## The impact of current tobacco product use definitions on estimates of transitions between cigarette and e-cigarette use

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### Background

- Definitions of **current tobacco product** use vary and depend on frequency of use, established use criteria, and the product type.
  - Established use: Do not-yet-established users count as "current" users?
  - Threshold of use: How frequently does an individual have to use to be a "current" user?
  - Product type: do the answers above differ for e-cigarettes vs cigarettes?
- It is not known how and to what extent estimates of **transition rates** between different tobacco products depend on the choice of current use definition.



#### Data

- PATH is a longitudinal study of tobacco use
- Waves 1–4 (2013–17)
- Include 24,309 adult participants (in at least two waves and no relevant missing data)
- Our variables are derived from questions about:
  - Established use of cigarettes or e-cigarettes/e-products
  - Number of days of use in the past 30 days of cigarettes and e-cigarettes/eproducts

### Methods – Multistate transition model

• Continuous time stochastic model tracking a person's tobacco-use state through time estimates underlying transition hazard rates



Brouwer et al. (2020). *Tobacco Control.* Example code is accessible at *tcors.umich.edu* 

#### Analysis

- Estimate hazard rates for transitions between never, non-current, cigarette, e-cigarette, and dual user states
  - For different thresholds for current use
    - 1+, 10+, 20+, and 30 days of the past 30 days
  - With and without established use criteria
    - Cigarettes: has smoked at least 100 cigarettes
    - E-cigarettes: ever a fairly regular user of e-cigarettes
- Two classes of models
  - Infrequent (below threshold) users are classified as non-current users
  - Infrequent users are distinct from both non-current and frequent (above threshold) users

### Tobacco use states



Infrequent users are distinct

#### Results – infrequent users are non-current



## Including non-established users reduces persistence, especially for e-cigarette and dual use

Non-established cigarette users **excluded** Non-established e-cigarette users **excluded**  Non-established cigarette users **excluded** Non-established e-cigarette users included Non-established cigarette users included Non-established e-cigarette users included



Never user 96.5	2.0	1.1	0.3	0.1
Non-current user	93.9	<mark>5</mark> .1	0.8	0.2
Cigarette user	9.3	85.4	1.1	4.3
ENDS user	21.9	7.1	56.9	14.1
Dual user	4.4	44.9	9.6	41.1



Current users use at least **1 day** in past 30

	Curr least	ent u t <b>20 (</b>	users days	use in pa	at ast 30	)	Cu lea
Never user	96.5	2.5	0.8	0.1	0.0		96.
Non-current	user	93.9	5.0	0.9	0.3		
Cigarette us	er	11.4	82.7	1.0	4.9		
ENDS user		21.8	7.6	54.8	15.9		
Dual user		<u>5</u> .1	42.7	10.2	41.9		

Current users use at least **30 days** in past 30



Transitions are largely robust to changing the threshold of use.

Using stricter definitions of use increases the fraction of ENDS users that transition to dual use, that is *more frequent users of ENDS are more likely to pick up cigarettes* 

#### Results – infrequent users are distinct

#### Infrequent use is <30 days, frequent is 30 days

Never 96.5	2.0	0.5	0.7	0.2	0.1	0.0	0.0	0.0	0.0	
Non-current	93.3	<mark>3.8</mark>	1.8	0.4	0.4	0.1	0.1	0.1	0.0	
Infrequent cig	22.6	48.6	23.9	0.3	0.6	1.8	0.7	1.0	0.4	
Frequent cig	5.3	6.0	82.9	0.1	0.9	0.3	0.8	2.6	1.1	1-wave cumulative
Infrequent e-cig	39.0	6.1	5.9	25.3	13.7	3.7	2.5	3.0	0.9	probability (%)
Frequent e-cig	10.3	1.9	5.0	6.0	60.4	2.3	7.8	3.1	<mark>3</mark> .2	75
Infrequent dual	11.7	25.8	22.5	5. <mark>4</mark>	3.6	13.4	6.1	9.4	2.1	25
Infreq cig, freq e-cig	3.9	4.2	14.8	2.5	20.5	5.8	30.6	9.3	8.4	U
Freq cig, infreq e-cig	3.0	3.5	50.7	1.3	2.5	2.1	5.3	25.7	5.9	
Frequent dual	4.8	2.4	35.5	1.0	6.6	1.9	7.1	20.8	19.9	

#### Results – infrequent users are distinct

#### Infrequent use is <30 days, frequent is 30 days

Never 96.5	2.0	0.5	0.7	0.2	0.1	0.0	0.0	0.0	0.0		Infrequent cigarette users are equally likely to stop			
Non-current	93.3	3.8	1.8	0.4	0.4	0.1	0.1	0.1	0.0		using or increase use			
Infrequent cig	22.6	<u>48.6</u>	23.9	0.3	0.6	1.8	0.7	1.0	0.4		frequency in the next wave.			
Frequent cig	5.3	6.0	82.9	0.1	0.9	0.3	0.8	2.6	1.1	1-wave cumulative	Frequent cigarette users stay			
Infrequent e-cig	39.0	6.1	5.9	<u>25.3</u>	13.7	3.7	2.5	3.0	0.9	probability (%)	nequent cigarette users.			
Frequent e-cig	10.3	1.9	5.0	6.0	60.4	2.3	7.8	3.1	3.2	75	Infrequent e-cigarette users			
Infrequent dual	11.7	25.8	22.5	5.4	3.6	13.4	6.1	9.4	2.1	25	using than they are to be			
Infreq cig, freq e-cig	3.9	4.2	14.8	2.5	20.5	5.8	30.6	9.3	8.4	0	using more in the next wave.			
Freq cig, infreq e-cig	3.0	3.5	50.7	1.3	2.5	2.1	5.3	25.7	5.9		Frequent e-cigarette users			
Frequent dual	4.8	2.4	35.5	1.0	6.6	1.9	7.1	20.8	19.9		frequent e-cigarette users.			

# Unlike before, this class of models is robust to including non-established users.

#### Non-established cigarette users **excluded** Non-established e-cigarette users **excluded**

Never	96 5 2.0	0.4	0.7	0.2	0.1	0.0	0.0	0.0	0.0	
Non-current	93.8	3.3	1.8	0.4	0.5	0.1	0.1	0.1	0.0	
nfrequent cig	24.4	47.2	24.1	0.4	0.5	1.5	0.7	0.9	0.4	
Frequent cig	5.7	5.7	82.9	0.1	1.0	0.2	0.6	2.5	1.2	
nfrequent e-cig	43.4	5.2	4.6	21.1	14.3	4.3	2.0	3.8	1.3	
Frequent e-cigs	11.9	1.1	5.3	5.9	61.1	1.5	7.3	2.6	3.5	
nfrequent dual	14.3	28.2	19.0	6.2	4.3	9.5	5.1	10.0	3.3	
nfreq cig, freq (	4.0	5.6	13.0	2.9	22.5	5.8	25.0	10.6	10.7	
Freq cig, infreq	3.2	3. <mark>8</mark>	52.1	1.4	2.2	1.9	4.3	24.0	7.3	
Frequent dual	25	33	37.6	14	79	28	13.1	19.9	11.5	

Non-established cigarette users **excluded** Non-established e-cigarette users included

94.9	4.0	0.3	0.4	0.2	0.0	0.0	0.0	0.0	0.0
	93.3	2.8	1.9	1.1	0.5	0.2	0.1	0.1	0.0
	24.2	45.7	23.3	0.7	0.5	2.8	0.7	1.6	0.5
	5.7	5.5	79.8	0.2	1.1	0.4	0.6	5.2	1.6
	53.2	5.0	5.1	18.7	9.1	3.5	1.2	3.3	0.8
	13.1	1.3	5.2	6.6	59.0	1.5	7.3	2.5	3.5
	16.2	33.7	19.2	5.1	2.5	10.9	3.0	7.5	1.9
	4.6	7.1	13.6	2.8	22.0	5.9	24.1	9.3	10.7
	3.5	4.3	59.4	1.0	1.5	1.7	2.3	21.1	5.1
	2.7	3.5	41.3	1.1	7.3	2.5	10.9	19.0	11.7

Non-established cigarette users included Non-established e-cigarette users included

16.9	2.5	0.3	0.1	0.2	0.1	0.0	0.0	0.0	0.0	
	95.9	2.1	0.9	0.6	0.2	0.2	0.0	0.1	0.0	
	27.8	44.6	20.5	0.8	0.5	3.1	0.8	1.4	0.5	1-wave
	5.8	5.9	79.4	0.2	1.1	0.4	0.5	5.2	1.5	cumulative transition probability (%)
	51.7	6.6	4.1	17.3	9.9	5.5	1.4	2.6	0.8	75
	11.6	1.5	5.2	6.1	60.3	1.8	7.6	2.4	3.7	50
	19.3	32.3	16.0	6.8	2.9	12.0	2.9	6.2	1.7	25
	4.8	7.9	13.0	2.9	21.4	6.1	24.5	8.8	10.6	0
	3.6	4.4	59.4	1.0	1.5	1.8	2.3	20.8	5.2	
	2.6	3.8	41.5	1.1	6.7	2.5	10.6	19.1	12.0	

Never 96.5	2.0	0.2	0.9	0.1	0.2	0.0	0.0	0.0	0.0	
Non-current	93.3	2.6	3.0	0.2	0.6	0.0	0.0	0.1	0.1	
Infrequent cig	30.2	33.9	31.5	0.2	0.8	0.8	0.5	0.7	1.3	
Frequent cig	6.6	3.6	84.0	0.1	0.9	0.2	0.4	1.7	2.5	1-wave cumulative
Infrequent e-cigs	42.9	2.9	9.8	19.6	16.2	2.0	2.0	2.3	2.3	probability (%)
Frequent e-cigs	14.2	1.3	6.3	4.4	58.1	1.2	4.9	2.7	6.9	75
Infrequent dual	17.1	23.6	21.5	5.5	6.2	8.1	5.7	6.1	6.2	25
Infreq cig, freq e-cigs	5.7	2.4	14.1	1.9	24.7	2.3	19.0	7.3	22.5	0
Freq cig, infreq e-cigs	3.5	2.2	57.6	0.5	3.0	0.7	1.7	17.4	13.3	
Frequent dual	3.8	1.3	37.B	0.8	7.5	0.7	5.4	13.8	29.4	

But, transitions involving infrequent use are not robust to changing the threshold of use.

Current users use at least **10 days** in past 30

Current users use at least 20 days														
i	in past 30													
lever 96	5.5 2.0	0.4	0.8	0.2	0.1	0.0	0.0	0.0	0.0	9				
Ion-current	93.3	3.3	2.3	0.3	0.5	0.1	0.1	0.1	0.1					
nfrequent cig	25.9	41.5	28.0	0.4	0.7	1.3	0.6	1.0	0.7					
requent cig	5.8	5.0	83.4	0.1	0.9	0.2	0.6	2.5	1.4					
nfrequent e-cigs	41.0	4.1	7.1	21.7	15.7	3.4	2.7	2.8	1.5					
requent e-cigs	12.0	1.9	5.6	<b>4.7</b>	60.1	1.4	6.3	3.3	4.7					
nfrequent dual	12.9	26.6	21.7	4.1	5.8	10.8	6.1	8.7	3.4					
nfreq cig, freq e-cigs	5.6	2.8	14.8	2.3	22.3	2.8	27.6	8.9	12.8					
req cig, infreq e-cigs	3.2	2.8	52.0	1.0	3.1	1.1	3.5	24.1	9.1					
requent dual	4.0	1.8	36.2	0.8	6.8	0.9	7.2	18.5	23.8					

	Cur in p	rent bast	t use 30	ers u	ise a	at lea	ast 3	80 da	ays	
96.5	2.0	0.5	0.7	0.2	0.1	0.0	0.0	0.0	0.0	
	93.3	3.8	1.8	0.4	0.4	0.1	0.1	0.1	0.0	
	22.6	48.6	23.9	0.3	0.6	1.8	0.7	1.0	0.4	
	5.3	6.0	82.9	0.1	0.9	0.3	0.8	2.6	1.1	1-wave cumulative
	39.0	6.1	5.9	25.3	13.7	3.7	2.5	3.0	0.9	probability (%)
	10.3	1.9	5.0	6.0	60.4	2.3	7.8	-3.1_	3.2	75
	11.7	25.8	22.5	5.4	3.6	13.4	6.1	9.4	2.	25
	3.9	4.2	14.8	2.5	20.5	5.8	30.6	9.3	8.4	0
	3.0	3.5	50.7	1.3	2.5	2.1	5.3	25.7	5.9	
	4.8	2.4	35.5	1.0	6.6	1.9	7.1	20.8	19.9	

#### Conclusions

- Product use definitions have important implications for assessing product use transitions and thus the public health implications of cigarette and e-cigarette control strategies.
- Transition models that treat infrequent users as non-current are more robust to thresholds of use and less robust to inclusion of nonestablished users
- Transition models that treat infrequent users as distinct are less robust to thresholds of use and more robust to inclusion of nonestablished users
- Greater attention needs to be placed on understanding patterns of infrequent use.

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