



Short Communication

Tobacco product transition patterns in rural and urban cohorts: Where do dual users go?

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ABSTRACT

Introduction: Understanding diverse tobacco product consumption represents a crucial area for tobacco regulatory science. With the increase in dual/poly use of tobacco products, transition patterns among exclusive and dual users are of considerable interest. We describe transition patterns of dual users over 18 months.

Methods: A cohort of 145 adults in urban and rural Ohio who reported dual tobacco product use at least some days/week was enrolled during 2014–17. Participants completed follow-up interviews every six months where they were classified into one of five categories: 1) exclusive combustible, 2) exclusive smokeless, 3) exclusive e-cigarette, 4) dual (at least 2 of the previous 3 categories), and 5) less than some days/week. Participants categorized as exclusive and dual (1–4) used their products at least some days per week. Separately within the rural and urban cohorts, 6, 12, and 18 month transition probabilities between the categories were estimated.

Results: The probability of remaining a dual user after 6 months is 43% in the rural and 37% in the urban cohort. The decline continues through 18 months with 24% of rural and 22% of urban dual users remaining in the category. The probability of a dual user consuming combustibles and e-cigarettes transitioning to exclusive combustible use in 6 months is over 50% in both the rural and urban cohorts.

Conclusions: Dual use is an unstable state with users being more likely to transition to exclusive combustible use than to remain in the dual use category. Transitions are similar in the rural and urban cohorts.

1. Introduction

The current U.S. marketplace presents consumers with wide selections of combustible and non-combustible tobacco products. As such, understanding the diversity of tobacco products used represents a crucial area for tobacco regulatory science (Backinger et al., 2008). A category of tobacco user, termed “dual or poly-user” is evident (Bombard et al., 2009; Brasky et al., 2018; Frost-Pineda et al., 2010; Haddock et al., 2001) and includes individuals who consume a diverse range of tobacco products. These products include combustible tobacco, the most dangerous product (Hajek et al., 2014), as well as non-combustible categories of smokeless tobacco (SLT) and electronic nicotine delivery systems (ENDS). Awareness and use of ENDS (e.g. e-cigarettes) has increased, especially among smokers who believe them safer than combustible products and of assistance in quitting cigarettes (Haddock et al., 2001). Surveillance patterns of diverse product use must be

expanded, since dual use potentially could influence population-level harm (Hatsukami et al., 2007; Jamal et al., 2016). Geographic factors can also influence social norms with regard to product preferences (Kasza et al., 2017). For example, dual use of cigarettes and SLT is prevalent in rural settings (Frost-Pineda et al., 2010); urban dual users may choose cigarettes (or small cigars) in combination with e-cigarettes (Haddock et al., 2001; Mejia et al., 2010).

Wave 1 findings of the Population Assessment of Tobacco and Health (PATH) Cohort, a nationally representative sample of U.S. youth and adults, indicated that 27.6% of adults use at least one tobacco product (O'Connor, 2012). Approximately 40% of adult and youth PATH Cohort tobacco users reported consumption of multiple products, with cigarettes and e-cigarettes the most commonly cited combination.

The different types and numbers of tobacco products consumed and the dynamics of product use (i.e. transitions between products) deserve further study. Longitudinal surveillance of diverse tobacco product use

Abbreviations: ENDS, Electronic nicotine delivery systems; PATH, Population Assessment of Tobacco and Health; SLT, Smokeless tobacco; TUAC, Tobacco User Adult Cohort; < SDW, Less than some days/week or none at all

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patterns in underserved rural and urban populations is especially important, as the burden of tobacco-attributable diseases is pronounced among these vulnerable groups (Pearson et al., 2012). Examination of transitions among products also allows for recognition of trends and patterns of use according to subgroups (e.g. socio-economic status, geographical location). Monitoring product use over time helps to examine whether preferences and types consumed are related to quitting intentions and successful long-term abstinence. Alternatively, these behaviors may be related to nicotine dependence (with no intention of quitting) or product substitution due to indoor air restrictions. In this paper, we describe transitions from baseline dual tobacco product use to subsequent use at six, twelve, and eighteen months among adult rural and urban community residents enrolled in the Tobacco User Adult Cohort (TUAC).

2. Methods

2.1. Study design

The TUAC longitudinal cohort enrolled participants residing in six rural counties and one urban county in the U.S. state of Ohio during 2014–15 with an overall response rate of 21.6%. Participants were interviewed face-to-face at baseline, six, twelve, and eighteen months and received a \$50 incentive for each interview. Complete study details are described elsewhere (Richardson et al., 2012). The study was approved by Ohio State University's Institutional Review Board.

2.1.1. Eligibility criteria

a) ≥ 18 years; b) resident of designated rural or urban counties; c) willing to provide informed consent; and d) meets criteria for inclusion in one of the following tobacco use groups: 1) exclusive combustible user: self-reports smoking > 100 cigarettes (or small cigars/cigarillos, pipes filled with tobacco, cigars, filtered cigars, or hookah) in lifetime and currently smoking at least some days/week; 2) exclusive SLT user: self-reports current use of chew, snuff, snus or dissolvable tobacco at least some days/week; 3) exclusive ENDS user: self-reports current use of an e-cigarette at least some days/week; and 4) dual user: self-reports current use in two or more of the categories described above (Backinger et al., 2008; Bombard et al., 2009; O'Connor, 2012) at least some days/week. For the purposes of this study, only dual users at baseline were included.

2.2. Measures

2.2.1. Baseline social-demographic characteristics

1) age; 2) gender; 3) sexual orientation; 4) race/ethnicity; 5) education; 6) household income; 7) marital status; 8) employment status; and 9) county of residence.

2.2.2. Six, twelve, and eighteen month tobacco product use

Self-reported tobacco product category as described above (Backinger et al., 2008; Bombard et al., 2009; O'Connor, 2012; Tomar et al., 2010) or an additional category to include tobacco product use with reduced frequency: 5) less than some days/week: tobacco product use less than some days/week or none at all ($< SDW$).

2.3. Statistical models and analyses

Using the tobacco product use data collected during the first 18 months of the study, we estimate the transition probabilities from the dual use category (Tomar et al., 2010) to category i , for $i = 1$ to 5 in 6, 12, and 18 months. Subdivision of the dual use category into the following 4 sub-categories will provide insight into the transition patterns into and out of them: Combustible/ENDS; Combustible/SLT; SLT/ENDS; Combustible/SLT/ENDS.

We use the multinomial model and the method of maximum

likelihood to estimate the transition probabilities resulting in estimates given by the sampled fractions observed in the study; 95% Wilson or Clopper-Pearson confidence intervals are reported for probabilities over 20%. Pearson chi-squared and Fisher exact tests are used to compare the rows of transition probabilities for the rural and urban cohorts. Due to small sample size, covariates are not adjusted for in our analyses. As there was no intervention, missing values are treated as missing completely at random. We use a significance level of 0.05 and software SAS 9.4 (SAS Institute, Cary, NC) in all our analyses.

3. Results

3.1. Sample characteristics

A total of 145 participants were dual users at baseline (rural $n = 67$; urban $n = 78$). The majority were male (55.2%), self-identified as straight (90.9%), middle-aged (mean = 44.8; standard deviation = 15.8 years), Caucasian (89.0%) and had at least some college education (57.9%). Over one-third (43.4%) reported a household income under \$25,000, with 41.4% married or partnered. About 49% were unemployed. Urban participants were younger, more racially diverse, slightly more educated, more likely to be employed and reported higher household incomes.

Among these dual users, 113 (77.9%) were combustible/ENDS users, 25 (17.2%) were combustible/SLT users, 4 (2.8%) were SLT/ENDS users, and 3 (2.1%) were combustible/SLT/ENDS users each using the listed products at least some days/week. Among the 113 combustible/ENDS users, 9 had used SLT products regularly in the past and the average length of combustible and ENDS use was 26.5 and 1.9 years, respectively. Eight of the 25 combustible/SLT users had used an ENDS product regularly in the past and the average length of combustible and SLT use was 19.8 and 15.7 years, respectively.

3.2. Cross-sectional and transition patterns of dual users

Table 1 displays the proportions of the baseline dual users in each of the five use categories at follow-up where participants in all categories except $< SDW$ use tobacco products at least some days per week. By 6 months, only 43% of rural and 37% of urban users remain dual users; by 18 months, these figures are reduced respectively to 24% and 22%. Chi-squared tests for comparisons of follow-up transition probabilities indicate that rural and urban groups show differences only for 12-month transitions.

Dual users are made up of 4 distinct sub-types: Combustible/ENDS, Combustible/SLT, SLT/ENDS, and Combustible/SLT/ENDS. To evaluate the prevalence of these categories among dual users, we take the available baseline data as random samples from the population of rural and urban dual users. For the rural group ($n = 67$), the estimated prevalence for the four sub-categories are 69%, 27%, 3% and 1%. For the urban group ($n = 78$) the corresponding values are 86%, 9%, 2.5% and 2.5%, respectively. A Fisher's exact test shows a significant difference between rural and urban dual user groups ($p = 0.019$) (Data not shown).

At 6-months, the corresponding values remain close to the baseline prevalence estimates; for rural users, they are 69%, 27%, 4% and 0% ($n = 49$), and for urban users, 82%, 11%, 5% and 2% ($n = 44$), respectively. At 18-months, they are 68%, 26%, 3%, and 3% for rural ($n = 31$), and 87%, 9%, 0%, and 4% for urban ($n = 23$) dual user groups. There was no significant difference between rural and urban dual user groups at 6 or 18 months ($p = 0.217$, and $p = 0.252$, respectively).

Table 2 exhibits the pattern of transitions between and out of the dual sub-categories into other categories at 18 months. For transitions from the Combustible/ENDS category, there are only minor differences between the patterns of the rural and urban participants; 74% of rural participants and 54% of urban participants revert to being exclusive

Table 1
Transition prevalences (and 95% Wilson confidence intervals) for dual users at baseline among rural and urban cohort members.^a

	Follow-up category	At least some days/week				< SDW	Total	χ^2 (p-value) ^b
		Comb	SLT	ENDS	Dual			
		6 month transition	Rural	43% (31.8, 55.2)	6%			
	Urban	43% (32.1, 54.0)	4%	9%	37% (27.3, 48.7)	7%		
12 month transition	Rural	57% (44.9, 68.6)	11%	3%	27% (17.6, 39.0)	2%	13.61 (0.009)	
	Urban	42% (31.1, 53.8)	3%	13%	30% (20.9, 42.1)	12%		
18 month transition	Rural	59% (46.5, 70.5)	10%	5%	24% (14.2, 34.9)	3%	6.89 (0.142)	
	Urban	49% (37.5, 61.1)	5%	14%	22% (13.3, 33.0)	11%		

Comb = Exclusive combustible; SLT = Exclusive smokeless; ENDS = Exclusive e-cigarette; Dual = Current use of two or more categories; < SDW = Less than some days per week.

^a Confidence intervals were suppressed for those percentages < 20%.

^b The chi-squared statistic with 4^o of freedom simultaneously compares the corresponding transition probabilities for the rural and urban cohort members.

combustible users while < 1/4 remain in their current category (Fisher exact test *p*-value 0.272). For the other three sub-categories the sample sizes are too small to draw any statistical conclusions. Descriptively speaking, for transitions from the Combustible/SLT category, nearly 30% remain in that category. Transitions from one dual sub-category into another are rare, and when a transition takes place, it is to either the exclusive combustible, SLT, or ENDS category, whichever is the relevant component of the baseline dual category. Similar observations hold when we examine 6-month and 12-month transitions from dual sub-categories.

Loss at follow-up was limited, with 3%, 9%, and 13% at 6, 12, and 18 months, respectively. No associations were found between loss to follow-up and demographic characteristics.

4. Discussion

This research described tobacco use transitions among dual users at baseline in a cohort of rural and urban adults. Since ENDS are a recent development, previous product transition studies included only cigarette smokers and smokeless tobacco users and described whether participants engaged in dual use of both types of products (Roberts et al., 2016; Ohio Medicaid Assessment Survey, 2015; Tam et al., 2015;

Tomar et al., 2010). At present, dual use includes ENDS, as product use has markedly increased, given their introduction and popularity in the U.S. market (O'Connor, 2012). Our findings represent one of the first attempts to longitudinally describe these transitions among adults classified as dual users at cohort entry.

Dual use among rural and urban cohort members was unstable with the majority of dual users switching to an exclusive use category at follow-up. The only significant difference between cohorts was observed at 12 months; however when we looked at transitions from dual to other states, there was no significant difference. At baseline, the majority of dual users reported consumption of cigarettes and ENDS. For those dual users who transitioned, the switch was primarily to an exclusive combustible product category. Since approximately 75% of dual users were also experienced combustible product users at baseline, it is not surprising that they returned to this exclusive category during follow-up. Reasons for their return are unknown, but may reflect less satisfaction with ENDS products.

Resumption of an exclusive combustible pattern of tobacco use is of concern. Among the diverse types of tobacco products, combustibles are considered to be responsible for the most harm to the population, given their toxic constituents and highly effective nicotine delivery system (Hajek et al., 2014). Compared to combustible tobacco, non-

Table 2
Estimates of baseline to 18 month transition probabilities of dual users at baseline.^a

Baseline category		18 month category					< SDW	Baseline total
		Dual use at least some days/week		Single product use at least some days/week				
		Comb/ENDS	Other combination	Comb	SLT	ENDS		
Comb/ENDS	Rural	14%	0%	74% (58.9, 84.7)	0%	7%	5%	42
	Urban	21% (12.5, 33.3)	0%	54% (41.6, 66.6)	0%	12%	12%	57
Other product combination	Rural	0%	42% (23.1, 63.7)	26% (11.8, 48.8)	32% (15.4, 54.0)	0%	0%	19
	Urban	0%	25% (3.1, 65.1) ^b	13%	38% (8.5, 75.5) ^b	25% (3.1, 65.1) ^b	0%	8
18 month total	Rural	6	8	36	6	3	2	61
	Urban	12	2	32	3	9	7	65

Comb = Exclusive combustible; SLT = Exclusive smokeless; ENDS = Exclusive e-cigarette; Dual = Current use of two or more categories; < SDW = Less than some days per week.

^a Confidence intervals were suppressed for those percentages < 20%.

^b Clopper-Pearson exact confidence interval; the rest are Wilson confidence intervals.

combustible products (i.e. SLT, ENDS) are believed to be less hazardous with lower health risks (Hajek et al., 2014; U.S. Department of Health and Human Services, 2014; Wetter et al., 2002). Where dual use falls on the continuum of harm deserves further attention, as this tobacco use category may influence population-level harm in a variety of directions. For example, switching from a combustible product to a non-combustible product, such as SLT or e-cigarettes, may deliver lower levels of toxic constituents and could be beneficial. Alternatively, adding new product(s) without discontinuing, or reducing, the amount of the original combustible product used may increase harm. Unfortunately, our findings indicated that very few dual users reduced their tobacco use to less than some days per week. When this did occur, the transition was observed more frequently in urban cohort members.

There are several limitations associated with this study. While the design included county-level address-based sampling with random selection of one adult per household, the findings are generalizable to Ohio adults residing in these counties. Of note, the socio-demographic characteristics of the cohort closely resemble those of tobacco users in Ohio (Zeller et al., 2009), where cigarette smoking and smokeless tobacco use remains higher than national estimates (Zhu et al., 2009) and like the U.S. in general, dual use is becoming increasingly prevalent (Zeller et al., 2009). The category of tobacco product use was based on self-report. However, an image of the participant's current self-reported tobacco product(s) was captured during each interview. Finally, those who completely quit tobacco use were included in the < SDW category at follow-up, as the number of total abstainers was small.

In summary, to extend regulatory science, consumer product preferences and the underlying factors associated with product switching and the uptake of dual products must be explicated. Future research is needed to better understand these behaviors including the intentions of the users, given the potential for non-combustible products, including ENDS, to serve as a harm reduction strategy in adults unmotivated or unable to quit smoking.

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Declaration of interests

All authors declare no conflicts of interest.

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