


# An Analysis of Nicotine Pouch Use by Middle School and High School Students Surveyed by the National Youth Tobacco Survey in 2021 and a Review of the Literature

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## Abstract

**Objectives:** The use of alternative nicotine products by middle and high school students is a growing concern due to industry marketing techniques, availability, and popularity of new products, and ambiguous nicotine concentrations. The 2021 National Youth Tobacco Survey (NYTS) provides information about the frequency, and characteristics of middle, and high school students who have used nicotine pouches. **Methods:** The National Youth Tobacco Surveys provide important information about the frequency of use of tobacco and alternative nicotine products by a representative sample of students in schools in the United States. The 2021 survey included questions about the use of nicotine pouches/dissolvable tobacco products. The results from the survey were analysis using descriptive statistics, and logistic regression to model the association between the use of these alternative nicotine products, and the use of electronic cigarettes or the use of conventional cigarettes. **Results:** A total of 20413 students participated in the survey year 2021; 17842 were included in the final data analysis. Their ages ranged from 9 to 18+. Identified risk factors for the use of alternative nicotine products included race, and age. The adjusted odds ratio (OR) was lower in non-Hispanic Black and Hispanic students, as compared to non-Hispanic White students. Older students had a substantially higher risk of using nicotine/dissolvable tobacco products, specifically, compared to students less than or equal to 13 years old. The OR increased 174% (OR: 2.74; 1.70-4.41) in 17-year-old students. The perception of harm associated with electronic cigarettes increased the likelihood of using alternative nicotine products. Students who did not smoke cigarettes (OR: 0.39; 0.27-0.56) or did not smoke electronic cigarettes (OR: 0.20; 0.18-0.40) had significantly lower OR for using alternative nicotine products. **Conclusions:** The 2021 National Youth Tobacco Survey indicates that a relatively small percentage of middle school and high school student have used nicotine pouches. However, with the increase in new, alternative tobacco products, understanding adolescent use in comparison to other tobacco products is an important trend to monitor.

## Keywords

nicotine, nicotine pouches, national youth tobacco survey, use, harm perception

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## Introduction

The tobacco industry is a powerful economic force throughout the world that continues to develop and promote alternative nicotine products, such as e-cigarettes, nicotine pouches, and dissolvable tobacco products. These products frequently have flavoring added to improve the experience, especially for new tobacco users. With the development of

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new, alternative tobacco products, it can be difficult for physicians, research scientists, and public health officials to remain current on how often these products are used, and their effects on users' health. Nicotine pouches—smokeless and tobacco free products that have a nicotine-containing cellulose matrix inside a fiber pouch—were introduced into the United States in 2016.<sup>1</sup> These pouches have a total nicotine content which ranges from 1.29 to 6.11 mg/pouch, which is equivalent to conventional tobacco products.<sup>2</sup> There has been a significant increase in the sale of nicotine pouches since 2016.<sup>1,3</sup> Dissolvable tobacco products are noncombustible tobacco products which contain finely grained tobacco mixed with additives, including water, flavoring, binders, and colorants. They dissolve in the users mouth, and do not require spitting up the product. A new federal law now gives the FDA the authority to regulate tobacco products containing nicotine from any source.<sup>4</sup> This law took effect April 14, 2022, and after July 13, 2022, any new non-tobacco nicotine product that has not received premarket authorization from FDA cannot be legally marketed. This law will cover both nicotine pouches and dissolvable tobacco products and underlines the potential adverse effects associated with all nicotine products.

These nicotine pouches and alternative tobacco products carry a level of intrigue and experimentation for adolescents that becomes dangerous when they begin to use them recreationally without understanding the adverse health, and addictive risks associated with such products. The majority of nicotine pouch users are young adults with a previous smoking history of either combustible, or non-combustible tobacco products, usually with the underlying assumption that the pouches are less harmful than other tobacco products. While historical data once suggested that non-smoking youth were unaware of non-conventional products like snus, the 2019 National Youth Tobacco Survey (NYTS) data showed that at least 30% of high school students had used a tobacco product.<sup>5</sup> This statistic and the increase in sales of novel nicotine products makes it important to understand the use pattern and the characteristics of middle, and high school students who use alternative products such as nicotine pouches and dissolvable nicotine products. The 2021 National Youth Tobacco Survey (NYTS) provides important information relevant to these questions, and provides the basis for this analysis.

## Methods

The National Youth Tobacco Survey (NYTS) began using electronic data collection methods starting in 2019 ([https://www.cdc.gov/tobacco/data\\_statistics/surveys/nyts/index.htm](https://www.cdc.gov/tobacco/data_statistics/surveys/nyts/index.htm)). The 2021 cycle again was conducted electronically. However, while the 2019 and 2020 studies relied upon tablet-based administration with offline data collection in schools, the 2021 methodology required a 100% online

survey administration due to the ongoing COVID-19 pandemic and varying local and state protocols. Approximately one half of the surveys were completed in school, and one half were completed on the Internet at home.<sup>6</sup> Therefore, the 2021 NYTS results cannot be compared to 2019, and 2020 surveys, which were conducted in-person on school campuses. Virtual survey assistance was provided by trained technical assistance providers as students completed the survey during a designated class period/class activity, whether at home or virtually. Students logged in to a secure website at which they were presented with a 2-min instructional video before completing the survey. Students unable to participate during the day of survey administration were asked to complete the survey at the next available opportunity. Participation in the NYTS was voluntary at both the school, and student levels. At the student level, participation was anonymous. The CDC's Institutional Review Board (IRB) requires that parents be given the opportunity to opt their student out of participating in the survey. Schools used either passive or active permission forms at their discretion. All responses were anonymous.

Survey administration started on January 18, 2021 and concluded on May 21, 2021. The final sample consisted of 508 schools, of which 279 participated, yielding a school participation rate of 54.9%. A total of 20 413 student questionnaires were completed out of a sample of 25 149 students, yielding a student participation rate of 81.2%. The overall participation rate, defined as the product of the school-level, and student-level participation rates, was 44.6%. The Supplemental Table lists categories with incomplete responses.

In this analysis, questions focusing on cigarette ever use, and e-cigarette ever use were compared with ever use of nicotine pouch/dissolvable tobacco products, combined in 1 group as alternative nicotine product users. Descriptive statistics were used to describe study participant characteristics. Categorical variables were summarized by frequencies, and continuous variables were summarized using means, and standard deviations or medians, and ranges as appropriate. Logistic regression was used to model the association between the use of alternative nicotine products, and the use of e-cigarettes, and, separately, the use of conventional cigarettes in the presence of other risk factors, including gender, race, age, perception of harm from cigarettes, e-cigarettes, e-cigarettes being more addictive than cigarettes, and the use of chewing tobacco. The samples were already weighted by the NYTS managers to account for unequal probabilities of selection response, and to match the sample demographic characteristics to the national population of middle, and high school students. The SAS proc surveylogistic procedure was used for data analysis to account for the complex survey design. Statistical significance was set at .05. Analyses were performed using the Statistical Analysis System (SAS, Windows version 9.4; SAS Institute, Cary, North Carolina)

**Table 1.** Subject Description by Cigarette Use and Nicotine Pouch/Dissolvable Tobacco Products Smoking.

Variable	Overall <sup>a</sup>	Cigarette + nicotine pouch/ dissolvable tobacco products	Cigarette, no nicotine pouch/ dissolvable tobacco products	No cigarette, nicotine pouch/ dissolvable tobacco products	No cigarette, no nicotine pouch/ dissolvable tobacco products
Gender					
Male	8973 (50.3)	129 (69)	564 (48.9)	108 (65.5)	8172 (50)
Female	8869 (49.7)	58 (31)	590 (51.1)	57 (34.5)	8164 (50)
Race					
NH-White	9435 (52.9)	150 (80.2)	644 (55.8)	100 (60.6)	8541 (52.3)
NH-Black	2924 (16.4)	5 (2.7)	190 (16.5)	17 (10.3)	2712 (16.6)
Hispanic	4418 (24.8)	27 (14.4)	265 (23)	41 (24.8)	4085 (25)
NH-Asian	812 (4.6)	0 (0)	32 (2.8)	5 (3)	775 (4.7)
NH-AI/AN	200 (1.1)	4 (2.1)	20 (1.7)	2 (1.2)	174 (1.1)
NH-NHOPI	53 (0.3)	1 (0.5)	3 (0.3)	0 (0)	49 (0.3)
Age					
<12	1198 (6.7)	4 (2.1)	24 (2.1)	5 (3)	1165 (7.1)
12	2762 (15.5)	4 (2.1)	69 (6)	9 (5.5)	2680 (16.4)
13	2898 (16.2)	15 (8)	133 (11.5)	20 (12.1)	2730 (16.7)
14	2735 (15.3)	14 (7.5)	162 (14)	12 (7.3)	2547 (15.6)
15	2536 (14.2)	24 (12.8)	167 (14.5)	30 (18.2)	2315 (14.2)
16	2311 (13)	42 (22.5)	215 (18.6)	35 (21.2)	2019 (12.4)
17	2227 (12.5)	50 (26.7)	222 (19.2)	34 (20.6)	1921 (11.8)
18+	1175 (6.6)	34 (18.2)	162 (14)	20 (12.1)	959 (5.9)
E-cig harm					
No harm	486 (2.7)	24 (12.8)	80 (6.9)	18 (10.9)	364 (2.2)
Little harm	2493 (14)	65 (34.8)	271 (23.5)	37 (22.4)	2120 (13)
Some harm	7324 (41)	65 (34.8)	502 (43.5)	64 (38.8)	6693 (41)
A lot of harm	7539 (42.3)	33 (17.6)	301 (26.1)	46 (27.9)	7159 (43.8)
Conventional cig harm					
No harm	327 (1.8)	20 (10.7)	48 (4.2)	11 (6.7)	248 (1.5)
Little harm	1306 (7.3)	42 (22.5)	164 (14.2)	20 (12.1)	1080 (6.6)
Some harm	7615 (42.7)	88 (47.1)	555 (48.1)	67 (40.6)	6905 (42.3)
A lot of harm	8594 (48.2)	37 (19.8)	387 (33.5)	67 (40.6)	8103 (49.6)
E-cig addiction comp. to cig					
Less addictive	1452 (8.1)	29 (15.5)	168 (14.6)	24 (14.5)	1231 (7.5)
Equally addictive	6094 (34.2)	68 (36.4)	436 (37.8)	53 (32.1)	5537 (33.9)
More addictive	5477 (30.7)	72 (38.5)	391 (33.9)	53 (32.1)	4961 (30.4)
Never heard, don't know	4819 (27)	18 (9.6)	159 (13.8)	35 (21.2)	4607 (28.2)
Tried chewing tobacco/snuff/dip					
Yes	528 (3)	126 (67.4)	165 (14.3)	55 (33.3)	182 (1.1)
No	17314 (97)	61 (32.6)	989 (85.7)	110 (66.7)	16154 (98.9)
Tried e-cig					
Yes	3129 (17.5)	177 (94.7)	795 (68.9)	88 (53.3)	2069 (12.7)
No	14713 (82.5)	10 (5.3)	359 (31.1)	77 (46.7)	14267 (87.3)

Abbreviations: AI/AN, American Indian/Alaskan native; e-cig, electronic cigarette; NH, non-Hispanic; NHOPI, native Hawaiian, other Pacific Islander.

<sup>a</sup>A total of 20413 students participated in the NYTS 2021. After excluding students with missing values, the total number of students included in the data analysis is 17842.

and the statistical program R version 4.0.2 (<https://cran.r-project.org/>).

## Results

A total of 20413 students participated in the NYTS 2021. After excluding students with missing values on important survey questions relevant to this study, the total number of

students included in the final data analysis was 17842. When students were classified by cigarette use, and/or nicotine pouch/dissolvable tobacco product usage, 187 students used both cigarettes and nicotine pouch/dissolvable tobacco products, and 165 students used only nicotine pouch/dissolvable tobacco products (Table 1). When students were classified by e-cigarette use, and/or nicotine pouch/dissolvable tobacco product usage, 265 students

**Table 2.** Subject Description by E-Cigarette Use and Nicotine Pouch/Dissolvable Tobacco Products Smoking.

Variable	Overall <sup>a</sup>	E-cigarette + nicotine pouch/ dissolvable tobacco products	E-cigarette, no nicotine pouch/ dissolvable tobacco products	No e-cigarette, nicotine pouch/ dissolvable tobacco products	No e-cigarette, no nicotine pouch/dissolvable tobacco products
<b>Gender</b>					
Male	8973 (50.3)	188 (70.9)	1283 (44.8)	49 (56.3)	7453 (51)
Female	8869 (49.7)	77 (29.1)	1581 (55.2)	38 (43.7)	7173 (49)
<b>Race</b>					
NH-White	9435 (52.9)	209 (78.9)	1715 (59.9)	41 (47.1)	7470 (51.1)
NH-Black	2924 (16.4)	10 (3.8)	332 (11.6)	12 (13.8)	2570 (17.6)
Hispanic	4418 (24.8)	39 (14.7)	696 (24.3)	29 (33.3)	3654 (25)
NH-Asian	812 (4.6)	0 (0)	76 (2.7)	5 (5.7)	731 (5)
NH-AI/AN	200 (1.1)	6 (2.3)	38 (1.3)	0 (0)	156 (1.1)
NH-NHOPI	53 (0.3)	1 (0.4)	7 (0.2)	0 (0)	45 (0.3)
<b>Age</b>					
<12	1198 (6.7)	5 (1.9)	37 (1.3)	4 (4.6)	1152 (7.9)
12	2762 (15.5)	4 (1.5)	122 (4.3)	9 (10.3)	2627 (18)
13	2898 (16.2)	21 (7.9)	219 (7.6)	14 (16.1)	2644 (18.1)
14	2735 (15.3)	18 (6.8)	391 (13.7)	8 (9.2)	2318 (15.8)
15	2536 (14.2)	38 (14.3)	514 (17.9)	16 (18.4)	1968 (13.5)
16	2311 (13)	63 (23.8)	614 (21.4)	14 (16.1)	1620 (11.1)
17	2227 (12.5)	72 (27.2)	637 (22.2)	12 (13.8)	1506 (10.3)
18+	1175 (6.6)	44 (16.6)	330 (11.5)	10 (11.5)	791 (5.4)
<b>E-cig harm</b>					
No harm	486 (2.7)	34 (12.8)	154 (5.4)	8 (9.2)	290 (2)
Little harm	2493 (14)	86 (32.5)	735 (25.7)	16 (18.4)	1656 (11.3)
Some harm	7324 (41)	101 (38.1)	1286 (44.9)	28 (32.2)	5909 (40.4)
A lot of harm	7539 (42.3)	44 (16.6)	689 (24.1)	35 (40.2)	6771 (46.3)
<b>Conventional cig harm</b>					
No harm	327 (1.8)	23 (8.7)	75 (2.6)	8 (9.2)	221 (1.5)
Little harm	1306 (7.3)	53 (20)	335 (11.7)	9 (10.3)	909 (6.2)
Some harm	7615 (42.7)	128 (48.3)	1451 (50.7)	27 (31)	6009 (41.1)
A lot of harm	8594 (48.2)	61 (23)	1003 (35)	43 (49.4)	7487 (51.2)
<b>E-cig addiction comp. to cig</b>					
Less addictive	1452 (8.1)	43 (16.2)	444 (15.5)	10 (11.5)	955 (6.5)
Equally addictive	6094 (34.2)	93 (35.1)	1089 (38)	28 (32.2)	4884 (33.4)
More addictive	5477 (30.7)	102 (38.5)	1014 (35.4)	23 (26.4)	4338 (29.7)
Never heard, don't know	4819 (27)	27 (10.2)	317 (11.1)	26 (29.9)	4449 (30.4)
<b>Tried chewing tobacco/snuff/dip</b>					
Yes	528 (3)	162 (61.1)	232 (8.1)	19 (21.8)	115 (0.8)
No	17314 (97)	103 (38.9)	2632 (91.9)	68 (78.2)	14511 (99.2)
<b>Tried cigarette</b>					
Yes	1341 (7.5)	177 (66.8)	795 (27.8)	10 (11.5)	359 (2.5)
No	16501 (92.5)	88 (33.2)	2069 (72.2)	77 (88.5)	14267 (97.5)

Abbreviations: AI/AN, American Indian/Alaskan native; e-cig, electronic cigarette; NH, non-Hispanic; NHOPI, native Hawaiian, other Pacific Islander.

<sup>a</sup>A total of 20413 students participated in the NYTS 2021. After excluding students with missing values, the total number of students included in the data analysis is 17842.

used both e-cigarettes, and nicotine pouch/dissolvable tobacco products, and 87 students used only nicotine pouch/dissolvable tobacco products (Table 2).

Risk factors for the use of nicotine pouches, and dissolvable products included age, and self-reported race. Older

students had a substantially higher risk of using these products, specifically compared to students  $\leq 13$  years old. For example, the increases in odds of having used these products in the 15, 16-, and 17-year old categories are 61% (adjusted odds ratio 1.61 [1.03-2.52]), 138% (2.38 [1.50,

**Table 3.** Nicotine Pouch/Dissolvable Tobacco Products use and Risk Factors.

Variable	Cases (N = 352)		Controls (N = 17 490)	
	Num (%)	Num (%)	Raw OR (95% CI)	Adjusted OR <sup>a</sup> (95% CI)
Gender				
Male	237 (67.33)	8736 (49.95)	Reference	
Female	115 (32.67)	8754 (50.05)	0.48 (0.35, 0.67)	0.77 (0.54, 1.09)
Race				
NH-White	250 (71.02)	9185 (52.52)	Reference	
NH-Black	22 (6.25)	2902 (16.59)	0.29 (0.17, 0.49)	0.64 (0.40, 1.03)
Hispanic	68 (19.32)	4350 (24.87)	0.46 (0.31, 0.69)	0.85 (0.57, 1.27)
Other	12 (3.41)	1053 (6.02)	0.30 (0.13, 0.71)	0.47 (0.27, 0.83)
Age				
≤13	57 (16.19)	6801 (38.89)		
14	26 (7.39)	2709 (15.49)	1.17 (0.65, 2.10)	0.78 (0.42, 1.43)
15	54 (15.34)	2482 (14.19)	2.59 (1.53, 4.40)	1.61 (1.03, 2.52)
16	77 (21.88)	2234 (12.77)	5.19 (3.08, 8.74)	2.38 (1.50, 3.79)
17	84 (23.86)	2143 (12.25)	6.40 (3.89, 10.53)	2.74 (1.70, 4.41)
18+	54 (15.34)	1121 (6.41)	6.87 (3.77, 12.52)	1.78 (0.99, 3.21)
E-cig harm				
No harm	42 (11.93)	444 (2.54)	Reference	
Little harm	102 (28.98)	2391 (13.67)	0.39 (0.23, 0.66)	0.78 (0.34, 1.75)
Some harm	129 (36.65)	7195 (41.14)	0.19 (0.11, 0.32)	0.54 (0.22, 1.37)
A lot of harm	79 (22.44)	7460 (42.65)	0.10 (0.05, 0.18)	0.40 (0.14, 1.18)
Cigarette harm				
No harm	31 (8.81)	296 (1.69)	Reference	
Little harm	62 (17.61)	1244 (7.11)	0.29 (0.17, 0.49)	0.30 (0.13, 0.73)
Some harm	155 (44.03)	7460 (42.65)	0.14 (0.08, 0.23)	0.31 (0.12, 0.76)
A lot of harm	104 (29.55)	8490 (48.54)	0.09 (0.05, 0.15)	0.38 (0.16, 0.91)
E-cig addiction comp. to cig				
Less addictive	53 (15.06)	1399 (8.00)	Reference	
Equally addictive	121 (34.38)	5973 (34.15)	0.54 (0.36, 0.79)	1.18 (0.67, 2.09)
More addictive	125 (35.51)	5352 (30.60)	0.74 (0.53, 1.05)	1.72 (1.01, 2.91)
Never heard/don't know	53 (15.06)	4766 (27.25)	0.25 (0.15, 0.42)	1.09 (0.57, 2.10)
Chewing tobacco etc. use				
Yes	181 (51.42)	347 (1.98)	Reference	
No	171 (48.58)	17 143 (98.02)	0.02 (0.01, 0.03)	0.08 (0.05, 0.11)
Cigarette use				
Yes	187 (53.13)	1154 (6.60)	Reference	
No	165 (46.88)	16 336 (93.40)	0.07 (0.04, 0.09)	0.39 (0.27, 0.56)
E-cigarette use				
Yes	265 (75.28)	2864 (16.38)	Reference	
No	87 (24.72)	14 626 (83.62)	0.06 (0.04, 0.08)	0.27 (0.18, 0.40)

<sup>a</sup>Adjusted for all other covariates; numbers in bold are statistically significant.

3.79]), and 174% (2.74 [1.70, 4.41]), respectively. The adjusted odds ratio for nicotine pouch/dissolvable tobacco products use was lower in non-Hispanic Black (0.64 [0.40, 1.03]), and Hispanic students (0.85 [0.57, 1.27]), compared to non-Hispanic White students. Compared with White students, those in the other race category had a 53% decrease in the odds of having used a nicotine pouch, or dissolvable tobacco products. Compared to the ORs from the simple logistic regression, the adjusted ORs in general had lower magnitude. This is because there is certain degree of

correlation among the risk factors included in the regression model, and the adjusted OR for a risk factor was estimated by taking into account of all other risk factors in the model.

The perception of harm related to cigarettes was strongly associated with lower risk of trying these products; specifically, students who considered that cigarette smoking has “little,” “some,” and “a lot of harm” had 70%, 69%, and 62% decrease in the odds of using these products, respectively (Table 3). In addition, students’ perception of the addictiveness of e-cigarettes versus

conventional cigarettes was also identified as a potential risk factor. For example, students who considered that electronic cigarettes are more addictive than conventional cigarettes had a 72% increase in the odds of using a nicotine pouch or dissolvable tobacco products, compared with those considering that electronic cigarettes are less addictive than conventional cigarettes. Students who did not use either electronic cigarettes (OR: 0.27; 0.18-0.40), or conventional cigarettes (OR: 0.39; 0.27-0.56) at a lower odds ratio of using nicotine pouches.

## Discussion

The National Youth Tobacco Survey data shows that 352 surveyed students had used nicotine pouch, and dissolvable tobacco products. Older students had a definite increase in the use of nicotine/dissolvable tobacco products compared to students  $\leq 13$  years old. The perception of harm associated with electronic cigarettes increased the likelihood of using alternative nicotine products. Rapp et al<sup>7</sup> analyzes NYTS results collected from 2015 through 2019, and determined that the perception of harm associated with both combustible cigarettes, and e-cigarettes increased, and the perception of addictiveness of the cigarettes increased over time. The explanation for these changes is uncertain, and may reflect educational efforts, or accumulating experience with various products. In our study, students who did not smoke cigarettes, or did not smoke electronic cigarettes had significantly lower odds ratios for using alternative nicotine products.

Nicotine pouches contain nicotine that is, absorbed across the oral mucous membranes. Stanfill et al<sup>2</sup> analyzes the nicotine content in 37 nicotine pouch brands from 6 manufacturers. The moisture content ranged from 1.12% to 47.2%, and the alkalinity ranged from a pH 6.86 to 10.1. The percent of free nicotine ranged from 7.7% to 99.2%. The total nicotine ranged from 1.29 to 6.11 mg per pouch; the free nicotine ranged from 0.166 to 6.07 mg per pouch. These authors concluded that these patches definitely contained nicotine, and that these products should be included in tobacco control research, policy, and practice. The highly-flavored pouches could increase experimentation by new users.

Yu et al<sup>8</sup> studied the *in vitro* biological activity of 2 commercially available tobacco-free nicotine pouch products, combustible cigarettes, and 1 snus product. The assays tested for cytotoxicity, mutagenicity, and nontoxicity. The total particulate matter from combustible cigarette smoke induced a statistically significant positive response in all 3 *in vitro* assays. The tobacco-free nicotine pouch product was negative in 2 of these assays, and weakly positive in the cytotoxicity assay. These authors concluded that the tobacco-free nicotine pouch had substantially reduced *in vitro* toxicity activity compared to traditional tobacco

products and that the tobacco pouch products provide an opportunity for tobacco harm reduction if smokers switched exclusively to this product.

Several investigators have studied the pharmacokinetics of nicotine pouches. Rensch et al<sup>9</sup> recruited 42 subjects who were current smokers and averaged 16.5 cigarettes/day for an average of 18.7 years. Six nicotine pouches brands were studied, and compared to the participants' own brands of cigarettes. The peak nicotine concentration was higher, and earlier after smoking a cigarette. The maximum concentration occurred at 7.5 min following cigarette smoking and 30 to 35 min following the use of a nicotine pouch. The half-lives for elimination ranged from 109 to 123 min and were similar in these various products. The areas under the curve were not significantly different in 4 of the 6 products compared to the participants' own cigarette brands. The subjective effects based on various questionnaires were similar for all favors but were lower than the effects related to cigarette smoking. Nicotine pouches did relieve cigarette withdrawal symptoms but not as much as the use of cigarettes. The frequency of adverse events was low. These authors concluded that the abuse potential for nicotine pouches was lower for than for cigarettes. Azzopardi et al<sup>10</sup> studied the nicotine pharmacokinetics of an oral nicotine pouch and compared it with 2 other nicotine replacement products, that is, gum and lozenge. The maximum concentration was higher for the nicotine pouches and the lozenge and was reached in 1 h. The nicotine half-life was 2.7 h. The areas under the curve were similar for nicotine pouches, and lozenges. The nicotine pouches had a greater product satisfaction with a higher number of positive responses to subjective satisfaction questions. All products were well-tolerated. Nicotine pouches have minimal side effects. These pharmacokinetic studies involved single doses of nicotine pouches. It is likely that the levels and elimination kinetics change with more frequent dosing and could increase the likelihood of toxicity.<sup>11</sup> In addition, abuse potential cannot be determined with single dose studies.

Thornley et al<sup>12</sup> and co-investigators did a randomized single blinded crossover trial of the effects of nicotine pouches on the relief of tobacco withdrawal symptoms and user satisfaction. They compared a 4 mg oral nicotine pouch with nicotine chewing gum, and a placebo pouch. Craving was significantly reduced by the nicotine pouch group, and its effect was greater than the nicotine gum, and the placebo. It had better ratings on other user satisfaction questions. Individual randomized to nicotine pouch were more likely to maintain tobacco abstinence during of the study day which involved a 21.5-h period. They suggested that this product would be a useful addition to the current nicotine replacement options. The fact that users report significant satisfaction with these products represents a concern when considering their use by novice users such as students.

There are a few studies on the use patterns of nicotine pouches. Tattan-Birch et al<sup>13</sup> surveyed adults in Great Britain to determine the frequency, or prevalence of nicotine pouch use. They determined that 1 in 400 adults were using nicotine pouches. It was more common in men than in women, and was less common in older age groups. Use was more common in current smokers and recent former smokers than in long-term former smokers, and never smokers. These pouches potentially have less hazard than smoking conventional cigarettes. Lee et al<sup>14</sup> used a model to determine the potential benefits of current use of nicotine pouches. Based on multiple assumptions, this model estimated that 600 000 to 700 000 lives would be saved in the United States by the use of this product. Patwardhan<sup>15</sup> and Fagerström reviewed the potential for nicotine pouches to function as a tobacco harm reduction tool. They suggested that a comprehensive regulatory science agenda was needed to maximize the public health potential in current smokers, and minimize unintended consequences. Ramstrom et al<sup>16</sup> studied the patterns of smoking and snus use in Sweden and concluded that the use of snus decreased the initiation of smoking and appeared to facilitate smoking cessation. Fagerstrom<sup>17</sup> analyzes the prevalence of smoking in countries which had a relatively high use of alternative nicotine products, and concluded that these products reduced smoking prevalence faster than other tobacco control measures. These studies suggest that the use of alternative products such as nicotine pouches could reduce the use of cigarettes. This possibility needs more study by tobacco control organizations.

The use of surveys in adolescents with a wide age range has definite limitations, and requires several assumptions. The participants must understand the questions. This particular survey requires that adolescents understand that nicotine pouches contain nicotine, a product that has potential for both long-term harm, and addiction. They need to understand the concepts of both harm, and addiction, which may be limited in younger students. At present, these surveys do not include questions about the potential for serious health consequences with any nicotine product. Other limitations include the use of self-reported data, use of intent to explain actual behavior, the loss of information on individuals not represented by study populations, and the lack of information about the duration, and intensity of the use of tobacco products by students.<sup>18,19</sup> In addition, the responses were not broken down according to whether the students classified themselves as lesbian, gay, bisexual, or transgender. The students might have responses that differ from other students. Some surveys were excluded from then the final analysis because of the missing data. Whether, or not these missing responses had an important effect on conclusions is unknowable but seems unlikely given the very large number of responses analyzes in this study. In addition, approximately 50% surveys were completed at home and 50% were completed at school. Student location during

ongoing education during the pandemic could influence survey responses, and might depend on the presence of parents or guardians.

## Conclusions

This study indicates that a relatively small number of middle school, and high school student used nicotine pouches, and dissolvable tobacco products in 2021. Students who have used electronic cigarettes, and conventional cigarettes were more likely to use these new novel products. These products may have some potential benefit in confirmed tobacco smokers, but they have no benefit in non-smoking students, and offer the risk of nicotine addiction. Physicians, public health officials, and educators should include conversations about nicotine pouch products in their routine professional activities, such as providing health care, and education, to middle school, and high school students. The sales of these products have increased significantly over the last 5 years, and the short term and long-term hazards are unknown.

## Author Contributions

ZS—literature review, data review, manuscript drafting, final approval; SR—literature review, manuscript drafting, final approval; SY—data analysis, manuscript revision, final approval, KN—literature review, manuscript drafting, manuscript revision, final approval.

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## Ethics Statement

The information used in this project is available from the Centers for Disease Control and Prevention and is open source on the Internet. The CDC's Institutional Review Board oversees the development and approval of these projects.

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## Supplemental Material

Supplemental material for this article is available online.

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