Trends in Tobacco Dependence Among U.S. Adults Who Smoke Cigarettes or Use E-Vapor Products

Cross-Sectional and Longitudinal Analyses of Population Assessment of Tobacco and Health (PATH) Study Waves 1 to 7 Data

Lai Wei; Yisha He; Raheema Muhammad-Kah; Mingda Zhang; Edward Largo

The 78th Tobacco Science Research Conference
Knoxville, Tennessee USA

Agenda

Background and Methods

Trends in Tobacco Dependence Index (TDI)
Cross-Sectional Analysis

TDI in Relation to Transition and Quitting
Longitudinal Analysis

Summary and Conclusions

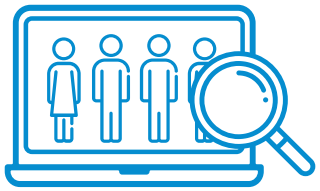
Background and Methods

Trends in tobacco dependence
in context of harm reduction have not been well studied

The Population Assessment of Tobacco and Health (PATH) Study
Sponsored by NIH and FDA

- **Ongoing nationally representative, longitudinal** cohort study of US youth and adults
- **Generates epidemiologic data on tobacco use behaviors** including patterns of use, attitudes, beliefs, exposures, and health consequences associated with the use of tobacco products

Allows us to assess tobacco dependence over time



We analyzed seven waves (2013-2023) of PATH Adult (18+) Data to identify trends in tobacco dependence among three study groups:

Cigarette Only
(CS Only)

Smoke cigarettes every day or some days, have smoked 100+ cigarettes in entire life, and do not use other tobacco products

E-vapor Only
(EV Only)

Use E-vapor products every day or some days, have used e-vapor products fairly regularly, and do not use other tobacco products

Cigarette and E-vapor Dual Use
(DU)

Smoke cigarettes every day or some days, have smoked 100+ cigarettes in entire life; use E-vapor products every day or some days, have used e-vapor products fairly regularly, and do not use other tobacco products

Background and Methods
Tobacco Dependence Index (TDI)

THE TOBACCO DEPENDENCE INDEX (TDI)

Developed by Strong et. al (2017) based on PATH adult data; Psychometrically validated with Wave 1 and follow-up wave data (Strong et. al, 2020 and 2022)

- **Facilitate tobacco dependence comparisons** across a range of tobacco products
- **Examine changes in dependence** related to switching behaviors

The TDI score is the average of 16 items

15 using a 1–5 scale ranging from "**not at all true of me**" to "**extremely true of me**"

1 2 3 4 5

Not at all True of Me — **Extremely True of Me**

One dichotomous item was scored 1 or 5

1 5

No **Yes**

PATH Tobacco Dependence Index Scale Items for Current Users of Cigarettes

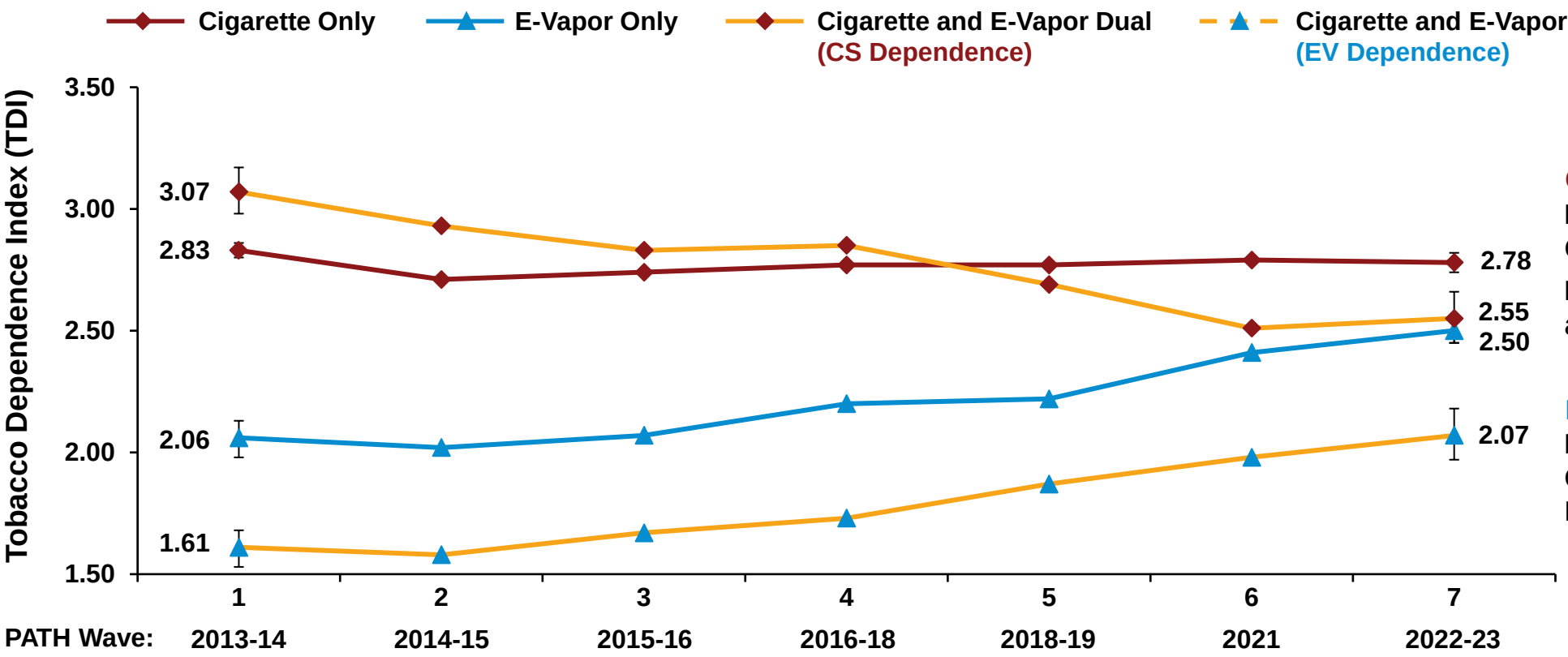
Current Smokers	Response Categories and Coding
I find myself reaching for cigarettes without thinking about it.	1=Not true of me at all 2 3 4 5=Extremely true of me
I frequently crave cigarettes.	
My urges keep getting stronger if I don't smoke cigarettes.	
Cigarettes control me.	
My cigarette smoking is out of control.	
I usually want to smoke cigarettes right after I wake up.	
I can only go a couple of hours without smoking cigarettes.	
I frequently smoke cigarettes without thinking about it.	
Smoking cigarettes really helps me feel better if I've been feeling down.	
Smoking cigarettes helps me think better.	
I would feel alone without my cigarettes.	
I would find it really hard to stop smoking cigarettes.	
I would find it hard to stop smoking cigarettes for a week.	
After not smoking cigarettes for awhile, I need to smoke cigarettes to feel less restless and irritable.	
After not smoking cigarettes for awhile, I need to smoke cigarettes in order to keep myself from experiencing any discomfort.	
In the past 12 months, did you find it difficult to keep from smoking cigarettes in places where it was not permitted?	1=No 5=Yes

A separate e-vapor dependence module (replacing cigarettes with electronic nicotine products)

Source: Shiffman, S., & Sembower, M. A. (2020). Dependence on e-cigarettes and cigarettes in a cross-sectional study of US adults. *Addiction* (Abingdon, England), 115(10), 1924–1931. https://doi.org/10.1111/add.15060

Trends in Tobacco Dependence (TDI)

Cross-Sectional Analysis of PATH Wave 1 to Wave 7 Data



CIGARETTE TDI Score

REMAINS FLAT in the Cigarette Only group,

DECLINES in the Cigarette and E-Vapor Dual User group

E-VAPOR TDI Score

IS RISING in both E-Vapor Only and Cigarette and E-Vapor Dual User Groups

ALCS Cross-Sectional Analysis of PATH Wave 1 to Wave 7 Adult (18+) Data. EV Only Sample Size: Wave 1 n=415, Wave 2 n=518, Wave 3 n= 620; Wave 4 n=777; Wave 5 n=1553; Wave 6 n=1694; Wave 7 n=2078.
In Waves 1 and 2, dependence variables without 'E' suffix were used for e-vapor dependence in e-vapor only group (if data on dependence variables with 'E' suffix were available, we used the dependence variable with 'E' suffix instead), and variables with 'E' suffix were used for e-vapor dependence in cigarette and e-vapor dual user group. Dependence variables without 'E' suffix were used for cigarette dependence in cigarette only group and cigarette and e-vapor dual user group.
In Waves 3 to 7, dependence variables with 'E' suffix were used for e-vapor dependence in e-vapor only group and cigarette and e-vapor dual user group; dependence variables without 'E' suffix were used for cigarette dependence in cigarette only group and cigarette and e-vapor dual user group. See PATH Wave 3 questionnaire for questionnaire programming details.

Trends in Tobacco Dependence (TDI)

Cross-Sectional Analysis of PATH Wave 1 to Wave 7 Data

E-Vapor Only Group

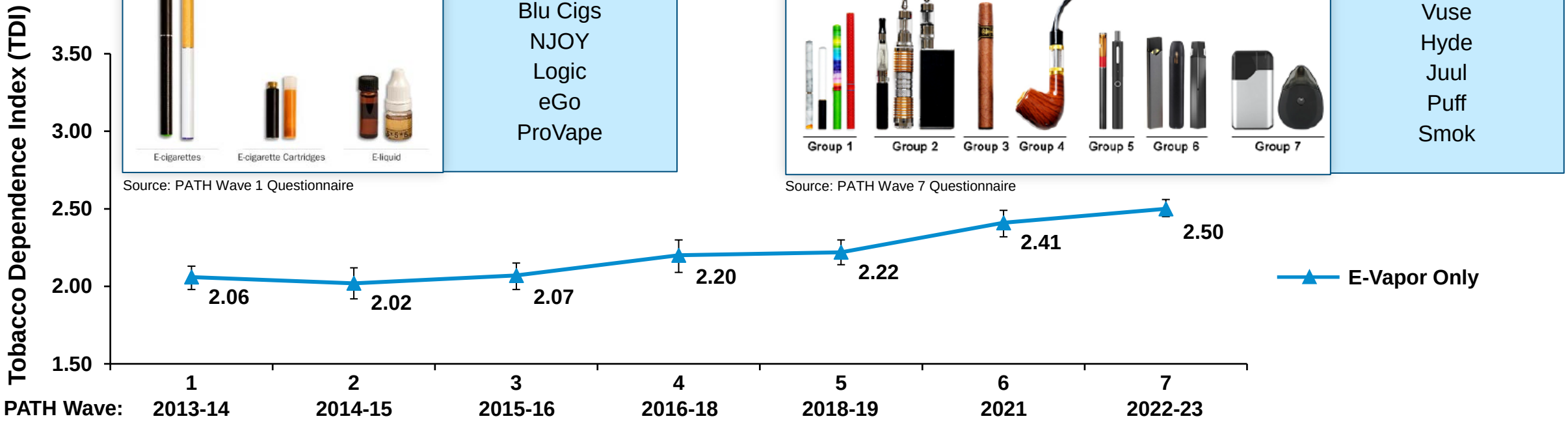
Increase in e-vapor TDI score coincides with evolution of e-vapor products

Wave 1 Top Brands
Blu Cigs
NJOY
Logic
eGo
ProVape

Source: PATH Wave 1 Questionnaire

Wave 7 Top Brands
Vuse
Hyde
Juul
Puff
Smok

Source: PATH Wave 7 Questionnaire



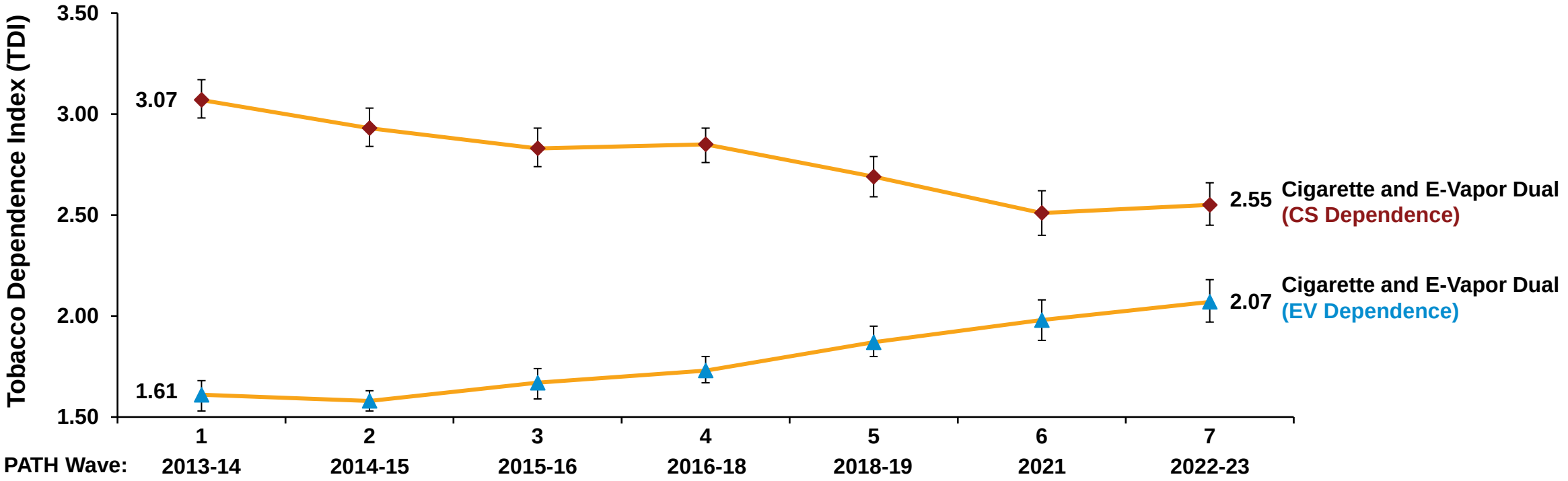
ALCS Cross-Sectional Analysis of PATH Wave 1 to Wave 7 Adult (18+) Data.
In Waves 1 and 2, dependence variables without 'E' suffix were used for e-vapor dependence in e-vapor only group (if data on dependence variables with 'E' suffix were available, we used the dependence variable with 'E' suffix instead), and variables with 'E' suffix were used for e-vapor dependence in cigarette and e-vapor dual user group. Dependence variables without 'E' suffix were used for cigarette dependence in cigarette only group and cigarette and e-vapor dual user group.
In Waves 3 to 7, dependence variables with 'E' suffix were used for e-vapor dependence in e-vapor only group and cigarette and e-vapor dual user group; dependence variables without 'E' suffix were used for cigarette dependence in cigarette only group and cigarette and e-vapor dual user group. See PATH Wave 3 questionnaire for questionnaire programming details.
Top brands are based on brand of e-cigarettes usually / last used among current e-vapor users.

Trends in Tobacco Dependence (TDI)

Cross-Sectional Analysis of PATH Wave 1 to Wave 7 Data

Cigarette and E-Vapor Dual Use Group

Patterns in cigarette dependence and e-vapor dependence trends suggest changing dual use behavior over time

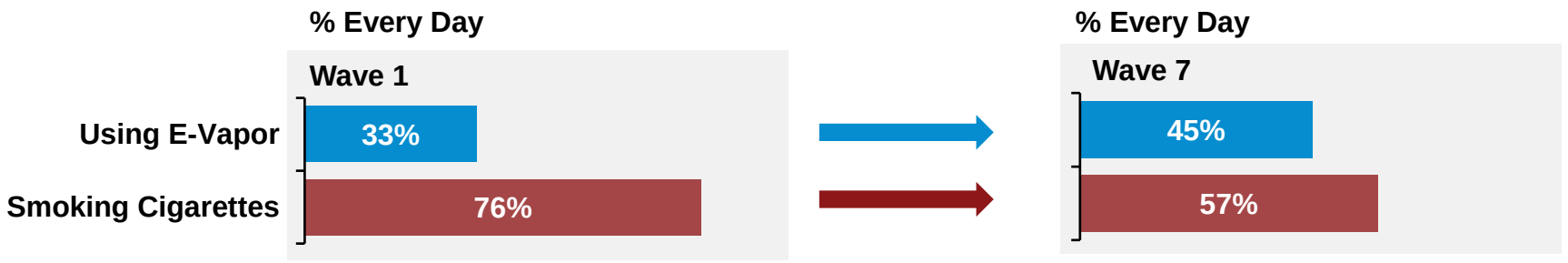


ALCS Cross-Sectional Analysis of PATH Wave 1 to Wave 7 Adult (18+) Data. Dual User Group Sample Sizes: Wave 1 n=680; Wave 2 n=802; Wave 3 n=687; Wave 4 n=784; Wave 5 n=915; Wave 6 n=639; Wave 7 n=719.
In Waves 1 and 2, dependence variables without 'E' suffix were used for e-vapor dependence in e-vapor only group (if data on dependence variables with 'E' suffix were available, we used the dependence variable with 'E' suffix instead), and variables with 'E' suffix were used for e-vapor dependence in cigarette and e-vapor dual user group. Dependence variables without 'E' suffix were used for cigarette dependence in cigarette only group and cigarette and e-vapor dual user group.
In Waves 3 to 7, dependence variables with 'E' suffix were used for e-vapor dependence in e-vapor only group and cigarette and e-vapor dual user group; dependence variables without 'E' suffix were used for cigarette dependence in cigarette only group and cigarette and e-vapor dual user group. See PATH Wave 3 questionnaire for questionnaire programming details.

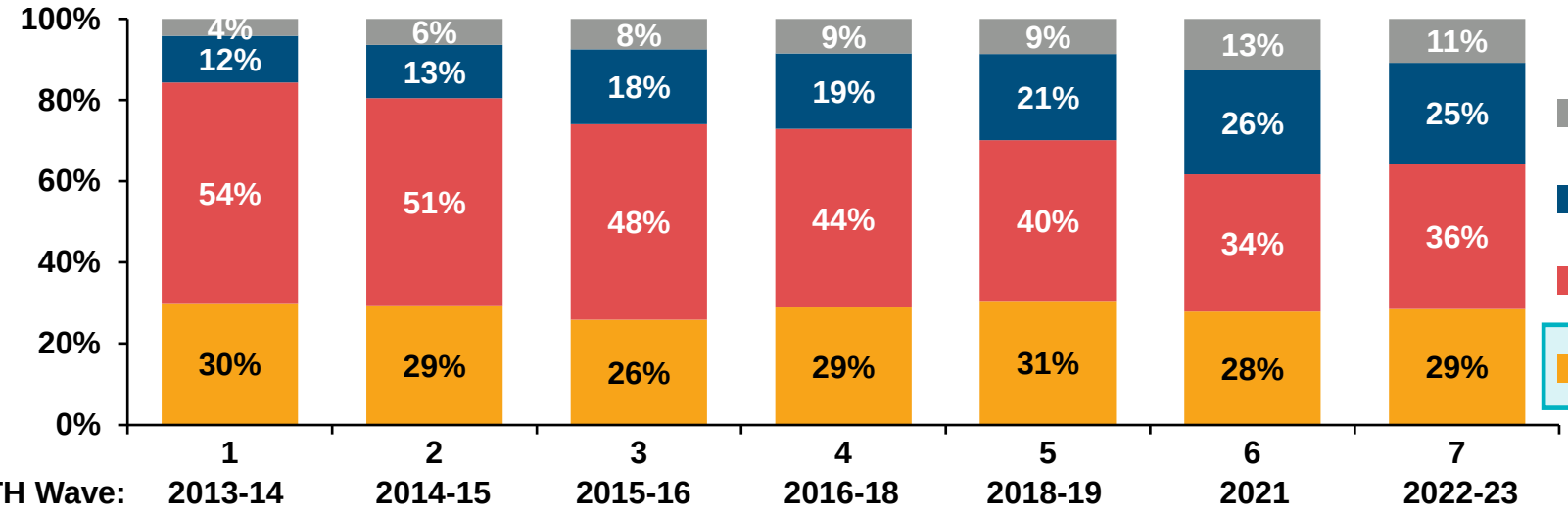
Changes in Cigarette and E-Vapor Dual Use Pattern

Cross-Sectional Analysis of PATH Wave 1 to Wave 7 Data

Cigarette and E-Vapor Dual Use Group



Proportion of Dual User Segment (Cigarette and E-Vapor Dual Group)



Wave 7 TDI

	Cigarette	E-Vapor
Infrequent Dual	1.47	1.49
Vapers Who Smoke	1.68	2.88
Smokers Who Vape	3.09	1.42
Frequent Dual	3.05	2.40

ALCS Cross-Sectional Analysis of PATH Wave 1 to Wave 7 Adult (18+) Data.
Dual User Group Sample Sizes: Wave 1 n=680; Wave 2 n=802; Wave 3 n=687; Wave 4 n=784; Wave 5 n=915; Wave 6 n=639; Wave 7 n=719.

Dual Segment Definition based on Past 30-Day Usage
Infrequent Dual: CS Days<20, EV Days<20;
Vapers who Smoke: CS Days<20, EV Days≥20;
Smoker who Vape: CS Days≥20, EV Days<20;
Frequent Dual: CS Days≥20, EV Days≥20.

Agenda

Background and Methods

Trends in Tobacco Dependence Index (TDI)
Cross-Sectional Analysis

TDI in Relation to Transition and Quitting
Longitudinal Analysis

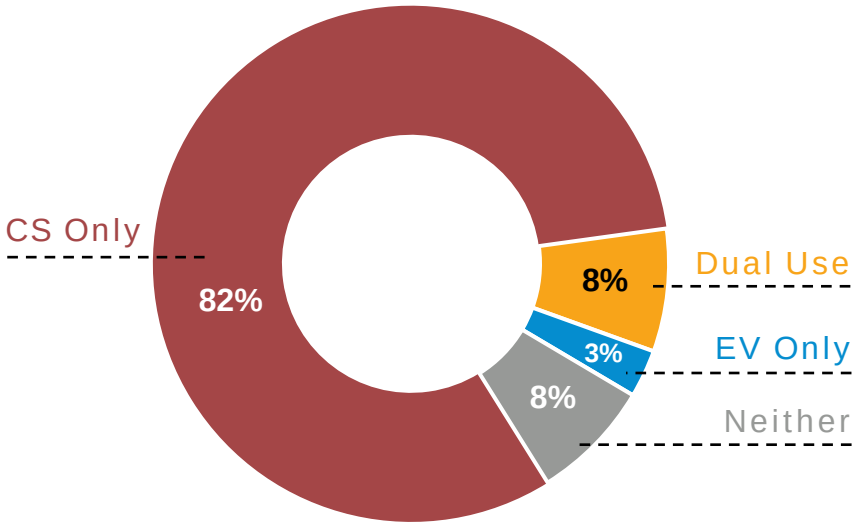
Summary and Conclusions

Tobacco Dependence in Relation to Transitions Longitudinal Analysis of PATH Wave 6 to Wave 7 Data

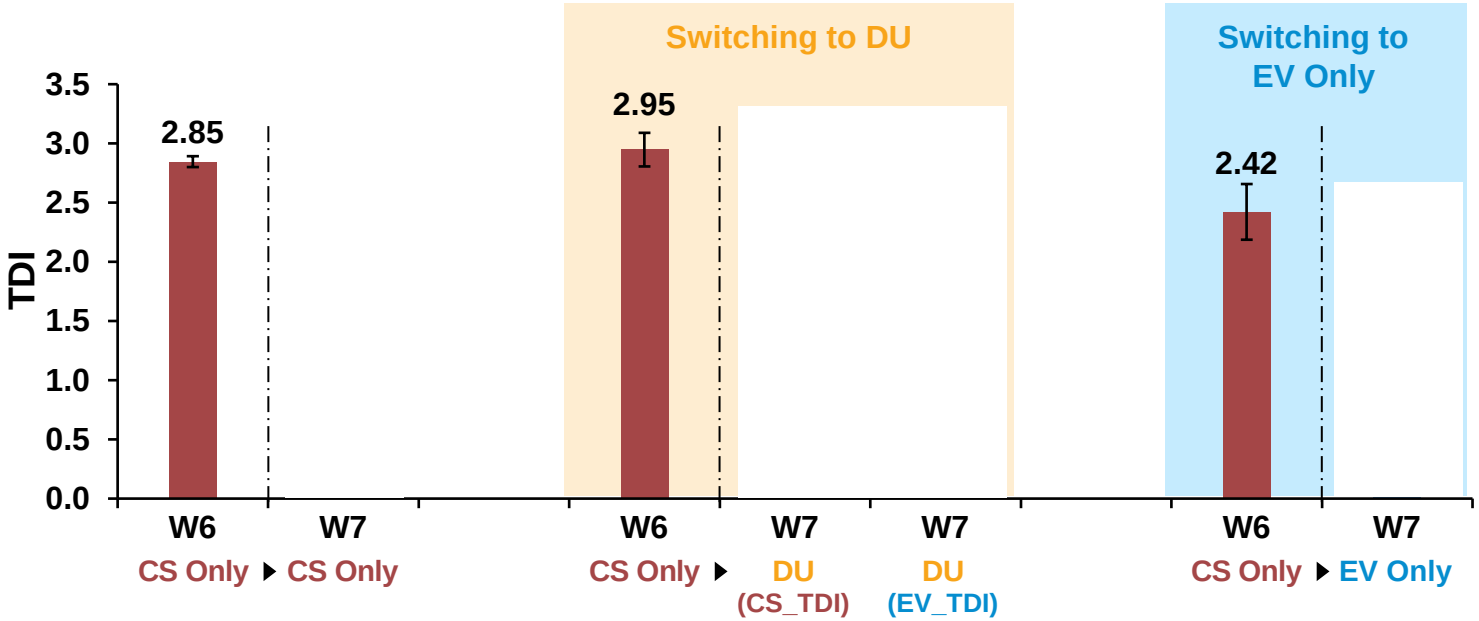
Wave 6 Cigarette Only Group

We observed a statistically significantly reduction in TDI **when switching to DU or switching to EV Only compared to continued smoking**

Wave 7 Follow-Up Use Status
(Wave 6 Cigarette Only Group)



TDI by Wave 7 CS and EV Use Status among CS Only at Wave 6



*Statistically significant reduction in TDI compared to baseline Wave 6 TDI score

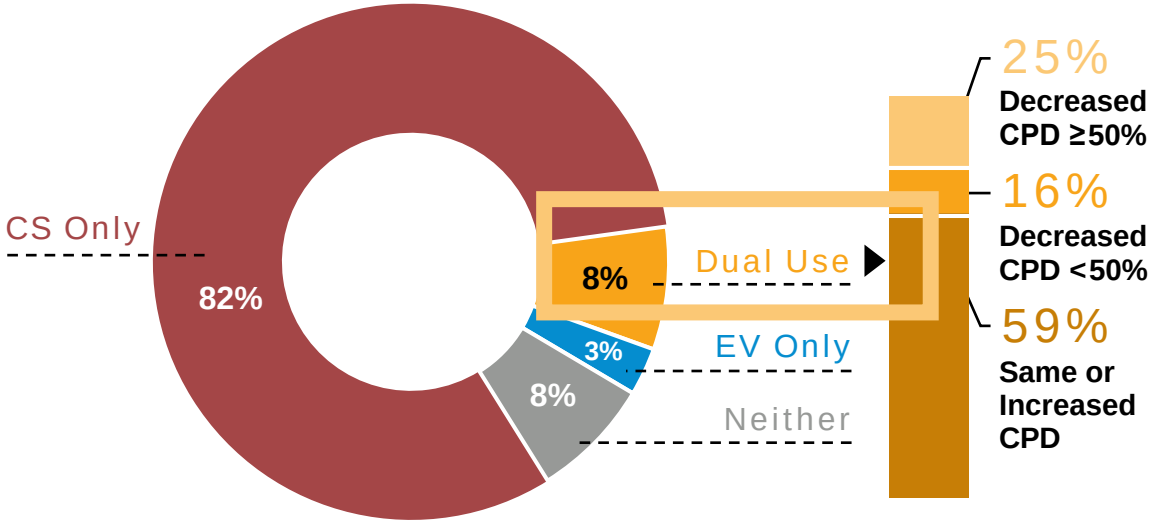
CPD=Cigarettes per day; CS Only=cigarettes only group; EV Only=E-vapor only group; DU=Dual use of cigarette and e-vapor group. Baseline sample size n = 3,344.
TDI score differences between Wave 6 and Wave 7 were tested using proc surveymeans, accounting for the complex PATH survey design. Bonferroni adjustment was applied in multiple comparisons; Adjusted alpha=0.05/4=0.0125.

Tobacco Dependence in Relation to Transitions Longitudinal Analysis of PATH Wave 6 to Wave 7 Data

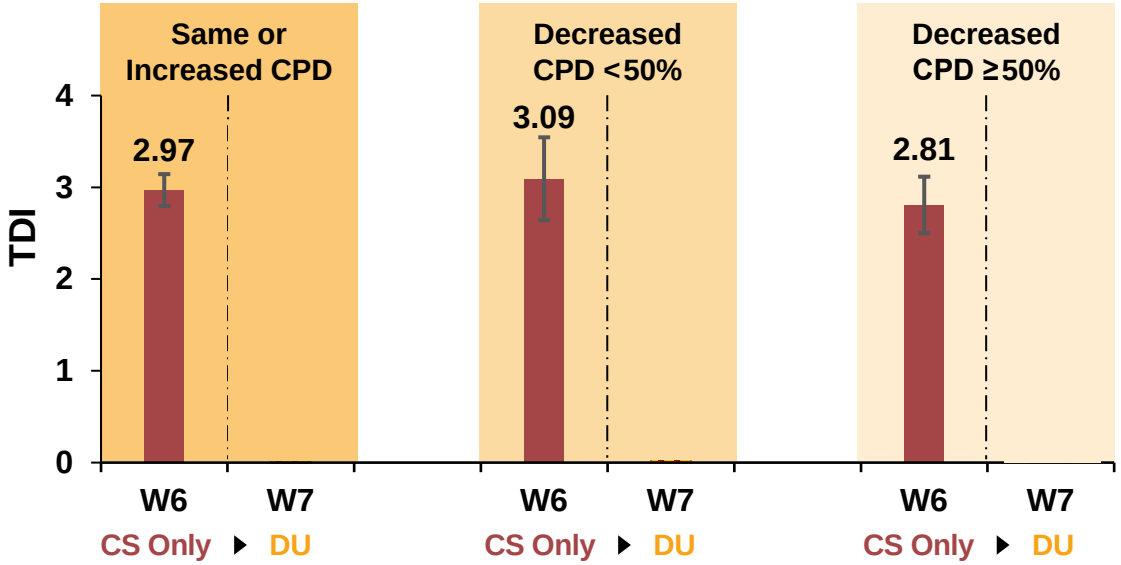
Wave 6 Cigarette Only Group ▶ Transition to Dual Use

We observed a statistically significantly reduction in TDI **when switching to dual use with Decreased CPD ≥50%**

Wave 7 Follow-Up Use Status
(Wave 6 Cigarette Only Group)



TDI (Cigarette Dependence) by Wave 7 CPD Change among Those who Switched from CS Only to Dual Use



***Statistically significant reduction in TDI compared to baseline Wave 6 TDI score**

CPD=Cigarettes per day; CS Only=cigarettes only group; EV Only=E-vapor only group; DU=Dual use of cigarette and e-vapor group. Baseline sample size n = 3,344, transitioning to dual use, n =472. TDI score differences between Wave 6 and Wave 7 were tested using proc surveymeans, accounting for the complex PATH survey design. Bonferroni adjustment was applied in multiple comparisons; Adjusted alpha=0.05/3=0.01667.

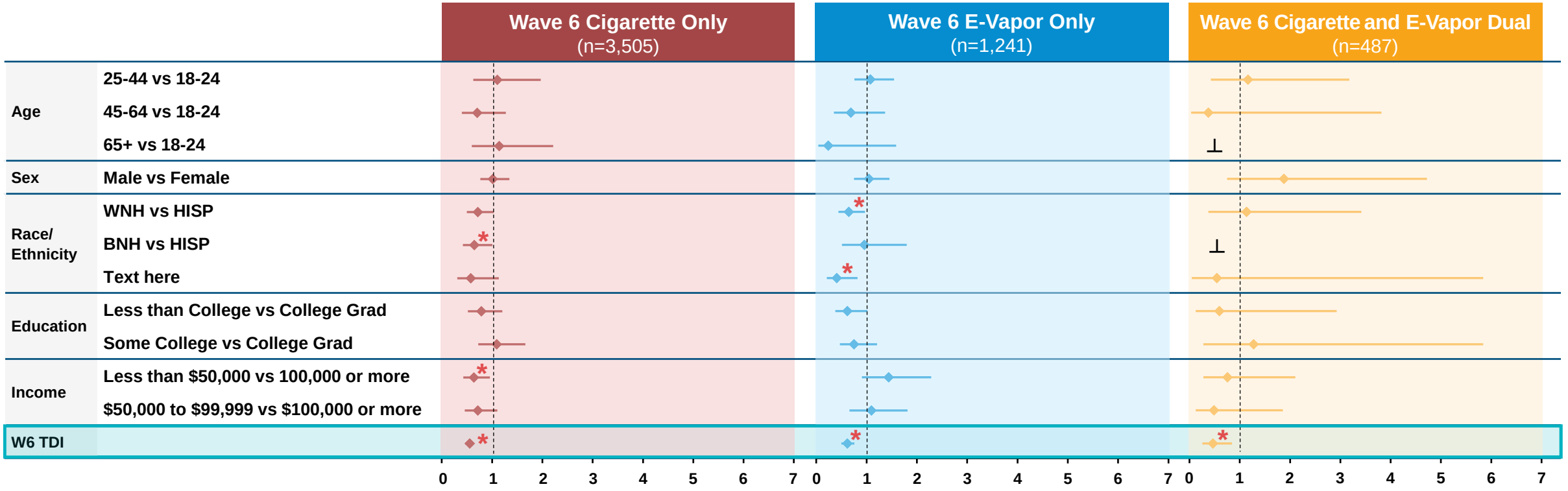
Association between Dependence and Quitting

Odds Ratio with 95% Confidence Interval (Model Outcome: Quitting All Tobacco)

Across the three study groups, individuals with
HIGHER DEPENDENCE **would be** LESS likely **to quit all tobacco**

W6 TDI Adjusted OR	0.53 CS Only	0.61 EV Only	0.47 CS and EV Dual

Odds Ratio of Quitting All Tobacco in Wave 7



BNH=Black Non-Hispanic; HISP=Hispanic; OTH=Other Non-Hispanic; WHN=White Non-Hispanic.
ALCS Longitudinal Analysis of PATH Wave 6 to Wave 7 Adult (18+) Data: Logistic regression models are fitted. Odds ratios are reported.

*Statistical significance at alpha=0.05 level
⊥ Low occurrence of event (quitting all tobacco), estimates are not reliable

Limitation

PATH Study Data

The tobacco dependence data used in this analysis are derived from self-reported information, which may be subject to reporting biases

Our longitudinal analysis utilized data from Waves 6 and 7, collected approximately two years apart. Because data are gathered at discrete intervals, we cannot determine the exact timing of behavior changes, which may influence observed changes in tobacco dependence levels

Tobacco Dependence Index (TDI)

While the TDI allows for comparisons of dependence between different tobacco product categories, **specific thresholds for classifying overall or product-specific dependence levels (e.g., low, medium, high) have not been established**

As the 16-item TDI was developed to assess tobacco dependence across tobacco products. **Some items were not selected to form TDI, although they may perform well in measuring product-specific dependence**

Summary and Conclusions

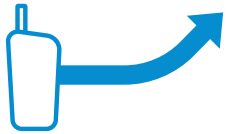
Trends in CS and EV Dependence

Cigarette TDI Score

REMAINS FLAT in the Cigarette Only group

DECLINES in the E-Vapor and Dual User group

E-vapor TDI Score



IS RISING in both E-Vapor Only and Cigarette and E-Vapor Dual User Groups

Statistically significant reduction in TDI scores when individuals switched from exclusive CS to

Exclusive E-vapor Use

OR

Dual Use **accompanied with reduction in cigarette consumption by ≥50%**

HIGHER TDI **was associated with** LOWER likelihood of quitting all tobacco

Summary and Conclusions

These findings provide valuable insights into the
trends in tobacco dependence among U.S. adults

AND HIGHLIGHT
the significant reduction in dependence
when individuals either

SWITCH COMPLETELY
from cigarettes to e-vapor

OR

SIGNIFICANTLY REDUCE
their cigarette consumption

which are important pathways
for tobacco harm reduction

Reference

Shiffman S, Sembower MA. Dependence on e-cigarettes and cigarettes in a cross-sectional study of US adults. *Addiction.* 2020 Oct;115(10):1924-31.

Strong DR, Pearson J, Ehlke S, Kirchner T, Abrams D, Taylor K, Compton WM, Conway KP, Lambert E, Green VR, Hull LC. Indicators of dependence for different types of tobacco product users: Descriptive findings from Wave 1 (2013–2014) of the Population Assessment of Tobacco and Health (PATH) study. *Drug and Alcohol Dependence.* 2017 Sep 1;178:257-66.

Strong DR, Leas E, Noble M, White M, Frissell KC, Glasser A, Katz L, Taylor K, Compton WM, Conway KP, Lambert E. Predictive validity of the adult tobacco dependence index: findings from waves 1 and 2 of the Population Assessment of Tobacco and Health (PATH) study. *Drug and Alcohol Dependence.* 2020 Sep 1;214:108134.

Strong DR, Leas E, Noble M, White M, Glasser A, Taylor K, Edwards KC, Frissell KC, Compton WM, Conway KP, Lambert E. Validation of the wave 1 and wave 2 Population Assessment of Tobacco and Health (PATH) study indicators of tobacco dependence using biomarkers of nicotine exposure across tobacco products. *Nicotine and Tobacco Research*. 2022 Jan 1;24(1):10-9.

Strong DR, Pierce JP, White M, Stone MD, Abrams DB, Glasser AM, Wackowski OA, Cummings KM, Hyland A, Taylor K, Edwards KC. Changes in Tobacco Dependence and Association With Onset and Progression of Use by Product Type From Waves 1 to 3 of the Population Assessment of Tobacco and Health (PATH) Study. *Nicotine & Tobacco Research*. 2023 Sep 4;25(11):1781-90.

United States Department of Health and Human Services. National Institutes of Health. National Institute on Drug Abuse, and United States Department of Health and Human Services. Food and Drug Administration. Center for Tobacco Products. *Population Assessment of Tobacco and Health (PATH) Study [United States] Public-Use Files.* Inter-university Consortium for Political and Social Research [distributor], 2025-04-08. https://doi.org/10.3886/ICPSR36498.v23

THANK YOU!