobacco cessation among concomitant users.

Study Goals

The goals of the current study were to examine (a) the prevalence of concomitant smoking and ST use in a sample of employed adults, (b) correlates of concomitant use, (c) tobacco use and cessation patterns over time among concomitant users, and (d) prospective predictors of tobacco cessation. Variables examined as correlates of concomitant use and predictors of tobacco cessation included demographics (age, ethnicity, marital status, education), workplace smoking policy, alcohol use, nicotine dependence and other smoking related constructs (e.g., cigarettes/day, ST uses/day, nicotine exposure, time to first cigarette, confidence in quitting, quit attempts), and transtheoretical model constructs (stage of change, processes of change, decisional balance). To the best of our knowledge, this is the first study to prospectively examine the natural history and predictors of tobacco use and cessation among adult concomitant users of cigarettes and ST in a community-based, nonclinical sample.

METHODS

Participants and Procedures

Four study centers, a coordinating center, the National Cancer Institute, and 114 worksites participated in the Working Well Trial—a large cancer prevention study designed to test the effectiveness of worksite health promotion interventions in reducing cancer risk behavior. Details of the study design [*24*] and outcomes have been reported elsewhere [*25*]. In brief, the trial used a randomized, matched-pair design in which worksites were stratified, matched into pairs, and randomly assigned within pairs to an intervention or control condition. Each study center targeted smoking, diet, and one additional cancer risk behavior. One study center, The University of Texas M.D. Anderson Cancer Center, addressed ST use in addition to smoking and diet. The M.D. Anderson sample included 40 predominantly blue-collar worksites and the current analyses are based on data from those worksites. Baseline data were collected in the fall of 1990 and again 4 years later. Permanent employees who worked at least 50% of the full-time work week were eligible for the baseline survey. Employees had to have worked with the company for at least 6 months to be eligible for the final survey.

Measures

Baseline tobacco use status. Current cigarette smokers were defined as individuals who had smoked at least 100 cigarettes in their lifetime, had smoked in the past 7 days, and reported no current use of ST. ST users reported current use of chewing tobacco, dip, or snuff, and no current smoking. Concomitant users had smoked at least 100 cigarettes in their lifetime, had smoked in the past 7 days, and reported current use of chewing tobacco, dip, or snuff. Former smokers reported smoking at least 100 cigarettes in their lifetime, no smoking in the past 7 days, and no current use of ST. Non-users reported smoking less than 100 ciga-

rettes in their lifetime, no smoking in the past 7 days, and no current use of ST. Data on former ST use were not collected.

Demographics. Demographic variables included sex, age, marital status, ethnicity, education, and alcohol use. Alcohol use was calculated as the average number of drinks/month.

Environmental influences. Environmental variables consisted of whether others in the household smoked and worksite smoking policy (smoking not allowed anywhere; allowed in a few smoking areas; allowed everywhere except a few non-smoking areas; or, no policy).

Tobacco consumption. Measures of tobacco consumption included the number of cigarettes smoked per day and the number of ST uses per day. In order to compare tobacco user groups on daily nicotine consumption, a nicotine exposure variable was computed for each participant. Because pharmacokinetic studies indicate that each ST use produces an absorbed dose of nicotine approximately double that of a cigarette [*26*], nicotine exposure is reported in "cigarette equivalents" and is defined as the number of cigarettes smoked per day plus two times the number of ST uses per day.

Smoking-related measures. Smoking-related items included minutes to the first cigarette of the day, number of quit attempts in the past year, confidence in quitting in the next 6 months, the contemplation ladder, stage of change, processes of change, and decisional balance. The contemplation ladder [*27*] ranges from 0 to 10 with 0 being "no thought of quitting" and 10 being "taking action to quit (e.g., cutting down, enrolling in a program)." Standard definitions of stage of change were used [*28*]. Precontemplators were not seriously thinking about quitting smoking in the next 6 months. Contemplators were defined as either (a) seriously thinking about quitting in the next 6 months but not in the next 30 days or (b) seriously thinking about quitting in the next 30 days but had not made a 24-h quit attempt in the past year. Preparers were seriously thinking about quitting in the next 30 days and had made at least one quit attempt in the past year. The short-form of the Processes of Change Inventory [*29*] is a 12-item measure that assesses four behavioral processes of change (counterconditioning, reinforcement management, self-liberation, and stimulus control) and two experiential (consciousness raising and self-reevaluation). Mean behavioral and experiential scale scores were computed. The six-item short-form of the Decisional Balance Inventory [*29*] contains three items each for the pros and cons of smoking.

ST-related measures. ST-related measures included the number of quit attempts in the past year, confidence in quitting in the next 6 months, and stage of change. Stage of change for ST use was defined using criteria identical to those used for smoking.

Abstinence status at follow-up. At the final survey, all baseline tobacco users were classified as a smoker, ST user, concomitant user, former smoker, or non-user using criteria identical to those used in the baseline survey. For identifying predictors of tobacco cessation, a dichotomous outcome variable of tobacco abstinence was created. Non-users and former smokers were classified as abstinent from tobacco whereas smokers, ST users, and concomitant users were classified as nonabstinent.

Data Analyses

Baseline comparisons. Baseline analyses focused on overall differences among tobacco use groups (i.e., non-users, former smokers, smokers, ST users, concomitant users) as well as comparisons of concomitant users to cigarette smokers and ST users. Analyses of variance and *t* tests were used for continuous variables, and chi-square tests for categorical variables.

Bivariate longitudinal analyses. Regression models using Generalized Estimating Equations (GEE; [*30*]) were used to evaluate the main effect of each predictor variable on tobacco cessation at the final survey as well as the interaction of that predictor variable with baseline tobacco use group. All analyses controlled for treatment group. Because a number of variables were not relevant and not measured for all tobacco use groups (e.g., smoking-related variables were not measured among ST users; ST-related variables were not measured among smokers), baseline ST users and concomitant users were evaluated in one set of analyses and baseline smokers and concomitant users were evaluated in another set of analyses. Therefore, tobacco use group was defined as a dichotomous measure comparing either ST users to concomitant users, or smokers to concomitant users. Because worksites rather than individuals were the unit of randomization, measures from individuals within worksites were not independent and were expected to be correlated. These correlations can inflate Type I error rates. In GEE, the standard errors of the regression coefficients are adjusted for the observed within cluster correlations and these adjusted standard error estimates were used to construct "robust" *z* statistics to test whether the regression coefficients were significantly different from zero.

Multivariate longitudinal analyses. The multivariate analyses of tobacco cessation also used GEE and followed the model-building procedures of Hosmer and Lemeshow [*31*]. Like the bivariate analyses, a model was constructed for ST users and concomitant users, and another model was constructed for smokers and

TABLE 1

Male Participant Characteristics by Baseline Tobacco Use Status: Cross-sectional Sample (N = 4,886)

	Non-users (N = 1,621)	Former smokers (N = 1,250)	Smokeless tobacco (ST) users (N = 859)	Smokers (N = 936)	Concomitant ST/cigarette users (N = 220)
Age	37.1 (9.6)	43.7 (10.0)	35.8 (9.8)	39.7 (9.4)	35.7 (9.2)
Marital status (% married)	82.5	91.0	82.8	82.6	79.1
Ethnicity (% White)	83.8	89.4	92.4	83.6	92.2
Education (% > high school)	64.0	58.3	51.0	55.5	43.6
Drinks/month	13.9 (36.0)	16.3 (35.0)	25.3 (50.2)	35.3 (64.7)	38.4 (71.7)
Others in household smoke (%)	9.2	16.3	19.8	43.2	50.5
Worksite smoking policy (%)					
Not allowed anywhere	6.2	7.1	3.9	3.8	2.0
Allowed in a few smoking areas	44.5	45.9	45.1	49.7	46.8
Allowed everywhere except a few non-smoking areas	22.8	25.0	31.0	33.4	29.8
No policy	26.5	22.0	20.0	13.2	21.5

Note. Differences between tobacco use categories were significant at $P < 0.001$ for all variables.

concomitant users. Predictor variables whose bivariate test yielded a P value <0.25 were included in an initial model. The variable with the highest P value was then removed from the model. After the removal of the variable, the estimated coefficients (and standard errors) for the remaining variables in the model were examined to determine if the excluded variable provided important adjustment for any of the retained variables. This process was repeated until only those variables with P values <0.10 were retained. After deriving the best fitting main effects model, interactions with bivariate P values <0.10 were examined. Interactions were tested by adding each interaction term individually to the best fitting multivariate main effects model. If the interaction included a variable that was not retained in the final main effects model (e.g., marital status), it was added to the model prior to testing the interaction. The final model contained only those interactions with P values <0.05. Treatment group was included as a control variable in all multivariate models, although it was never statistically significant.

RESULTS

Participants

Baseline. Adequate data were available to classify 6,280 of the 6,867 baseline participants (92%) into tobacco use categories. Of these baseline respondents, 232 (4%) were concomitant users of cigarettes and ST, 1,227 (20%) were smokers only, 891 (14%) were ST users only, 1,505 (24%) were former smokers, and 2,425 (39%) were non-users. The sample was primarily male (80%). Among the women (n = 1,239), there were no concomitant users, 259 (21%) were smokers only, 12 (1%) were ST users only, 225 (18%) were former smokers, and 743 (60%) were non-users. Because of the exceedingly small number of women who were concomitant or ST users, all analyses focused exclusively on the male participants.

Table 1 displays baseline characteristics by tobacco use status for all male participants. As shown, concomitant users of cigarettes and ST were more likely to be younger, unmarried, White, and have lower education levels compared to the other tobacco use groups, although they were very similar to ST users with respect to age and ethnicity. Concomitant users drank more alcohol and were more likely to live with a smoker. The worksite smoking policies of smokers, ST users, and concomitant users were generally similar, although worksites of concomitant users were less likely to completely prohibit smoking (not allowed anywhere) than were worksites of smokers and ST users, and were more likely to have no policy on smoking than were worksites of smokers. Compared to non-users and former smokers, worksites of concomitant users were less likely to completely prohibit smoking and more likely to allow smoking everywhere except a few non-smoking areas.

Cohort. Of the 2,015 male ST users, smokers, and concomitant users at baseline (Table 1), 1,244 (62%) were still employed at their baseline worksite 4 years later and completed the final survey. These individuals formed the cohort used in the longitudinal analyses of tobacco cessation. Baseline male tobacco users who were lost to follow-up did not differ from the longitudinal cohort on age, marital status, education, drinks/month, other household smokers, or worksite smoking policy. However, only 52% of the baseline male concomitant users were successfully followed-up and included in the cohort versus 60% of smokers and 66% of ST users. In addition, 63% of Whites versus only 51% of non-Whites were included in the cohort ($P < 0.001$).

Baseline characteristics of the cohort by tobacco use status are shown in Table 2. To facilitate identifying the specific characteristics of concomitant users, they were compared to smokers and ST users separately. Compared to ST users, concomitant users were signif-

TABLE 2

Characteristics of the Male Tobacco Use Cohort by Baseline Tobacco Use Category (N = 1,244)

	Smokeless tobacco (ST) users (N = 567)	Smokers (N = 562)	Concomitant users (N = 115)	P value (ST users vs concomitant users)	P value (smokers vs concomitant users)
Demographics					
Age	35.9 (9.1)	39.5 (9.0)	35.5 (8.6)	0.74	<0.001
Marital status (% married)	83.8	84.9	75.7	0.04	0.02
Ethnicity (% White)	93.5	86.8	91.3	0.39	0.19
Education (% > high school)	52.5	55.0	44.3	0.11	0.04
Drinks/month	23.2 (46.4)	35.5 (64.8)	34.8 (74.2)	0.03	0.92
Environmental variables					
Others in household smoke (%)	18.7	43.9	51.3	<0.001	0.14
Worksite smoking policy (%)				0.33	0.04
Not allowed anywhere	4.4	3.7	0.9		
Allowed in a few smoking areas	44.3	47.4	45.3		
Allowed everywhere except a few non-smoking areas	30.4	34.3	29.2		
No policy	20.9	14.6	24.5		
Tobacco consumption					
Number of cigarettes/day		24.6 (13.8)	19.5 (14.5)		<0.001
Number of ST uses/day	7.6 (5.8)		5.0 (4.5)	<0.001	
Estimated nicotine exposure	15.6 (13.9)	24.6 (13.8)	29.2 (17.0)	<0.001	0.002
Smoking-related variables					
Minutes to first cigarette		59.1 (97.9)	82.7 (141.3)		0.03
Number of quit attempts in past year		1.8 (4.4)	3.8 (6.1)		<0.001
Confidence in quitting		2.5 (1.3)	2.6 (1.3)		0.39
Contemplation ladder		6.0 (2.7)	6.2 (2.7)		0.36
Stage of change (%)					0.07
Precontemplation		42.1	33.7		
Contemplation		35.7	33.7		
Preparation		22.2	32.7		
Processes of change					
Behavioral		2.1 (0.6)	2.2 (0.6)		0.26
Experiential		2.4 (0.9)	2.3 (0.8)		0.63
Decisional balance					
Pros of smoking		2.4 (1.0)	2.2 (1.0)		0.16
Cons of smoking		2.7 (0.9)	2.6 (1.0)		0.04
Smokeless tobacco-related variables					
Number of quit attempts in past year	1.3 (3.0)		1.2 (2.5)	0.80	
Confidence in quitting	2.7 (1.4)		2.9 (1.5)	0.40	
Stage of change (%)				0.06	
Precontemplation	55.1		61.3		
Contemplation	15.2		20.4		
Preparation	29.7		18.3		

Note. t tests were used for continuous variables and chi-square tests were used for categorical variables.

icantly less likely to be married, drank more alcohol, were more likely to live with a smoker, and had fewer ST uses per day but higher estimated nicotine exposure. Concomitant users appeared somewhat less ready to change their ST use than did ST users, but stage of change for ST use only approached significance (P = 0.06).

Compared to smokers, concomitant users were significantly younger, less likely to be married, had a lower educational level, smoked fewer cigarettes per day but had higher estimated nicotine exposure, waited longer to smoke their first cigarette of the day, made more smoking quit attempts in the past year, and indicated lower cons of smoking. Worksites of concomitant users were less likely to completely prohibit smoking and more likely to have no policy on smoking than were worksites of smokers. Although concomitant users appeared to be more ready to change their smoking behavior than did smokers, differences on stage of change for smoking only approached significance (P = 0.07).

Longitudinal Prediction of Tobacco Cessation

There were significant differences among baseline tobacco use groups on tobacco abstinence at follow-up among the cohort ($\chi^2(2) = 7.0$, $P = 0.03$). ST users were most likely, and concomitant users least likely, to quit using tobacco between the baseline and the final surveys (Table 3). Moreover, the vast majority of base-

TABLE 3

Baseline Tobacco Use Category by Follow-up Tobacco Use Status

Baseline tobacco use group	Abstinent from tobacco at follow-up (%)	Continuing tobacco user at follow-up		
		Smokeless tobacco user (%)	Smoker (%)	Concomitant user (%)
Smokeless tobacco user	20.1	76.6	0.9	2.5
Smoker	15.7	1.4	79.7	3.2
Concomitant user	11.3	17.4	27.0	44.3

Note. The analysis compared baseline tobacco use groups on tobacco abstinence at follow-up (abstinent or nonabstinent). $\chi^2(2) = 7.0$, $P = 0.03$.

line smokers and ST users (77–80%) remained exclusive users of either ST or cigarettes. Only about 3% became concomitant users and only about 1% switched tobacco products (i.e., ST to cigarettes or cigarettes to ST). However, concomitant users exhibited substantial shifting among tobacco use categories. In addition to being the least likely to quit using tobacco, less than half (44%) of the baseline concomitant users were still using both ST and cigarettes 4 years later, while 17% had switched exclusively to ST and 27% had switched exclusively to cigarettes.

Bivariate analyses. Table 4 displays the results of the GEE analyses evaluating the main effect of each predictor variable as well as its interaction with tobacco use group in predicting tobacco cessation at the final survey. All analyses controlled for treatment group. Concomitant users were compared to smokers and ST users separately.

Predicting cessation among smokers and concomitant users. In comparing smokers to concomitant users, the main effect of tobacco use group on cessation was nonsignificant (Table 4). Significant main effects (with no interaction of the predictor variable and tobacco use group) were found for number of quit attempts in the past year, confidence in quitting, contemplation ladder, and the pros of smoking. Tobacco cessation was associated with a greater number of prior quit attempts, more confidence in quitting, higher scores on the contemplation ladder, and lower scores on the pros of smoking.

Interactions between tobacco use group (smokers versus concomitant users) and predictor variables were found for cigarettes per day, estimated nicotine exposure, and minutes to first cigarette. For the significant interactions, the relation between the predictor variable and abstinence was calculated for smokers and concomitant users separately. For smokers, abstinence was significantly associated with fewer cigarettes per day (OR = 0.95; $P < 0.0001$), lower estimated nicotine exposure (OR = 0.95; $P < 0.0001$), and waiting longer to smoke the first cigarette of the day (OR = 1.00; $P = 0.007$), whereas none of the predictors were significantly related to cessation among concomitant users (all P values >0.10).

Predicting cessation among ST users and concomitant users. Among ST and concomitant users, the main effect of tobacco use group was significant in predicting tobacco cessation (Table 4). ST users were more likely to quit using tobacco than were concomitant users. A significant main effect was found for ST stage of change. Precontemplators appeared to be less likely to quit using tobacco than preparers, although this finding only approached significance.

Significant interactions were found between tobacco use status and marital status, ST uses per day, and estimated nicotine exposure. Cessation was associated with fewer ST uses per day among ST users (OR = 0.96; $P < 0.02$) and more ST uses per day among concomitant users (OR = 1.15; $P < 0.02$). Lower estimated nicotine exposure (OR = 0.98; $P < 0.02$) was related to cessation among ST users and unrelated to cessation among concomitant users (OR = 1.02; $P = 0.14$). Although marital status was not significantly related to cessation among either ST or concomitant users, being married tended to be positively related to abstinence among ST users (OR = 1.50; $P = 0.11$) and negatively related to abstinence among concomitant users (OR = 0.50; $P = 0.16$).

Multivariate analyses. When predicting tobacco cessation for smokers versus concomitant users, cigarettes/day and estimated nicotine exposure were highly correlated and estimates were unstable when both variables were included in the model. Similarly, ST uses/day and estimated nicotine exposure were highly correlated and yielded unstable estimates when both variables were included in the model predicting tobacco cessation among ST users and concomitant users. Because cigarettes/day and ST uses/day were more strongly related to outcome and appeared more stable in the multivariate models than did nicotine exposure, nicotine exposure was dropped from the multivariate models for all comparisons. As noted previously, variables considered for inclusion in the multivariate models were those bivariate predictors with $P < 0.25$ and interactions with $P < 0.10$.

Predicting tobacco cessation for smokers versus concomitant users. The best fitting multivariate main effects model included two variables in addition to baseline tobacco use category. Cigarettes/day was significantly related to cessation (OR = 0.96, $P = 0.001$) and drinks/month approached significance (OR = 0.996, $P = 0.07$). Increases in cigarettes/day and drinks/month were associated with a decreased likeli-

TABLE 4

Longitudinal Prediction of Tobacco Cessation: Bivariate Analyses

	Smokers vs concomitant users			ST users vs concomitant users		
	OR	*P*	*P* for interaction with tobacco use group	OR	*P*	*P* for interaction with tobacco use group
Tobacco use group (i.e., smokers or smokeless tobacco (ST) users vs concomitant users (reference):	1.48	0.17	Not applicable	1.94	0.04	Not applicable
Demographics						
Age	1.00	0.86	0.45	1.02	0.19	0.86
Marital status (% married)	1.05	0.88	0.09	1.23	0.40	0.01
Ethnicity (% White)	0.88	0.71	0.48	0.72	0.35	0.67
Education (% > high school)	1.28	0.28	0.69	1.20	0.33	0.96
Drinks/month	1.00	0.11	0.35	1.00	0.48	0.27
Environmental variables						
Others in household smoke (%)	0.78	0.26	0.66	1.25	0.31	0.11
Worksite smoking policy (%)	Overall $P = 0.96$		0.79	Overall $P = 0.18$		0.85
Not allowed anywhere	1.18	0.79		2.20	0.07	
Allowed in a few smoking areas	0.93	0.79		1.78	0.04	
Allowed everywhere except a few non-smoking areas	1.02	0.94		1.42	0.35	
No policy	Reference group			Reference group		
Tobacco consumption						
Number of cigarettes/day	0.96	0.0001	0.02			
Number of ST uses/day				0.97	0.16	0.02
Estimated nicotine exposure	0.97	0.004	0.0004	0.99	0.13	0.02
Smoking-related variables						
Minutes to first cigarette	1.00	0.03	0.03			
Number of quit attempts in past year	1.05	0.03	0.80			
Confidence in quitting	1.33	0.0001	0.58			
Contemplation ladder	1.09	0.02	0.16			
Stage of change (%)	Overall $P = 0.07$		0.79			
Precontemplation	0.54	0.05				
Contemplation	0.92	0.80				
Preparation	Reference group					
Processes of change						
Behavioral	1.27	0.13	0.24			
Experiential	1.02	0.86	0.58			
Decisional balance						
Pros of smoking	0.82	0.05	0.33			
Cons of smoking	1.23	0.08	0.36			
Smokeless tobacco-related variables						
Number of quit attempts in past year				1.02	0.56	0.31
Confidence in quitting				1.04	0.51	0.95
Stage of change (%)				Overall $P = 0.05$		0.21
Precontemplation				0.60	0.07	
Contemplation				1.08	0.82	
Preparation				Reference group		

hood of tobacco cessation. After controlling for cigarettes/day and drinks/month, baseline tobacco use category (smoker vs concomitant user) was strongly related to tobacco cessation (OR = 2.43, $P = 0.01$). Smokers were more likely to quit using tobacco between the baseline and the final surveys than were concomitant users.

Based on the results of the bivariate analyses, three interaction terms were considered for inclusion in the multivariate model: marital status × tobacco use group, cigarettes/day × tobacco use group, and minutes to first cigarette × tobacco use group. Only the interaction of cigarettes/day × tobacco use group was significant ($P = 0.009$) and included in the final model. Cigarettes/day was a predictor of abstinence for smokers (OR = 0.95, $P < 0.001$) but not for concomitant users (OR = 1.0, $P = 0.92$). For smokers, fewer cigarettes/day was associated with a greater likelihood of cessation.

Predicting tobacco cessation for ST users versus concomitant users. The best fitting multivariate main effects model for ST and concomitant users included two variables in addition to baseline tobacco use category. Baseline tobacco use category (ST users versus concomitant users) was not significantly related to ces-

sation (OR = 1.77, $P = 0.16$). ST uses/day was significantly related to abstinence (OR = 0.95, $P = 0.04$) as was ST stage of change ($P = 0.02$). With preparers serving as the reference category, the comparison of precontemplators to preparers approached significance with precontemplators less likely to successfully quit using tobacco (OR = 0.57, $P = 0.06$). The comparison of contemplators to preparers was not significant (OR = 1.22, $P = 0.56$).

Both interactions evaluated for inclusion in the multivariate model were significant and included in the final model. The marital status × tobacco use group interaction ($P = 0.04$) indicated that while being married was not significantly associated with cessation among either ST users or dual users, the direction of the relationship was positive among ST users (OR = 1.56, $P = 0.22$) and negative among concomitant users (OR = 0.57, $P = 0.45$). The ST uses/day × tobacco use group interaction ($P = 0.01$) indicated that a greater number of ST uses/day was inversely associated with cessation among ST users (OR = 0.94, $P = 0.01$) and positively associated with cessation among concomitant users (OR = 1.15, $P = 0.03$).

DISCUSSION

This study is one of the first to prospectively examine the characteristics, tobacco use patterns, and predictors of tobacco cessation among concomitant users of cigarettes and ST using a nonclinical sample. Participants were employed adults residing in the southeastern United States who participated in the Working Well cancer prevention trial. The study yielded several key findings: (a) the prevalence of concomitant smoking and ST use was high among males (i.e., 5%) and nonexistent among females; (b) the characteristics of concomitant users were relatively distinct from those of both smokers and ST users; (c) concomitant users exhibited substantial variability in their tobacco use patterns and were less likely to stop using tobacco from baseline to follow-up than were smokers or ST users; (d) indicators of nicotine dependence predicted tobacco cessation for both smokers and ST users, but were largely unrelated to tobacco cessation among concomitant users; and (e) demographics, environmental variables, and measures derived from the transtheoretical model [*32*] were not consistent predictors of tobacco cessation after controlling for nicotine dependence.

Prevalence and Characteristics of Concomitant Users

Data from national surveys suggest that the prevalence of concomitant smoking and ST use is about 0.6–0.8% of the U.S. adult population [*1–3*]. Among females who participated at the M.D. Anderson site of the Working Well Trial, there were no concomitant users and only a handful of ST users, whereas the prevalence of concomitant use was exceedingly high (5%) among males. These employed male adults residing in the Southeast displayed unique characteristics compared to smokers and ST users. They were less likely to be married and had higher estimated nicotine exposure than either smokers or ST users. Concomitant users, in general, did not appear to be more similar to ST users than smokers or vice versa. That is, concomitant users differed from smokers on a number of variables (concomitant users were younger, less educated, less likely to work where smoking was prohibited) where they did not differ from ST users. Similarly, concomitant users differed from ST users on a number of characteristics (concomitant users drank substantially more alcohol, were more likely to live with a smoker) where they did not differ from smokers. Thus, concomitant users appear to be a relatively unique group of tobacco users.

Concomitant use did not appear to be a function of smokers who began using ST in response to environmental constraints on smoking. The worksite smoking policies of concomitant users were less likely to completely prohibit smoking and more likely to have no policy on smoking than were worksites of smokers. Furthermore, there was no significant difference between concomitant users and smokers with respect to the likelihood that there were other smokers in the household, and neither worksite smoking policy or other household smokers were significant predictors of tobacco cessation. Thus, concomitant use might reflect greater environmental opportunity to engage in any tobacco use rather than a response to constraints on smoking that can be overcome by using ST during those times when smoking is restricted.

Tobacco Use Patterns

Concomitant users were significantly less likely to quit using tobacco over the course of 4 years than were users of cigarettes or ST (11% tobacco cessation for concomitant users versus 16% for smokers, and 20% for ST users). Bivariate analyses showed concomitant users to be less likely to cease tobacco use than ST users and multivariate analyses indicated that concomitant users were less likely to achieve tobacco cessation than were smokers. Moreover, the tobacco use patterns of concomitant users exhibited considerable variability over time. Less than half (44%) of the baseline concomitant users were still concomitant users 4 years later, while 17% had switched exclusively to ST and 27% had switched exclusively to cigarettes. In contrast, among baseline users of single tobacco products (i.e., ST or cigarettes), only about 3% became concomitant users and only about 1% switched tobacco products (i.e., ST to cigarettes or cigarettes to ST). The vast majority of ST users and smokers (77–80%) remained exclusive users of either ST or cigarettes.

Previous research with clinical samples suggested that some smokers may switch to ST use as a method for quitting smoking. Our findings show that about 4.5% of baseline smokers either begin using ST exclusively or in combination with smoking during the course of the study, and these individuals may reflect smokers who tried to quit by using ST. However, 3.4% of baseline ST users began to smoke either exclusively or in combination with ST use during the same time period. Given these similar rates of uptake of the other tobacco product from baseline to follow-up, it is unclear whether a similar phenomenon might be occurring among ST users, or whether uptake of another tobacco product has any relation to attempts to quit using one's primary tobacco product.

Predictors of Tobacco Cessation

An interesting finding with respect to predictors of tobacco cessation was that traditional indicators of nicotine dependence, whether based on use of a single tobacco product or on use of both cigarettes and ST, were not related to tobacco cessation among concomitant users in expected ways. For example, indicators of nicotine dependence that predicted cessation among smokers (e.g., cigarettes/day, time to first cigarette) did not predict cessation among concomitant users. Similarly, while fewer ST uses/day was associated with cessation among ST users, the direction of the relation between ST uses/day and cessation was opposite to the expected direction for concomitant users (i.e., greater ST uses/day was related to cessation). This latter finding is not attributable to a potentially inverse relation between cigarette and ST consumption among concomitant users such that greater ST use is associated with lower cigarette consumption (i.e., there was no relation between ST uses per day and cigarettes per day; $r = -0.01$). One possibility is that these nicotine dependence measures do not predict well among concomitant users because they are based on single tobacco products and, therefore, do not adequately capture total tobacco consumption. However, a total estimated nicotine exposure variable based on both cigarette and ST use predicted cessation for both smokers and ST users, but was unrelated to cessation among concomitant users.

With respect to other predictors of tobacco cessation, few variables possessed much predictive power once the tobacco consumption variables were entered in the multivariate models. For example, of the several variables derived from the transtheoretical model, none were significant in the multivariate analysis of smokers and concomitant users, and only ST stage of change remained significant in the analysis of ST users and concomitant users. It may be the case that transtheoretical model variables do not predict well for concomitant users because they address only one tobacco product (although this would not account for a lack of predictive ability among smokers and ST users). Therefore, we conducted post hoc analyses of the smoking and ST stage of change variables, which indicated that among concomitant users in the preparation stage for smoking, only 26% were in the preparation stage for ST. Among concomitant users in the preparation stage for ST, only 46% were in the preparation stage for smoking. Because our analyses focused on cessation of all tobacco use, the predictive ability of transtheoretical measures may indeed have been hampered by their focus on single tobacco products. Nevertheless, the variables associated with nicotine dependence were stronger predictors than the transtheoretical model variables and the general inability of the transtheoretical model variables to predict tobacco cessation after controlling for addiction related variables is consistent with other recent findings [*33*,*34*]. Of the demographic and environmental variables examined, only marital status appeared to have any influence once the models controlled for tobacco consumption. Being married tended to be positively related to abstinence among ST users and negatively related to abstinence among concomitant users, although these relations were not statistically significant.

Future research should attempt to disentangle the precise roles that nicotine dependence and motivation play in concomitant smoking and ST use. Doing so will likely require the development of new measures or algorithms for quantifying these key constructs when tobacco use consists of multiple products rather than a single product. It may also be important to identify the form of tobacco that concomitant users consider to be their primary tobacco product.

Study Limitations

There are several limitations to the current study. One is that more concomitant users than smokers or ST users were lost to follow-up. It is frequently assumed that individuals lost to follow-up tend to be heavier users. If this were true, it is likely that the differences between concomitant users and users of single tobacco products were attenuated. Although it might be expected that individuals lost to follow-up would be characterized by greater instability as manifest by younger age, lower marriage rates, lower education, greater alcohol use, etc., compared to those individuals who were successfully followed-up, that was not the case. The only other difference between the cohort and those individuals lost to follow-up was that Whites were more likely to be included in the cohort than non-Whites. Because non-Whites made up only a small proportion of baseline concomitant users, the results would have been largely generalizable to Whites only regardless of the differential follow-up rates. Given that the vast majority of ST users are

White in national surveys [*1*], Whites do appear to be at highest risk for concomitant use and our results should be generalizable to that population, but not to minority populations.

Another limitation is that we were constrained by the study design of the Working Well Trial, which was not designed to focus on concomitant use and did not include a number of relevant measures. For example, data were not collected on time to first tobacco use rather than simply time to first cigarette, former use of ST, time frames for current use of ST, and processes and decisional balance scales for ST use. In addition, the lack of frequent assessments limits our ability to examine the frequency of movement among tobacco products. Because there was little movement among the smokers and ST users over the course of 4 years, it is more likely that our results adequately capture the phenomenon of interest for these individuals. However, the substantial shifting among tobacco products for the concomitant users suggests that these individuals may be quite fluid in their use of specific tobacco products. Furthermore, the current study relied on measures that examined smoking and ST use separately rather than tobacco use more globally. In order to identify strong predictors of concomitant use and cessation, measures will need to take into account use of multiple tobacco products.

Finally, although there was no biochemical verification of tobacco use status at the baseline and final surveys and this could be considered a limitation, there is evidence for the veracity and validity of self-reported tobacco use in population-based surveys [*35*].

CONCLUSIONS

After decades of rapid decline, the prevalence of cigarette smoking leveled off in the early 1990s and has remained relatively constant since that time. Conversely, the prevalence of ST use has increased since the early 1970s [*1,36*]. Given the high prevalence of concomitant smoking and ST use found in the current study and other research suggesting that approximately a quarter of ST users are also smokers [*1*], the increase in ST use may be driven in part by an increase in ST use among current smokers [*12*]. Our findings are consistent with this notion, although the data also indicate that almost as many ST users initiate smoking as vice versa. The lack of a clear directional effect for shifting among tobacco products is consistent with other research where some studies find that ST use is more likely to precede smoking [*37,38*], some show that smoking is more likely to precede ST use [*6*], and others indicate that use of either product predicts initiation of the other [*39*]. The results did not suggest that concomitant use was driven by uptake of ST among smokers attempting to overcome smoking restrictions in the workplace, but the effects on concomitant use of social norms discouraging smoking and other restrictions cannot be disregarded.

While the deleterious health effects of smoking are well documented (e.g., cardiovascular disease; chronic obstructive pulmonary disease; cancers of the lung, bladder, cervix [*40*]), the health effects of ST use are less well known and include oral cancer and other oral pathologies (e.g., periodontal disease, leukoplakia; see [*12,41,42*]). ST use also affects some cardiovascular parameters (e.g., blood pressure, heart rate) that may lead to greater risk for cardiovascular disease [*43,44*]. Because the health risks associated with cigarettes and ST are different in some respects, and because their effects may be additive if not synergistic, the concomitant use of cigarettes and ST may increase the risk of tobacco-attributable death and disease relative to use of either product alone. Coupled with the high prevalence of concomitant use among this population of Southern men, the public health impact of concomitant use may be substantial, but largely unrecognized for many populations.

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