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Tobacco use transitions in the United States: The National Longitudinal Study of Adolescent Health

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ABSTRACT

Objectives. The purpose of this study is to evaluate and describe transitions in cigarette and smokeless tobacco (ST) use, including dual use, prospectively from adolescence into young adulthood. *Methods.* The current study utilizes four waves of the National Longitudinal Study of Adolescent Health (Add Health) to examine patterns of cigarette and ST use (within 30 days of survey) over time among a cohort in the United States beginning in 7th–12th grade (1995) into young adulthood (2008–2009). Transition probabilities were estimated using Markov modeling. *Results.* Among the cohort (N = 20,774), 48.7% reported using cigarettes, 12.8% reported using ST, and 7.2% reported dual use (cigarettes and ST in the same wave) in at least one wave. In general, the risk for transitioning between cigarettes and ST was higher for males and those who were older. Dual users exhibited a high probability (81%) of continuing dual use over time. *Conclusions.* Findings suggest that adolescents who use multiple tobacco products are likely to continue such use as they move into young adulthood. When addressing tobacco use among adolescents and young adults, multiple forms of tobacco use should be considered.

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Tobacco use among adolescents and young adults poses a significant public health concern given that nearly 90% of U.S. adult smokers begin smoking by age 18 (Centers for Disease Control and Prevention, 2012). Experimentation with tobacco products is common among adolescents and young adults (U.S. Department of Health Human Services, 2012). In 2013, current tobacco use across all products was highest among adults aged 18–25 compared to all other age groups: 30.6% reported past month use of cigarettes and 5.8% reported smokeless tobacco (ST), defined to include chewing tobacco and snuff, use in the past month (Substance Abuse and Mental Health Services Administration, 2014). Overall, adolescent reports of past 30-day use of ST declined until about 2007 and since then have remained stable (Johnston et al., 2012). Data from the 2011 National Youth Tobacco Survey estimated that 2.2% of middle school students and 7.3% of high school students reported using ST in the last 30 days (Centers for Disease Control and Prevention, 2012). Additionally, ST use prevalence is substantially higher among some adolescent subgroups, such as 12th-grade White males and in certain regions of the country (Substance Abuse and Mental Health Services Administration, 2014; Nelson et al., 2006). While prevalence rates provide information about the use of cigarettes and ST, little research has examined how adolescents and young adults may transition between these products.

Use of multiple tobacco products is also common among adolescents and young adults. Among high school students who report currently using tobacco, more than half of the males and nearly one-half of the females report using more than one product in the last 30 days (2009 Youth Risk Behavior Surveillance System). Numerous studies have documented use of novel, non-cigarette tobacco products by adolescents, particularly in social settings, including use of hookah, little cigars, flavored tobacco products, and non-conventional cigarettes (Agaku et al., 2013; Amrock et al., 2014; King et al., 2014; Parascandola et al., 2008). Research has shown that among tobacco users younger than 26 years of age, the proportion of those using more than one tobacco product increased significantly between 2002 and 2011 (Fix et al., 2014). Dual product use is a concern because evidence suggests that people who use both cigarettes and ST demonstrate higher estimated nicotine exposure levels and find cessation more difficult to achieve than those who use only ST or only smoke (Hatsukami and Severson, 1999; Spangler et al., 2001; Wetter et al., 2002; McClave-Regan and Berkowitz, 2011). However, use of non-cigarette tobacco products among adolescents and young adults, alone or in conjunction with cigarette smoking, is less studied than cigarette smoking alone and presents a complex scientific and public health challenge.

Currently, little is known about patterns of multiple tobacco product use over time, including within person transitions between use of cigarettes and ST from adolescence into young adulthood. A number of studies suggest that ST use is associated with use of other tobacco

Abbreviations: CU, current use; RTD, reported to date; ST, smokeless tobacco.

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products, including cigarettes (Boyle et al., 2012). However, substantial gaps remain for characterizing ST use and its relationship to cigarette smoking and there has been a call for longitudinal research to address this need (Fix et al., 2014; NIH state-of-the-science conference statement on tobacco use, 2006). The main limitation of research to date regarding cigarette and ST use transitions is a dearth of prospective analysis. To the best of our knowledge, five prospective studies have been conducted in the U.S. examining cigarette and ST use (Wetter et al., 2002; O'Connor et al., 2003; Severson et al., 2007; Timberlake et al., 2009; Tomar, 2003). These studies have primarily focused on the *gateway hypothesis:* that ST use may increase the risk of becoming a cigarette smoker. However, the findings from these studies are inconsistent. Although informative, prior research did not address the potential for multiple transitions between ST and cigarettes that may occur over time.

The current study aimed to address these gaps in understanding transitions in use of two products: cigarettes and ST. Using data from the National Longitudinal Study of Adolescent Health (Add Health), in which a cohort was followed from adolescence into young adulthood, the current study will 1) describe prevalence of cigarette smoking, ST use, and the use of both products, 2) analyze patterns of tobacco use over time, including transitions between ST and cigarette product use, and 3) examine how the transitions differ across demographic groups.

Methods

Participants and procedure

Add Health is a study of adolescent health-related behaviors (Udry et al., 2009). The nationally based sampling frame involved the selection of a random sample of 80 high schools (public, private, and parochial) and 54 associated feeder schools throughout the United States and is representative of U.S. schools with respect to region, urbanicity, school size, school type, and ethnic distribution. All students were eligible for selection into the core in-home sample (University of North Carolina and Carolina Population Center). Data were collected in participants' homes. A computer-assisted interview was conducted by a trained interviewer. For sensitive topics, participants responded via audio computer-assisted self interview. A sample of 20,774 male and female adolescents in grades 7 through 12 were selected to participate in the initial in-home survey conducted between April and December 1995 (Wave I). Participants were interviewed at Wave II (n = 14,738) approximately 1 year later (April–August 1996), at Wave III (n = 15,197) approximately 6 years later (August 2001–April 2002), and at Wave IV (n = 15,701) approximately 13 years later (January 2008–February 2009). Wave II surveyed those from the Wave I in-home interviews, but excluded those who were in the 12th grade at Wave I who were not part of the genetic sample, and those who were only in the Wave I disabled sample. (Information regarding the genetic and disabled samples can be found at http://www.cpc.unc.edu/projects/addhealth/design/wave1.) Wave III and Wave IV samples consist of Wave I respondents who could be located and re-interviewed.

Measures

Smokeless tobacco use

At each wave participants were asked, "During the past 30 days, on how many days have you used chewing tobacco (such as Red Man, Levi Garrett, or Beechnut) or snuff (such as Skoal, Skoal Bandits, or Copenhagen)?" Responses were dichotomized to indicate use (yes or no) for each wave.

Cigarette smoking

At each wave participants were asked, "During the past 30 days, on how many days did you smoke cigarettes?" Responses were dichotomized to indicate use (yes or no) for each wave.

Demographic information (Wave I)

Participants' self-reported sex and age were recorded. Four race categories were constructed based on self-reported data: White, Black, Native American, and Asian (Udry et al., 2003). Region was categorized as West, Midwest, South, and Northeast.

Data analysis

For the purpose of cross-sectional description of the data, participants were classified according to *ever-reported* tobacco use status across all four waves: "**neither**" if the participant never reported cigarette or ST use; "**cigarettes only**" if the participant only ever-reported cigarettes; "**ST only**" if the participant only ever-reported ST; and "**both cigarettes and ST**" if the participant ever-reported using both products (not necessarily reported at the same wave). "Both cigarettes and ST" was further divided into those who reported past 30-day cigarette and ST use at different waves (switching) or those who reported past 30-day cigarette and ST use at the same wave (dual use).

The primary and secondary endpoints, "reported to date" (RTD) and "current use" (CU) were derived from the participants' reports of past 30-day cigarette and ST use. RTD for a given participant and wave was set to "neither," "cigarettes only," "ST only," or "both cigarettes and ST." RTD incorporated all reports to date of each product. The RTD state of "both cigarettes and ST" indicated that both cigarette and ST use had been reported, but not necessarily at the same wave. The secondary analysis endpoint, CU, was defined based only on the status at a given wave: "neither," "cigarettes only," "ST only," or "dual" (both cigarettes and ST reported at the same wave). Transitions from "cigarettes only" to "ST only" (and vice versa) or from multiple to single product use were captured in the CU endpoint.

For both the primary and secondary endpoints, we used Markov modeling to estimate the probabilities of transitioning between tobacco use states. Markov modeling permitted estimation based on data collected at each wave over the full longitudinal study and all observed transitions between states over time (e.g. neither, cigarettes only, ST only, or dual) (Jackson, 2011; Kalbfleisch and Lawless, 1985; Kay, 1986; White et al., 2009). In continuous-time Markov modeling, the probability of transitioning is the outcome variable and the models allow the transitions to have occurred at any point in time from one survey to the next. In these analyses, probabilities were reported on a per-year basis, that is, for a transition with the passage of 1 year at any point in adolescence and young adulthood. The change in 1 year is analogous to a one-unit change of an explanatory variable in a regression analysis. That is, the models estimate the probabilities of transitions over any interval of time during adolescence and young adulthood, not restricted to the specific time points at which surveys were conducted. Model covariates in the primary analysis were gender, age at assessment, region at assessment, and race. Hazard ratios and 95% confidence intervals indicated the associations with demographic factors and were adjusted for all variables noted. Comparisons of transitions between different pairs of states are presented in the Supplementary Material. Markov model analysis of the secondary endpoint, CU, was performed for the entire sample and the subset most likely to use ST: white males (note: demographic factors were not included in this analysis due to data sparseness for some transitions). Participants who completed only one survey are not included in the Markov modeling. Data management and analysis were performed in SAS v 9.2 (SAS Institute, Cary, NC) and R version 2.15 (R Foundation for Statistical Computing).

Results

Table 1 shows adolescent and young adult ever-reported tobacco use based on demographic variables of interest. Rows A and B show respondents' ever-reported cigarette smoking status (without regard to ST use). Among the total population (N = 20,774), 48.8% reported using cigarettes (without regard to ST use) within 30 days during at least one wave. Rows C and D show ever-reported ST use (without regard to cigarette smoking): 12.9% of respondents—21.4% of males and 4.5% of females—reported using ST within 30 days during at least one wave. Rows E-I provide counts of singular and multiple product use; 9.2% reported using both products during at least one wave. Males were more likely than females to report using both cigarettes and ST (15.7% vs. 3.0%). Whites (11.5%) and Native Americans (8.6%) were more likely to report using both products than were Blacks (4.9%) or Asians (4.5%). Use of both product types was highest in the Midwest (11.4%) and lowest in the West (6.9%). Row I provides the subset of respondents who used both products during the same 30-day period. For those who ever-reported using both ST and cigarettes, dual use was more prevalent than switching. That is, while 9.2% of respondents reported use of both products (Row H), 7.2% did so during the