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**Western Illinois
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Youth E-Cigarette Use in Illinois and the Midwest: Insights from A Panel Study

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Abstract

This paper explores e-cigarette use among young people in Illinois and the Midwest; data were from the Population Assessment of Tobacco and Health (PATH) study. Results of data analysis suggest that (i) 11% of adolescents reported using electronic nicotine products during the past 12 months; (ii) fruit and candy were the most preferred e-liquid flavors, and (iii) the majority of e-cigarette users were White, male, and 15-17 years of age. The paper concludes with discussions of behavioral strategies to combat e-cigarette use.

Introduction

Youth e-cigarette use remains an epidemic...

CDC Director Robert Redfield, MD²

According to the Center for Disease Control and Prevention, cigarette smoking causes 480,000 deaths per year³. Although smoking related diseases and death plague the adults, the smoking habit starts early, around 11-18 years of age⁴. In Illinois, during 2015 to 2019, the proportion of 16-year old who had used an electronic vapor product or e-cigarette frequently increased at the rate of 24.7% per annum (Table 1); overall, e-cigarette use among young persons in Illinois increased at the rate of 10% per annum⁵.

¹ Professor, Illinois Institute for Rural Affairs, Western Illinois University.

² <https://consumer.healthday.com/cancer-information-5/electronic-cigarettes-970/youth-vaping-down-but-still-popular-cdc-761124.html>.

³ See, https://www.cdc.gov/tobacco/data_statistics/fact_sheets/health_effects/tobacco_related_mortality/index.htm#death.

⁴ Same reference as footnote 2.

⁵ Among high school students nationally, e-cigarette use increased from 1.5% in 2011 to 16% in 2015 before declining to 11.7% in 2017; see Cullen KA et al (2019). e-Cigarette Use Among Youth in the United States, JAMA, 322(21):2095-2103.

Table 1: ACGR of E-Cigarette Use by Age: Illinois, 2015-2019

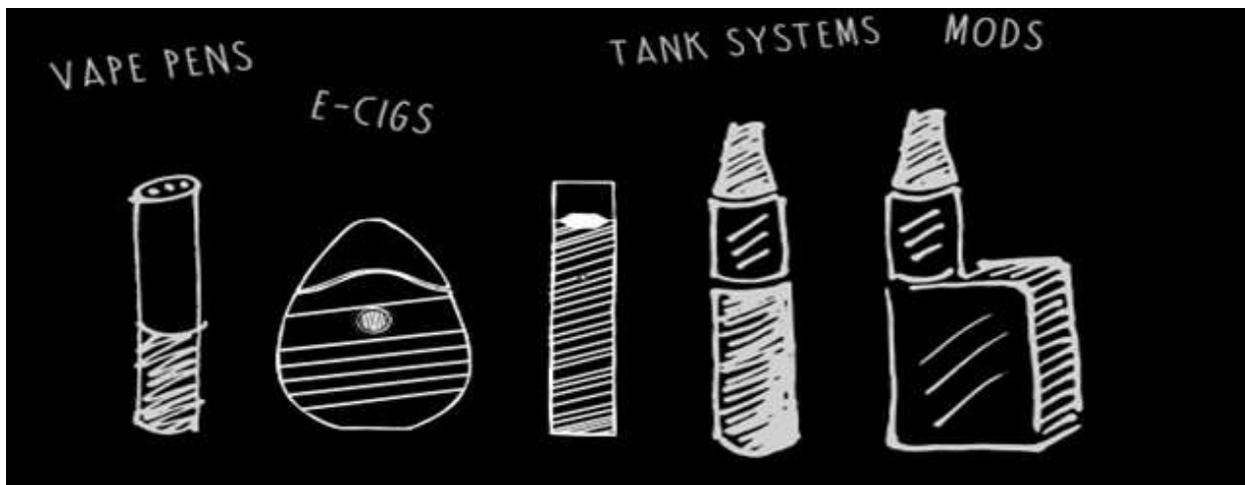
	Years			ACGR
	2015	2017	2019	
12 years old or younger	6%	0%	1%	-0.39919
13 years old	1%	0%	0%	NA
14 years old	5%	6%	4%	0.066091
15 years old	13%	21%	11%	0.048891
16 years old	12%	28%	22%	0.24709
17 years old	34%	24%	32%	0.078754
18 years old or older	30%	20%	31%	0.107343
N, 100%	25108	15923	37018	0.097056

Note: ACGR = Annual compound growth rate;
Source: Youth Risk Behavioral Surveillance System, 2020.

The term ‘e-cigarettes’ refers to electronic nicotine delivery systems. The semantics, or meaning of e-cigarettes include products such as vape pens, tank systems, and mods (Figure 1). The products use an “e-

liquid” that contains nicotine derived from tobacco⁶, as well as flavorings, propylene glycol, vegetable glycerin, etc. The liquid is heated to produce aerosol for user to inhale.

Figure 1: E-Cigarettes Product Categories⁷



⁶ It can also be synthetic nicotine; see, for example, <https://www.mdanderson.org/cancerwise/what-is-synthetic-nicotine.h00-159541323.html>.

⁷ Adapted from https://www.cdc.gov/tobacco/basic_information/e-cigarettes/about-e-cigarettes.html.

An e-cigarette can be a closed one where the cartridge cannot be reused, or an open system that permits cartridge refills. According to industry reports, the US market for e-cigarettes was \$6.3bil in 2021 and is expected to grow at the rate of 2% per annum during the next five years to \$7.1bil in 2027. The closed

system category enjoys the largest share of the market and vape shops account for the majority of retail sales. Table 2 is a summary of the supply side of the industry.

Table 2: E-Cigarettes, Industry Profile

Variable	Value
Market size, revenue (as at 2021)	\$6.31billion
Market size estimates for 2027	\$7.08billion
Market share, closed system devices	44%
Major distributor, in terms of 2021 revenue (\$6.3bil)	
> Vape shops	46%
> Convenience stores	31%
> Online	23%
Industry structure:	
> Lifecycle stage	Growth
> Competition	High
> Regulation level	High
> Concentration	Low
Major players' Market Share:	
> Juul Labs, Inc	13%
> Reynolds American Inc.	7%

Source: IBIS World, industry report, OD6196.

The fact that the e-cigarette product category is growing and demand for e-cigarettes among school-age students in Illinois is on the rise is of great concern to policymakers; recent initiatives such as senate Bills 512 and 555 which regulate e-cigarette marketing are in

response to the rising e-cigarette use in the state⁸.

What more could be done to combat e-cigarette uptake among the youth? This paper addresses this question using a data driven approach; risk factors for e-cigarette use are identified and

⁸ Senate bills 512 and 555 were signed into law by Governor Pritzker in August 2021; see, <https://www.myradiolink.com/2021/08/24/gov->

[pritzker-signs-legislation-preventing-underage-electronic-cigarette-sales/](https://www.pritzker.gov/newsroom/pritzker-signs-legislation-preventing-underage-electronic-cigarette-sales/).

cigarette use are identified and empirically assessed to facilitate implementation of behavior modification strategies.

Conceptual Model and Hypotheses

The stage model⁹ of cigarette smoking suggests that the pathways to e-cigarette use are (i) preparation, the stage during which attitude towards e-cigarette develops; (ii) initiation or trial; (iii) incubation or experimentation stage during which smoking is irregular, the person doesn't self-identify herself as a smoker, and (iv) maintenance of behavior; the person becomes a regular e-cigarette user. The final stage, maintenance, is the nicotine dependent stage; empirical research suggests that one's progression from the trial stage to regular use is around two to three years¹⁰.

The stage model is analogous to the awareness-trial-repeat-purchase model (ATR) in marketing¹¹. Under this model, consumers of a product first gain awareness of the product, make a trial purchase, and become repeat users of the product. For cigarette smoking, the 'habit' could develop because of the reinforcing effects of nicotine and/or social approval.

The awareness and trial stages for e-cigarettes for adolescents could come from the presence of smokers in the family. For example, Table 3 suggests that adults believe that e-cigarettes are less harmful than combustion cigarettes and this could lead adults who smoke combustion cigarettes to switch to e-cigarettes. Since adolescents gain access to cigarettes from home, it is possible that smokers in the family play the roles of initiator, influencers, and purchaser of e-cigarettes for adolescents¹².

Thus,

H₁: There will be positive association between adolescents' e-cigarette use and the presence of smokers in the family, and

H₂: E-cigarette habit will be positively related to social approval for the product's use.

Table 3 lists the correlates of both combustible cigarette and e-cigarette use among adolescents, grades 6-12, and adults, aged ≥ 18 years. A typical adolescent e-cigarette smoker tends to be a White male, with low GPA and access to cigarettes at home.

⁹ Leventhal, H., & Cleary, P. D. (1980). The smoking problem: a review of the research and theory in behavioral risk modification. *Psychological bulletin*, 88(2), 370.

¹⁰ Kandel, D. B., Hu, M. C., Griesler, P. C., & Schaffran, C. (2007). On the development of nicotine dependence in adolescence. *Drug and alcohol dependence*, 91(1), 26-39.

¹¹ Ehrenberg, A. (1972). *Repeat-Buying: Theory and Applications*. Amsterdam: North Holland.

¹² Initiator would be the person who stimulates the need for the product; influencer directs need satisfaction to a specific product, and purchaser is the actual purchaser of the product. In the case of e-cigarettes, the roles would be played by one or more smokers in the family.

Table 3: Correlates of Combustible and E-Cigarette Use: Adolescents and Adults

Source	Findings Generalized to	
	Adolescents	Adults
Conrad et al (1992).	Socioeconomic status (+); Peer smoking (+); Intention to smoke (+).	
Elders, M.J (1994).	Mean age of initiation: 14.5; Mean age of daily use: 17.7.	
Davis et al (1997).	Physical activity (-)	
Resnick et al (1997).	Access to cigarettes at home (+); Frequent parental presence at home (-); Grade point average (-); Importance placed on religion and prayer (-).	Hours of work (+).
Shrier et al (1998).	Alcohol use (+)	
Choi et al (1999).	White male (+); Smokers in the family (+).	
Cho et al (2011).	Male (+); Smoking combustion cigarette has a + impact on smoking e-cigs.	
Choi et al (2013).		Belief that e-cigarette is: less harmful (+); not addictive (+)
Pepper et al (2013).	Awareness about e-cigarettes (+ for Whites).	
Regan et al (2013).		Education (-)

Note: References can be obtained by emailing the author, a-athiyaman@wiu.edu

Methodology

Data on adolescent use of e-cigarettes were sourced from the Population Assessment of Tobacco and Health (PATH) study¹³, a panel study of 53,178

adolescents and adult tobacco users. Microdata for four waves, 2015-2019, were sourced to address the research question and related hypotheses; the focus was on the Midwest region¹⁴ (Table 4).

¹³ See, <https://www.icpsr.umich.edu/web/NAHDAP/studies/36498>

¹⁴ The Midwest region includes the East North Central division: Illinois, Indiana, Michigan, Ohio,

and Wisconsin; and the West North Central division: Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota.

Table 4: Microdata on Adolescents: PATH Waves and Sample Size

Wave	Data Collection Dates	Total No. of Adolescents in the Study	Total in the Midwest
One	October 2015-October 2016	11,814	2,915
Two	December 2016-January 2018	14,798	5,617
Three	December 2017-December 2018	13,131	4,235
Four	December 2018-November 2019	12,098	3,370

Note: PATH definition of wave one is wave 3, two is wave 4, three is wave 4.5, and four is wave 5; see footnote 13.

Probability models were used to study the processes of change in e-cigarette use among adolescents¹⁵. Transition probabilities for e-cigarette use were estimated for successive pairs of waves, the stability of the transition matrices assessed using Chi-square tests, and predictions about adolescent use of e-cigarettes were constructed using the probabilities.

Findings

The first wave of the panel study (Table 4) had 2,915 respondents from the

Midwest. The majority of these respondents were White, male, and 15-17 years of age. One-in-four respondents were either Black or Hispanic.

When asked about the use of electronic nicotine products, even once or twice, during the past 12 months, 11% reported usage. Statistically significant differences were observed between White and Black respondents; a higher proportion of Whites indicated e-nicotine use. Also, a higher proportion of 15-17-year-old had used e-nicotine products in the past 12 months (Table 5).

Table 5: Use of Electronic Nicotine Products in the Past 12 Months

Predictor Variable	E-Nicotine Use	
	Yes	χ^2, p
Age: 12-14 (n = 767)	8%	14.23, p < 0.01
Age: 15-17 (n = 2143)	13%	
Race: White (n=1666)	14%	27.31, p < 0.01
Race: Black (n=732)	6%	
Race: Other (n=377)	11%	

¹⁵ See for example, Cox, D. R., & Miller, H. D. (2017). *The theory of stochastic processes*. Routledge.

Of the e-product categories shown in Figure 1, vape pen, personal vaporizer, or mod were used by 76% of e-nicotine users, 16% used e-hookah, and 4% e-cigars. Flavor-wise, it is fruit and candy that were used by the majority (Table 6).

Of the nonusers of the e-nicotine product, 18% (n=513) expressed curiosity about the product. Of these, 10% (n=52) had strong to moderate intentions to try the product “next year”.

Table 6: E-Nicotine Product Use: Flavors, Influencers, and Smoking Intentions

Have you ever been curious about using an e-nicotine product?

Response	% of Respondents (n = 2327)
Very curious	2%
Somewhat curious	5%
Little curious	15%
Not at all curious	78%

If a best friend were to offer an e-nicotine product, would you try it?

Response	% of Respondents (n = 2330)
Definitely yes	0%
Probably yes	4%
Probably not	16%
Definitely not	80%

Do you think that you will try an e-nicotine product in the next year?

Response	% of Respondents (n = 2330)
Definitely yes	0%
Probably yes	2%
Probably not	16%
Definitely not	82%

When you first used the e-nicotine product, which flavor did you use?

Flavor	% of Respondents (n = 202)
Tobacco	6%
Menthol	7%
Fruit	45%
Candy including chocolate	35%

To address the research question and to test the hypotheses, the 2,915 wave 1

respondents were traced through all the four waves and the resulting longitudinal

data of 619 respondents were classified with respect to a given set of categories at successive time points.

For each wave, each of the 619 responses can be classified as either “yes” or “no” to the question, “In the past 12 months, have you used an electronic nicotine product, even one or two times?” For each individual, his responses in the four waves could be

listed, and since there are two possible responses, there will be $2^4 = 16$ possible response patterns.

Let $p(YY)$ be the probability of a “yes” response in a given wave among those who responded “yes” in the previous wave. In this way, the four transition probabilities are obtained (Table 7).

Table 7: Matrix of Transition Probabilities

Wave 1	Wave 2	
	Yes	No
Yes (n=41)	0.439	0.561
No (n=578)	0.040	0.960
Wave 2	Wave 3	
	Yes	No
Yes (n=41)	0.732	0.268
No (n=578)	0.125	0.875
Wave 3	Wave 4	
	Yes	No
Yes (n=102)	0.657	0.343
No (n=517)	0.162	0.838

To test the equality of the transition matrices in Table 7, a χ^2 test was performed; the equality hypothesis was rejected¹⁶. This suggests that e-cigarette use among nonusers is on the rise; the probability of nonusers in the previous wave using e-cigarette in the next wave ($p(NY)$) registered a 35%

growth per year during the survey years. Relatedly, the probability of “no e-cigarette use” in successive waves decreased at the rate of -3% per year.

Hypothesis 1 was predicated on the assumption that the presence of smokers in the family will influence adolescent’s e-cigarette use. This

¹⁶ The test was performed by pooling the data in Table 7; the three matrices were combined into

a single 2 x 2 table. The computed χ^2 statistic was significantly large, 329.93

hypothesis gained support in empirical tests, $r=0.22$, $t=5.4$, $p<0.01$ ¹⁷.

relationship is statistically significant; the correlation between the variables is 0.39.

Table 8 shows the influence of social approval on e-cigarette use¹⁸. The

Table 8: Social Approval as a Predictor of E-cigarette Use

E-Cigarette Use	Likelihood of E-Cigarette Trial, if Offered by a Best Friend		
	Definitely Not	Probably Not	Probably Yes
Yes	5%	31%	55%
No	95%	69%	45%
N	1764	572	127

Note: $\chi^2 = 446.62$, $p < 0.01$; C (coefficient of contingency) = 0.39; $t = 21.01$, $p < .01$

Summary and Conclusion

This paper explored e-cigarette use by young people in Illinois and the Midwest. The term ‘e-cigarettes’ refers to electronic nicotine delivery systems. The products use an “e-liquid” that contains nicotine derived from tobacco, as well as flavorings, propylene glycol, vegetable glycerin, etc. The liquid is heated to produce aerosol for user to inhale.

Microdata from the PATH study were used to explore the processes of change, from a nonuser of e-cigarette to an e-cigarette user. Results of statistical analysis suggest that:

1. the presence of smokers in the family is associated with adolescent’s e-cigarette use;
2. the likelihood of e-cigarette trial, given that the product is offered by his or her best friend, is 0.66;
3. 11% of adolescents reported using electronic nicotine products during the past 12 months;
4. Fruit and candy were the most preferred e-liquid flavors, and

¹⁷ The question, “Not including yourself, does anyone living in your home own an e-cigarette or other electronic nicotine product?” was correlated with the respondent’s answer to the question about e-cigarette use in the past 12 months (see Table 7).

¹⁸ Social approval was measured by the question, “If one of your best friends were to offer you an electronic nicotine product, would you try it?”. The criterion variable was e-cigarette use in the past 12 months.

-
5. the majority of e-cigarette users were White, male, and 15-17 years of age.

In summary, e-cigarettes use remains a threat to the nation's health; the flavors of e-cigarettes are reinforcing, appealing to young. Since nicotine is an addictive substance, adolescents who are exposed to nicotine via e-cigarette can progress to stronger nicotine delivery systems such as combustible cigarettes¹⁹.

How to prevent vaping initiation? Behavioral theory states that human behavior is controlled by the environment²⁰. Once these controlling variables have been identified, they can be altered to modify the behavior.

The two controlling variables (S^{D21}) that have been identified in this study are the "presence of e-nicotine product at home" and "offer of an e-cigarette from a friend". To eliminate S^D , parental involvement is necessary. Specifically, parents have to get more involved with their children, in their daily activities; parental involvement, their presence and conversations with their children, deter nicotine-product use among children²².

In general, policymakers should use the "agent, host, and vector" classification in

epidemiology to think about strategies to manage e-cigarette use among adolescents.

For example, the 'agent' is the e-nicotine product. As at February 2020, approximately 3,000 cases of vaping associated lung injury and 68 deaths have been reported to the CDC²³. Yet, long-term health consequences of e-cigarette use are yet to be known; research is needed to bridge this gap in knowledge.

The 'host' is the user of e-cigarettes; the antecedent manipulation strategy discussed above, S^D , is currently being trialed by the American Lung Association²⁴. Although, campaign tracking research is needed to assess the effectiveness of the PSA, it is likely that it will decrease the problem behavior.

Finally, the 'vector' includes the manufacturer and the distributors of e-cigarettes. Recently, the Food and Drug Administration ordered Juul, the market leader in e-cigarette category, to stop selling and distributing its products in the nation. A day later, a federal appeals court blocked the ban. Now, Juul has agreed to settle investigations into its marketing practices by paying \$435mil to states and territories²⁵. Illinois' senate bills 512 and 525 are the right steps to stem industry advertising and promotion²⁶.

¹⁹ Same reference as footnote 2.

²⁰Bower, G. H., & Hilgard, E. R. (1981). *Theories of learning*. Prentice-Hall.

²¹ The antecedent stimulus for behavior; technically, a discriminative stimulus or S^D .

²² See, for example, Kessler, D. (1995). Nicotine addiction in young people. *The New England Journal of Medicine*, July 20, 186-189.

²³ https://www.cdc.gov/tobacco/basic_information/e-cigarettes/severe-lung-disease.html.

²⁴ <https://abc11.com/vaping-e-cigarettes-smoking-parents/12113697/>.

²⁵ <https://thehill.com/policy/healthcare/3631202-juul-to-settle-multi-state-youth-vaping-investigation-for-438-million/>.

²⁶ Same reference as footnote 8.