Original Investigation

Smokeless tobacco cessation cluster randomized trial with rural high school males: Intervention interaction with baseline smoking

Margaret M. Walsh, M.S., Ed.D.,¹ Timothy J. Langer, B.S.,¹ Niall Kavanagh, B.S.,¹ Chuck Mansell, M.A.,² William MacDougall, Ed.D.,³ Catherine Kavanagh, B.S.,¹ & Stuart A. Gansky, Dr.PH.¹

¹ Department of Preventive and Restorative Dental Sciences, School of Dentistry, University of California, San Francisco, CA

² Upper Lake High School, Upper Lake, CA

³ Konocti School District, Lower Lake, CA

Corresponding Author: Dr. Margaret M. Walsh, M.S., Ed.D., Department of Preventive and Restorative Dental Sciences, School of Dentistry, University of California, San Francisco, 3333 California Street, Suite 495, San Francisco, CA 94143-1361, USA. Telephone: 415-476-9883; Fax: 415-502-8447; E-mail: margaret.walsh@ucsf.edu

Received November 18, 2009; accepted January 30, 2010

Abstract

Introduction: Adolescent males in rural areas use smokeless tobacco (ST). We assessed the efficacy of a school-based nurse-directed ST intervention among rural high school males.

Methods: Study high schools were randomly selected from a public high school list of California rural counties. Consenting high schools were stratified by school size and randomly assigned within strata to intervention or no-intervention groups. After gaining parental consent, male students completed baseline and 1-year follow-up questionnaires. The intervention included peer-led educational sessions and an oral exam by the school nurse who also provided brief tobacco cessation counseling. We used binary generalized estimating equation (GEE) models accounting for clustering within schools to test no difference between groups after adjusting for year in high school using both completers only and multiple imputation for those lost to follow-up. Subgroup analyses assessed Baseline Factor × Group interaction in GEE models.

Results: Twenty-one rural counties (72%), 41 randomly selected high schools (56%), and 4,731 male students (50%) participated with 65% retention. Nonsmoking ST users in the intervention group were significantly more likely to stop using ST at follow-up than those in the no-intervention group; there was no intervention effect among baseline ST users who also smoked. A higher percentage of baseline nonsmoking ST users reported smoking at follow-up than baseline non-ST-using smokers who reported using ST.

Discussion: A school-based nurse-directed ST cessation program was efficacious among rural nonsmoking ST-using high school males. The potential program reach holds significant public health value. Baseline ST use facilitated smoking at follow-up.

Introduction

Smokeless tobacco (ST) use can lead to nicotine addiction and significant health risks (Boffetta, Aagnes, Weierpass, & Anderson, 2005; Hatsukami, Lemmonds, & Tomar, 2004; Tomar, 2007). Although ST use is not as prevalent as cigarette smoking, its use is persistent in certain subgroups. In rural areas, prevalence of ST use is about three times that of urban areas (Mumford, Levy, Gitchell, & Blackman, 2006). Moreover, in 2007, an estimated 13% of high school males in the United States were current ST users (Eaton et al., 2008). ST use among high school males in rural areas of California (CA) from 2000 to 2004 overall was 10% ranging from 5% among freshman to 15% among seniors (Gansky, Ellison, Kavanagh, Isong, & Walsh, 2008). In addition, prevalence of ST use was even higher among subgroups of male students, such as 42% among rodeo athletes, 32% among smokers, 19% among wrestling athletes, 18% among baseball players and Future Farmers of America members, and 16% among football players. The purpose of this study was to determine the efficacy of a school-based nurse-directed ST cessation program among male high school students in rural CA and to examine tobacco product switching from baseline to 1-year follow-up.

Methods

Study design, power analysis, and eligibility

This stratified randomized controlled trial was approved by the Institutional Review Board at the University of California, San Francisco. Given a two-sided $\alpha = .05$ chi-square test adjusted for clustering within high schools with an intraclass correlation of .02, a total sample size of 40 high schools each with an average enrollment of 150 male ST users was estimated to be needed to provide 90% power to detect a significant difference

doi: 10.1093/ntr/ntq022

Advance Access published on May 3, 2010

© The Author 2010. Published by Oxford University Press on behalf of the Society for Research on Nicotine and Tobacco.

All rights reserved. For permissions, please e-mail: journals.permissions@oxfordjournals.org

in quitting of 15% in intervention high schools to 5% in no-intervention high schools.

For a high school to be eligible for inclusion in the study, it had to be located in one of 29 totally rural CA counties (a population density of 250 persons or less per square mile and no township of >50,000 persons; California State Rural Health Association, 2009). In these rural counties, there were 217 eligible high schools. Student eligibility criteria were: male enrolled in a study high school, parental consent if 17 years of age and younger, student-signed informed assent, and reported tobacco use within the past 30 days to be considered a tobacco user.

Sample selection, recruitment, informed consent, and randomization

Study investigators contacted the tobacco control coordinator in the County Office of Education (COE) in each of the 29 totally rural counties (of 58 total) in CA to explain the study and to gain agreement for collaboration to recruit county high schools. Twenty-one (72.4%) of 29 counties agreed to work with study investigators to gain permission from school district superintendents and high school principals in their county by writing a letter of study support. High schools were randomly selected from a list of public high schools in these counties from the California Public Schools Directory (1993) and recruited over 4 years.

In brief, from 2000 to 2004, 41 high schools were enrolled in the study: 8 in Year 1, 15 in Year 2, 10 in Year 3, and 8 in Year 4. Investigators contacted high school principals to explain the study and gain consent for their high schools' participation the following Fall. As a participation incentive, investigators donated \$150 to each participating high school supporting their graduation dance. Schools declining to participate were replaced with another randomly selected school.

The high school principal's cover letter and study consent form were included in the students' fall registration packets. The cover letter explained the purpose, methods, benefits, and risks of the study and provided a toll-free telephone number for parents who had questions for a study investigator. Year 1 of the study used active parent consent, but subsequent years used passive parent consent (i.e., opt out) as detailed elsewhere (Gansky et al., 2008). Student participants provided written assent. Participating high schools, stratified on size of school and enrollment year, were randomly assigned to either the intervention or the no-intervention group.

Questionnaire assessment

Baseline

For each high school, a local person (either staff from the COE or the participating high school, i.e., teachers, school nurse, school secretary) was hired and trained by a study investigator as a local study staff person (LSSP). The LSSP explained the purpose of the study, screened students for eligibility, gained written student informed assent, and oversaw questionnaire completion. The questionnaire was an 18-item 10-min self-administered questionnaire to assess demographics and tobacco use and correlates of use. To assure confidentiality of responses, face pages with name, address, and telephone number were separated from questionnaires. Each student put the completed

questionnaire in an envelope and placed both the sealed envelope and detached face page in a pre-addressed prepaid express mailbox in the front of the room. The LSSP mailed the box to study investigators. (Further details of this process and specific items measured have been reported elsewhere [Gansky et al., 2008].)

As a participation incentive, subjects were offered the opportunity to participate in three drawings for \$50 that would include only students from their school who turned in the completed questionnaire. Upon receipt of the surveys, study investigators conducted the drawing from names on the face sheets returned from a particular study school and informed school officials who announced the school's three winners of the \$50 drawing. Student checks were mailed 3–6 weeks after the drawing.

One-year follow-up

Students were mailed a follow-up questionnaire 1 year after baseline to assess tobacco use and related variables. Nonrespondents to the mailed questionnaire were called by telephone and those reached completed the questionnaire over the telephone by a trained interviewer. No more than three attempts were made to contact nonrespondents by telephone. As an incentive to complete the follow-up questionnaire, subjects were offered the same incentives as described for the baseline questionnaire, and the same procedures were followed for conducting the drawing, informing the winners, and providing the prizes.

Description of the intervention

As part of intervention development, we established at each school a study advisory board consisting of no more than three to four administrators, teachers, and parents. This board met once in person before the study started to gain feedback on the study design and to inform program implementation and once by telephone at the end of the study to discuss sustainability of the program. The intervention had three components: a peer-led educational session, an oral exam with feedback, and three nurse-led group cessation counseling sessions. Each peer-led educational session was scheduled during class time by school staff to reach freshmen through senior students, lasted 45 min, and consisted of student peers showing and then leading a discussion about 2 videos and 10 slides related to ST use and the role of the tobacco industry in targeting young males.

The second intervention component, an oral exam with feedback, was conducted by the school nurse who also pointed out any tobacco-associated lesions to students in their own mouths and applied a brief tobacco intervention using a 5 A's approach (Fiore et al., 2008). This approach consisted of verbally asking about tobacco use, advising users to quit, assessing readiness to quit in the next month, assisting with the quitting process by offering a self-help guide and the opportunity to participate in three group cessation counseling sessions, and arranging follow-up with interested tobacco users. In addition, students with oral lesions were scheduled 1 week later for a follow-up exam by the nurse. Parents of students with persistent lesions were informed by the nurse who facilitated follow-up evaluation with a study dentist.

The third component consisted of three noncompulsory, 1-hr nurse-led cessation sessions scheduled after school approximately 1 week apart. The first session focused on assessment, education,

preparation to get ready to quit, and the importance of social support. The second session focused on setting a quit date and skills to cope with cravings and temptation to use. The third session reviewed progress and focused on relapse prevention.

Recruitment and training of interventionists

School nurses

Counties or individual schools provided study investigators with lists of county school nurses who visited high schools monthly in rural areas of CA. Investigators then recruited and trained 55 school nurses in 3-hr regional trainings that included a printed procedure manual, videos on how to perform oral assessment, screening, tobacco cessation counseling procedures, and role playing with feedback on student partners. Those nurses who were unable to attend regional trainings were provided an individual 3-hour training at a convenient consenting high school. School nurses also were trained to complete and return an adverse events form after oral screenings and cessation counseling.

Student peer leaders

Student leaders were identified by their peers on the baseline questionnaire in response to the question "Who in your class do you look up to and admire?" Investigators then contacted identified-peer leaders and explained that, if they agreed to help, they would receive credit toward community service and a letter from the study principal investigator indicating their contribution as a peer leader for use in applications for college and/or employment. One hundred and fifty-three peer leaders were recruited and trained in a 3-hr session at each high school that consisted of lecture/discussion, viewing videos and slides, and role playing with feedback. Students were allowed to select slides that they felt comfortable presenting.

Data analysis

We used survey analysis methods to estimate study retention adjusting for clustering within schools. Baseline balance among randomization group was assessed with logit link exchangeable correlation generalized estimating equation (GEE) models for binary factors and cumulative logit independence correlation GEE models for ordinal factors. The following baseline factors were assessed for their relationship to lost to follow-up (attrition) with logit link exchangeable correlation GEE models: intervention group, racial/ethnic group, year in high school, wave of study, cigarette use in the prior 30 days, cigar use in the prior 30 days, dip/chew use in the prior 30 days, perceiving tobacco use to cause moderate/great harm, being a Future Farmers of America member, being an athlete (rodeo, football, baseball, track, soccer, basketball, and other), month of enrollment, Tobacco Use Prevention Education program at school, continuation school, school Academic Performance Index score, and school area poverty status. A multivariable lost to follow-up GEE model was developed from the individual factors with $p \leq .05$ with backward elimination of factors with $p > .10$ for a final model.

We used logit link exchangeable correlation GEE models accounting for clustering within schools to test the hypotheses of no association between intervention group and ST cessation among baseline ST users since randomization provides the basis

for valid inference. Odds ratios (ORs) and 95% CIs were calculated. Subgroup analyses assessed Baseline Factor $\times$ Group interactions in GEE models; since the baseline data (Gansky et al., 2008) showed Smoking $\times$ Race/Ethnicity differences in ST use, examining Baseline Smoking $\times$ Intervention Group was of particular interest; other subgroup analyses assessed included continuation school, baseline first ST use within 30 min of waking, baseline number of ST uses per week, and phone/mail follow-up. Analyses used participants with both baseline and 1-year follow-up tobacco use data. However, multiple imputation (MI) with 20 imputations and Markov chain Monte Carlo was used to impute missing data with the factors relating to loss-to-follow-up, baseline smoking status, intervention group, ST use at follow-up, and Baseline Smoking $\times$ Intervention Group. GEE assumes that missing data are missing completely at random, while MI makes the less stringent assumption of data being missing at random, providing more robust inferences.

Initiating a new form of tobacco was assessed by comparing the percent of baseline exclusive ST users who reported using smoked tobacco at the 1-year follow-up with that of baseline exclusive smoked tobacco users who reported using ST at follow-up with exact binomial 95% CIs; nonoverlapping CIs would indicate a significant difference.

Results

Twenty-one of 29 rural counties (72%), 41 of 73 randomly selected high schools (56%; of the 217 eligible schools), and 4,731 of the 9,391 eligible students (50%) participated in the study. At 1-year follow-up, 3,072 students participated for 65% retention. Year in high school (52% retention for senior, 62% for juniors, 68% for sophomores, and 72% for freshman), race/ethnicity (46% retention for Black, 56% "other" race/ethnicity, 72% for Asian/Pacific Islander, 63% for Hispanic/Latino, 66% non-Latino White, and 65% Native American), baseline ST use (52% retention for user and 66% for nonuser), perception of harm (55% for none/low and 67% for moderate/great), baseball (64% retention for nonparticipant and 70% participant), and soccer (64% retention for nonparticipant and 71% participant) were significantly related to retention in a multivariable GEE model. The intervention group had 63% retention, while the no-intervention group had 67% retention (GEE $p = .713$; multivariable GEE model $p = .316$). Baseline ST use among retained participants was 7.6% (5.3%–9.8%) in the control group and 8.0% (4.9%–11.2%) in the intervention group, while among those lost to follow-up, baseline ST use was 12.9% (10.5%–15.2%) in the control group and 13.5% (9.9%–17.2%) in the intervention group. A GEE interaction test of Group $\times$ Retention as it related to baseline ST use was nonsignificant ($p = .941$).

Overall, most ST users in our study used dip exclusively or both dip and chewing tobacco (40% each); used ST on at least 5 days in the past week; used Copenhagen, a brand of ST offering a high level of bioavailable nicotine (Hoffmann et al., 1995); and used ST within 30 min of waking, suggesting nicotine dependence (Boyle, Jensen, Hatsukami, & Severson, 1995; Ebbert, Patten, & Schroeder, 2006). The mean age ST users reported first having tried ST was 12.1 years, and the mean age they began regular ST use was 13.5 years (data not shown).

Table 1 shows the baseline characteristics of the study sample by randomization group. The majority of students were White,

Table 1. Baseline characteristics of study sample by group (N = 4,731)

	Intervention (N = 2,270)	No intervention (N = 2,461)	GEE ^a , <i>p</i> value
	<i>n</i> (%)	<i>n</i> (%)	
Race/ethnicity			
White/non Latino	1,460 (64)	1,735 (70)	.626
Latino and other Hispanic	356 (16)	267 (11)	.699
Other	114 (5)	122 (5)	.972
Asian/Pacific Islander	141 (6)	91 (4)	.047
Native American	75 (3)	98 (4)	.989
Black	52 (2)	67 (3)	.637
Year in high school			.006
Freshman	774 (34)	645 (26)	
Sophomore	740 (33)	624 (25)	
Junior	451 (20)	614 (25)	
Senior	298 (13)	569 (23)	
Activity participation ^b			
None	882 (39)	810 (33)	.340
Baseball	413 (18)	444 (18)	.583
Football	649 (29)	768 (31)	.552
Basketball	439 (19)	517 (21)	.593
Other	388 (17)	502 (20)	.151
Future Farmers of America	278 (12)	425 (17)	.772
Track and Field	291 (13)	258 (11)	.292
Soccer	197 (9)	312 (13)	.016
Wrestling	170 (7)	229 (9)	.327
Rodeo	69 (3)	92 (4)	.190
Current tobacco use			
Cigarettes	285 (13)	355 (15)	.673
Cigars	215 (9)	270 (11)	.959
Cigarettes or cigars	377 (17)	470 (19)	.880
ST (dip or chew)	229 (10)	229 (9)	.659
Cigarettes and ST	128 (6)	143 (6)	.907
Perception of risk			.450
associated with ST use			
No/slight risk	265 (12)	248 (10)	
Moderate risk	699 (31)	759 (31)	
Great risk	1,260 (57)	1,412 (58)	
High school type			
Continuation	91 (4)	114 (5)	.950

Note. GEE = generalized estimating equation; ST = smokeless tobacco.

^aGEE is a model adjusting for clustering within schools.

^bNot mutually exclusive categories (except "None").

followed by Latino and other Hispanic, Asian/Pacific Islander, Native American, and Black. Overall baseline prevalence of ST use, smoking, and combined cigarettes and ST use were 9%, 14%, and 6%, respectively (data for overall not shown in table). Three of the 24 baseline characteristics—Asian/Pacific Islander, year in high school, and playing soccer—differed significantly between the two randomization groups at baseline; although none would be considered statistically significant with a Bonferroni multiple comparison correction ($\alpha^* = .002$), subsequent analyses were also performed adjusting for year in high school.

Table 2 shows 1-year follow-up by randomized group: the overall prevalence of ST use, the percent initiation of ST use among baseline non-ST users, and the percent of ST cessation among baseline ST users. There were no significant differences

between the intervention and no-intervention groups overall, in initiation or in quitting (all ORs' 95% CIs include 1.0).

Subgroup analysis, however, showed that baseline smoking was a significant intervention effect modifier: Baseline Smoking $\times$ Group yielded $p = .019$ and adding year in high school as a covariate did not change that result. In addition, ST use intensity (low/moderate/heavy), first ST use after waking (≤ 30 min/ > 30 min), year in high school, and high school type (continuation/regular) were not significant effect modifiers (all $p > .861$).

Table 3 shows 1-year follow-up ST use by baseline smoking status: overall prevalence of ST use, ST initiation, and ST cessation among males who were baseline nonsmokers and baseline smokers. A highly significant intervention effect was seen in

Table 2. One-year follow-up prevalence of overall ST use, ST initiation, and ST cessation in prior 30 days by randomization group (complete and imputed data)

	Intervention <i>n</i> (%)	No intervention <i>n</i> (%)	OR	95% CI	GEE ^a , <i>p</i> value	MI GEE ^a , <i>p</i> value
Overall ST use	84 (6)	117 (7)	0.83	0.52–1.32	.426	.650
Initiation (baseline non-ST users)	34 (3)	51 (3)	0.78	0.49–1.23	.286	.268
Cessation (baseline ST users)	64 (52)	59 (48)	1.43	0.88–2.32	.145	.213

Note. GEE = generalized estimating equation; MI = multiple imputation; OR = odds ratio; ST = smokeless tobacco.

^aGEE is a model adjusting for clustering within schools; MI with 20 imputations.

reported ST quitting among the baseline nonsmokers ($p < .001$): 62% of those who used ST but did not smoke at baseline in the intervention group reported quitting compared with 36% of those in the no-intervention group. These results remained when adding year in high school as a covariate.

Of baseline ST users who smoked, 40% used ST within 30 min of waking compared with 22% of exclusive baseline ST users ($p = .011$). The number of days per week of ST use was similar between baseline dual users and baseline ST only users ($p = .747$). Thus, ST users who smoked at baseline appeared to be more addicted than exclusive baseline ST users but did not differ in the number of days of ST use per week. Table 4 shows the percentage of exclusive baseline smokers (i.e., non-ST users) and exclusive baseline ST users (i.e., nonsmokers) who reported using another form of tobacco at 1-year follow-up. Exclusive baseline ST users (i.e., baseline nonsmokers) reported a significantly higher percentage smoking at follow-up than exclusive baseline smokers (i.e., baseline ST nonusers) reported using ST at follow-up. (Exact binomial 95% CIs do not overlap, demonstrating statistical significance.) Thus, ST use appears to have facilitated initiation of smoking in this adolescent population.

No adverse events were reported during the study.

Discussion

The results indicate that a low-intensive, school-based nurse-directed ST cessation program targeting high school male stu-

dents in rural areas of CA significantly promoted cessation among baseline nonsmoking ST users compared with no intervention but had no effect on baseline ST users who also smoked. This finding is consistent with those reported in studies of similar interventions targeting ST-using male college and high school athlete populations with very low smoking prevalence (Gansky, Ellison, Kavanagh, Hilton, & Walsh, 2002; Walsh et al., 1999, 2003).

A possible explanation for the lack of an intervention effect among baseline ST users who also smoked is that combined smoking and ST use among high school males results in a higher level of nicotine addiction (shown by more individuals with ST use within 30 min of waking) that leads to persistent use and difficulty quitting. This explanation is consistent with reports that dual tobacco users differ from users of a single tobacco product (Wetter et al., 2002), escalate more quickly to heavy tobacco use and nicotine dependence (Rosendahl, Galanti, & Gilljam, 2008), smoke more cigarettes than exclusive smokers, and had a doubling of lung cancer mortality rate in epidemiological studies compared with exclusive smokers (Accortt, Waterbor, Beall, & Howard, 2002; Accortt, Waterbor, Beall, Howard, & Brooks, 2005).

In this study, school was the unit of randomization since students from the same school were likely to be more correlated than those from different schools. Analyses for intervention effects used GEE models to account for the school clusters. In addition, we considered that one possible explanation for our findings might be seasonal effects, that is, ST use during sport

Table 3. One-year follow-up prevalence of ST use, ST initiation, and ST cessation in prior 30 days by randomization group and baseline smoking status (complete and imputed data)

	Intervention <i>n</i> (%)	No intervention <i>n</i> (%)	OR	95% CI	GEE ^a , <i>p</i> value	MI GEE ^a , <i>p</i> value
Baseline nonsmokers	42 (3)	71 (5)	0.62	0.36–1.09	.095	.200
Initiation (baseline non-ST users)	21 (2)	37 (3)	0.63	0.36–1.13	.121	.103
Cessation (baseline ST users)	34 (62)	19 (36)	0.36	0.28–0.48	<.001	.003
Baseline smokers	42 (20)	46 (17)	1.24	0.73–2.12	.429	.270
Initiation (baseline non-ST users)	13 (9)	14 (7)	0.88	0.51–1.51	.638	.774
Cessation (baseline ST users)	30 (51)	40 (56)	1.14	0.52–2.53	.740	.605

Note. Baseline Smoking $\times$ Group interaction, GEE, $p = .019$; MI GEE, $p = .032$. GEE = generalized estimating equation; MI = multiple imputation; OR = odds ratio; ST = smokeless tobacco.

^aGEE is a model adjusting for clustering within schools; MI with 20 imputations.

Table 4. One-year initiated using tobacco in new form follow-up of baseline exclusive ST users and exclusive smokers

	New tobacco form initiation		
	No	Yes	% Yes
Baseline exclusive	<i>n</i> (%)	<i>n</i> (%)	95% <i>CI</i>
Smoker	319 (92.2)	27 (7.8)	5.2–11.2
ST user	87 (80.6)	21 (19.4)	12.5–28.2

Note. ST = smokeless tobacco.

seasons and warmer weather but smoking during off seasons and colder weather, however, no such seasonal effect was evident. Moreover, although several baseline correlates of ST use were associated with loss to follow-up, there was no difference between the intervention and no-intervention groups in this regard. Baseline ST users, however, were more likely to be lost to follow-up than nonusers.

This study also found that a greater percentage of baseline “nonsmoking ST users” smoked at 1-year follow-up than baseline “non-ST-using smokers” who used ST at follow-up. These findings are consistent with those of Forrester, Biglan, Severson, and Smolkowski (2007) who reported that use of ST in a population of adolescent boys in 7th and 9th grades was a significant risk factor for subsequent smoking 2 years later even when controlling for other factors, such as parent, sibling, or close friend smoking; low academic grades; 30-day alcohol use; and a scale measure of deviant behavior. Moreover, in that study, smoking did not predict ST use between 9th and 11th graders 2 years later, suggesting that the relationship between ST use and smoking went only in one direction (Severson, Forrester, & Biglan, 2007).

Currently, there is debate in the literature among those who report that ST use is a risk factor for cigarette smoking (Forrester et al., 2007; Haddock et al., 2001; Severson et al., 2007; Tomar, 2003a, 2003b; Tomar & Loree, 2004) and those who report no such relationship (Kozlowski, O'Connor, Edwards, & Flaherty, 2003; O'Connor, Flaherty, Edwards, & Kozlowski, 2003; O'Connor, Kozlowski, Flaherty, & Edwards, 2005). Although the suggestion that ST use precedes cigarette smoking has been in the literature for some time (Hatsukami & Severson, 1999; Severson et al., 1991), recent policy discussions on whether ST can serve as a safer alternative to cigarette smoking and whether ST manufacturers could adjust their warning labels have highlighted this issue. Our findings support the position that ST use appears to be a gateway to cigarette smoking among adolescent males in rural areas and presents a serious public health concern. Given this trajectory, the most appropriate messages for young males in rural areas may be those that are general messages that target all tobacco use rather than ST- or smoking-specific messages. This suggestion is consistent with a similar recommendation of Bombard, Rock, Pederson, and Asman (2008) based on population estimates using 2002 and 2004 National Youth Tobacco Survey data indicating that 62% of

male middle school and high school cigarette smokers used other tobacco products, especially ST and cigars.

A limitation of our study is that our self-reported findings are not validated by biochemical assay due to budgetary constraints. Research has indicated, however, that biochemical checks may be omitted without serious risk to reliability and validity under rigorous research conditions where confidentiality has been promised and accepted (Akers, Massey, Clarke, & Lauer, 1983).

The results of this study indicate that a high school-based nurse-led tobacco intervention program facilitates ST use cessation among nonsmoking high school males in rural areas. They also suggest that ST use in this young male population leads to smoking onset. Because of the high ST use among males in rural high schools and the potential reach of such a nurse-led program, the public health impact would be significant even with modest ST use cessation rates. Such programs are needed to help stop transition from experimental ST use to tobacco dependence and to counter the tobacco industry's marketing of new moist snuff products with increased levels of free nicotine content (Alpert, Koh, & Connolly, 2008) designed to appeal to youth and new users (Carpenter, Connolly, Ayo-Yusef, & Ferris Wayne, 2009).

Policy makers need to (a) expand the role of high school nurses in rural areas to provide a youth tobacco intervention program such as the one reported here; (b) expand labels on ST products to include a warning that ST use has been shown to lead to smoking in groups of young male ST users; and (c) recommend funding of careful surveillance programs to determine whether or not the problem of ST use leading to later smoking among young males persists, especially in light of the tobacco industry's aggressive marketing of new ST products.

Funding

This work was supported by the National Institute of Dental and Craniofacial Research at the National Institutes of Health (Grant Number US DHHS NIH/NIDCR P60 DE13058).

Declaration of Interests

None declared.

Acknowledgments

We gratefully acknowledge the support of the school district superintendents in study counties and the high school principals of the participating high schools in furthering our research. We also wish to acknowledge the invaluable efforts of the following county staff associated with either the County Office of Education or the County Department of Health Services: K. Kahuse, Modoc County; J. Welcome, Shasta County; B. Minert, Plumas County; W. Bushang, Lassen County; J. Young, Siskiyou County; A. Prisco, San Benito County; J. Miller, Humboldt County; R. Carstenson, El Dorado County; P. Jacobs, Mariposa County; W. Donaldson, Solano County; C. Anderson, Tuolumne County; and Dr. Witte, Yolo County. We also are grateful to Dr. James Ellison for assistance with data management and to Joanna Hill for administrative assistance.

References

- Accortt, N., Waterbor, J., Beall, C., & Howard, G. (2002). Chronic disease mortality in a cohort of smokeless tobacco users. *American Journal of Epidemiology*, 156, 730–737.
- Accortt, N. A., Waterbor, J. W., Beall, C., Howard, G., & Brooks, C. M. (2005). Need to educate primary caregivers about the risk factor profile of smokeless tobacco users. *Journal of Cancer Education*, 20, 222–228.
- Akers, R. L., Massey, J., Clarke, W., & Lauer, R. M. (1983). Are self-reports of adolescent deviance valid? Biochemical measures, randomized response, and the bogus pipeline in smoking behavior. *Sociological Forces*, 62, 234–251.
- Alpert, H. R., Koh, H., & Connolly, G. N. (2008). Free nicotine content and strategic marketing of moist snuff tobacco products in the United States: 2000–2006. *Tobacco Control*, 17, 332–338.
- Boffetta, P., Aagnes, B., Weierpass, E., & Anderson, A. (2005). Smokeless tobacco use and risk of cancer of the pancreas and other organs. *International Journal of Cancer*, 114, 992–995.
- Bombard, J. M., Rock, V. J., Pederson, L. L., & Asman, K. J. (2008). Monitoring polytobacco use among adolescents: Do cigarette smokers use other forms of tobacco. *Nicotine & Tobacco Research*, 10, 1581–1589.
- Boyle, R. G., Jensen, J., Hatsukami, D. K., & Severson, H. H. (1995). Measuring dependence in smokeless tobacco users. *Addictive Behaviors*, 20, 443–450.
- California Public Schools Directory. (1993). *Bureau of Publications*. Sacramento, CA: California Department of Education.
- California State Rural Health Association. (2009). *Fact sheet*, HTML Retrieved 1 September 2009, from <http://www.csrha.org>
- Carpenter, C. M., Connolly, G., Ayo-Yusef, O. O., & Ferris Wayne, G. (2009). Developing smokeless tobacco products for smokers: An examination of tobacco industry documents. *Tobacco Control*, 18, 54–59.
- Eaton, D. K., Kann, L., Kinchen, S., Shanklin, S., Ross, J., Hawkins, J., et al. (2008). Youth risk behavior surveillance—United States, 2007. *Morbidity and Mortality Surveillance Summary*, 57, 1–131. Retrieved 1 September 2009, from <http://www.cdc.gov/mmwr/preview/mmwrhtml/SS5704a1.htm>
- Ebbert, J. O., Patten, C. A., & Schroeder, D. R. (2006). The Fagerstrom test for nicotine dependence-smokeless tobacco (FTND-ST). *Addictive Behaviors*, 31, 1716–1721.
- Fiore, M. C., Jaen, C. R., Baker, I. B., Bailey, W. C., Benowitz, N. L., Curry, S. J., et al. (2008). *Treating tobacco use and dependence*, clinical practice guideline, Rockville, MD: U.S. Department of Health and Human Services, Public Health Service.
- Forrester, K., Biglan, A., Severson, H. H., & Smolkowski, K. (2007). Predictors of smoking onset over two years. *Nicotine & Tobacco Research*, 9, 1259–1267.
- Gansky, S. A., Ellison, J. A., Kavanagh, C., Hilton, J. F., & Walsh, M. M. (2002). Oral screening and brief spit tobacco cessation counseling: A review and findings. *Journal of Dental Education*, 66, 1088–1098.
- Gansky, S. A., Ellison, J. A., Kavanagh, C., Isong, U., & Walsh, M. M. (2008). Patterns and correlates of spit tobacco use among high school males in rural California. *Journal of American Association of Public Health Dentistry*, 69, 116–124.
- Haddock, C. K., Weg, M. V., DeBon, M., Klesges, R. C., Talcott, G. W., Lando, H. A., et al. (2001). Evidence that smokeless tobacco use is a gateway for smoking initiation in young adult males. *Preventive Medicine*, 32, 262–267.
- Hatsukami, D. K., & Severson, H. H. (1999). Oral spit tobacco: Addiction, prevention and treatment. *Nicotine & Tobacco Research*, 1, 21–44.
- Hatsukami, D. K., Lemmonds, C., & Tomar, S. L. (2004). Smokeless tobacco use: Harm reduction or induction approach? *Preventive Medicine*, 38, 309–317.
- Hoffmann, D., Djordjevic, M. V., Fan, J., Zang, E., Glynn, T., & Connolly, G. N. (1995). Five leading U.S. commercial brands of moist snuff in 1994: Assessment of carcinogenic N-nitrosamines. *Journal of the National Cancer Institute*, 87, 1862–1869.
- Kozlowski, L. T., O'Connor, R. J., Edwards, B. Q., & Flaherty, B. P. (2003). Most smokeless tobacco use is not a causal gateway to cigarettes: Using order of product use to evaluate causation in a national US sample. *Addiction*, 98, 1077–1085.
- Mumford, E. A., Levy, D. T., Gitchell, J. G., & Blackman, K. O. (2006). Smokeless tobacco use 1992–2002: Trends and measurement in the current population survey-tobacco use supplements. *Tobacco Control*, 15, 166–171.
- O'Connor, R. J., Flaherty, B. P., Edwards, B. Q., & Kozlowski, L. T. (2003). Regular smokeless tobacco use is not a reliable predictor of smoking onset when psychosocial predictors are included in the model. *Nicotine & Tobacco Research*, 5, 535–543.
- O'Connor, R. J., Kozlowski, L. T., Flaherty, B. P., & Edwards, B. Q. (2005). Most smokeless tobacco use does not cause cigarette smoking: Results from the 2000 National Household Survey on Drug Abuse. *Addictive Behaviors*, 30, 325–326.
- Rosendahl, K. I., Galanti, M. R., & Gilljam, H. (2008). Trajectories of smokeless tobacco use and of cigarette smoking in a cohort of Swedish adolescents: Differences and implications. *Nicotine & Tobacco Research*, 10, 1021–1027.
- Severson, H. H., Forrester, K. K., & Biglan, A. (2007). Use of smokeless tobacco is a risk factor for cigarette smoking. *Nicotine & Tobacco Research*, 9, 1331–1337.
- Severson, H. H., Glasgow, R., Wirt, R., Brozovsky, P., Zoref, L., Black, C., et al. (1991). Preventing the use of smokeless tobacco and cigarettes by teens: Results of a classroom intervention. *Health Education Research*, 6, 109–120.
- Tomar, S. L. (2003a). Is use of smokeless tobacco a risk factor for cigarette smoking? The U.S. experience. *Nicotine & Tobacco Research*, 5, 561–569.

- Tomar, S. L. (2003b). Smokeless tobacco use is a significant predictor of smoking when appropriately modeled. *Nicotine & Tobacco Research*, 5, 571–573.
- Tomar, S. L. (2007). Epidemiologic perspectives on smokeless tobacco marketing and population harm. *American Journal of Preventive Medicine*, 33(Suppl. 6), S387–S397.
- Tomar, S. L., & Loree, M. (2004). Errors in analyzing associations between use of smokeless tobacco and cigarettes. *Addiction*, 99, 260–262.
- Walsh, M. M., Hilton, J. F., Masouredis, C. M., Gee, L., Chesney, M. A., & Ernster, V. L. (1999). Smokeless tobacco cessation intervention for college athletes: Results after 1 year. *American Journal of Public Health*, 89, 228–234.
- Walsh, M. M., Hilton, J. F., Ellison, J., Gee, L., Chesney, M. A., Tomar, S. L., et al. (2003). Spit (smokeless) intervention for high school athletes: Results after 1 year. *Addictive Behaviors*, 28, 1095–1113.
- Wetter, D. W., McClure, J. B., de Moor, C., Cofta-Gunn, L., Cummings, S., Cinciripini, P. M., et al. (2002). Concomitant use of cigarettes and smokeless tobacco: Prevalence, correlates, and predictors of tobacco cessation. *Preventive Medicine*, 34, 638–648.