



Purpose: This report is to provide awareness to school administrators, employees, scientists, and the general public regarding the chemical composition of vape products that were recovered from students in Western Pennsylvania over a three year period spanning 2019 to 2022.

Overview: Vaporizer (“vape”) and electronic cigarette (“e-cig”) use among youth is on the rise. Added flavorings, lack of odor, and a perception of safety contribute to this increase in popularity, among other factors. Vape products most commonly contain nicotine, but can contain other chemicals and/or drugs like tetrahydrocannabinol (THC), the primary psychoactive component in cannabis (marijuana). The presence or absence of potentially harmful components of vaping liquid is often unknown to a consumer, adding a level of inherent risk or harm from use. Additionally there are concerns of battery fires and/or contamination by the device itself. In addition to nicotine- and THC-containing products, it remains of particular interest whether other drugs, such as synthetic cannabinoids or opioids like fentanyl, are contained in or substituted for the vape liquid. The FDA and the CDC recently published a report stemming from a survey of vape products and their use, and interestingly the vape products tested as part of this study are reflective of those survey responses.¹

Objective: A partnership between the Center for Forensic Science Research and Education (CFSRE) and the Drug Enforcement Administration (DEA) Intelligence Group at the Pittsburgh District Office was established to evaluate vape products that were recovered from high schools. The main objective was to differentiate nicotine from cannabis vape products (or others) through comprehensive drug testing, in addition to determining if potentially harmful substances were present and if there was any evidence of mixing, substitution, and/or adulteration with other drugs or substances. Sampling was not random but rather “for cause” and the sample set may not be reflective of the larger population. Unique school identifiers are not provided within this report.

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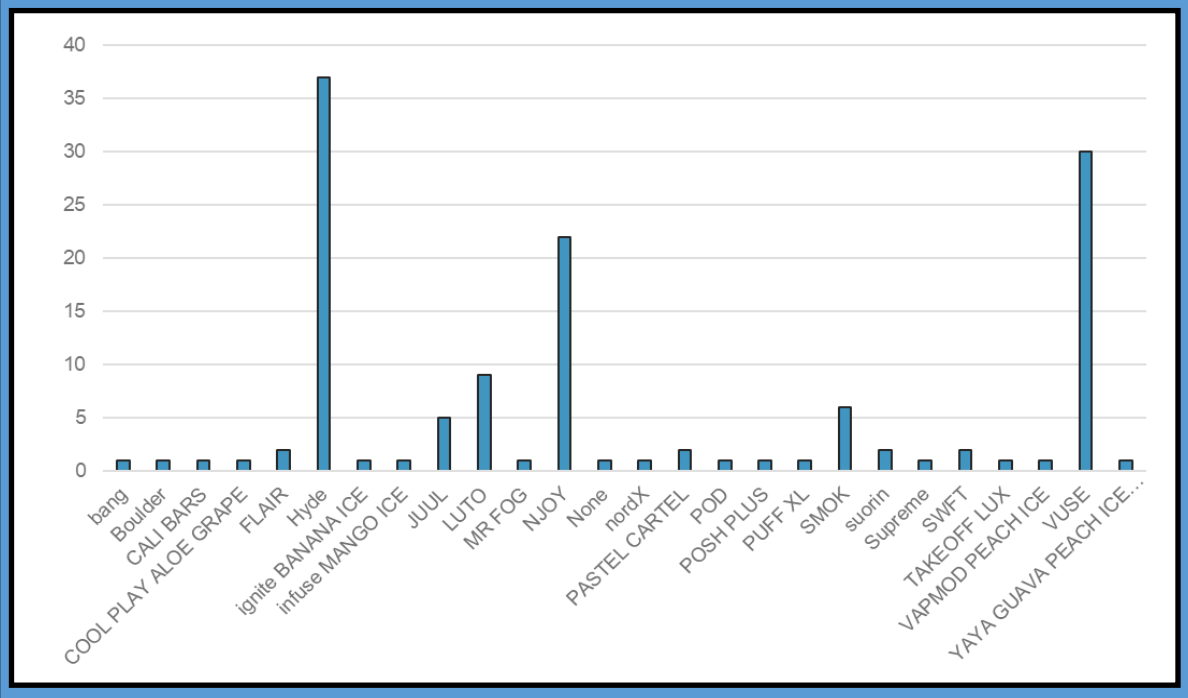
Summary and Key Findings:

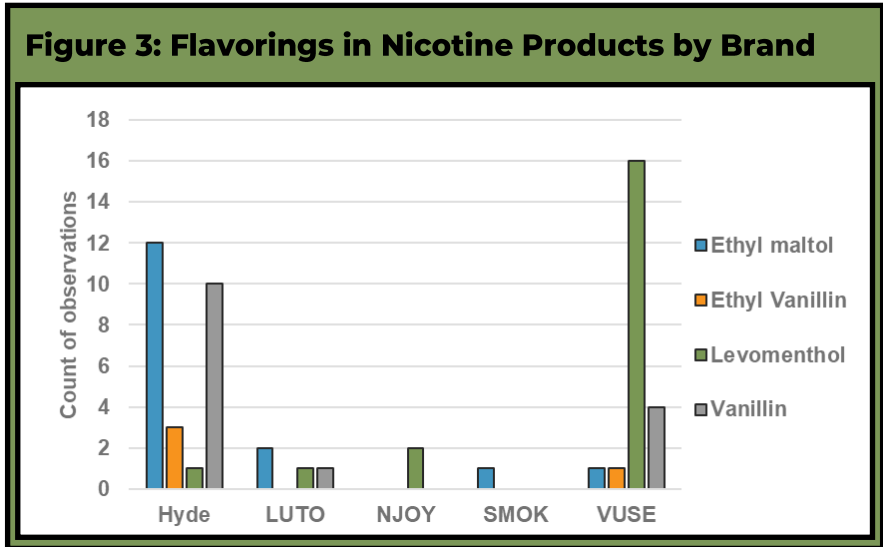
- ◆ 170 vape products were analyzed by GC-MS.
- ◆ All contained nicotine or cannabis-related drugs; no synthetic cannabinoids, fentanyl, nor other drugs were detected.
- ◆ No evidence of adulteration, mixing, or substitution was observed; nicotine was detected in all suspected nicotine-containing products.
- ◆ 29 of the 170 vape products tested contained cannabinoids, such as delta-9 THC, delta-8 THC, CBN, and CBD.
- ◆ Cannabis-containing products (with one exception) had distinctly different physical appearance from nicotine-containing products.
- ◆ ~20% of cannabis products contained vitamin E acetate, a compound associated with the respiratory condition EVALI.

Nicotine Products:

The top five brands observed in this sample set were marked as *Hyde*, *LUTO*, *NJOY*, *SMOK*, *VUSE* (Figure 1). Interestingly, *Puff* was not common in this sample set, but was the most common brand indicated in the CDC/FDA survey. *VUSE*, *SMOK*, and *NJOY* were in the top five responses. Three of the five *JUUL* Brand products were recovered during the 2019-2020 school year, suggesting that this brand may have fallen out of favor. *Hyde*, the most popular brand in this sample set, was not a pre-defined response for the CDC/FDA survey so its popularity was likely under-represented in the survey results. *LUTO* (Figure 2) was not listed in the CDC/FDA survey, but was the fifth most frequent in this study.

Figure 1: Branding Observed for Nicotine-Containing Products





Nicotine Products (Continued):

Two examples of e-cigarettes of the *LUTO* brand are shown in Figure 2. Public health professionals often believe that the colors and graphics on this type of packaging may be more inviting to youth, which is viewed as a concern. One of nine *LUTO* samples was recovered in the 2020-2021 school year; the other eight were recovered in the 2021-2022 school year, which may suggest brand popularity is increasing.

Figure 3 shows the commonly observed chemical flavorings that were detected among nicotine-containing products. In general, levomenthol was detected most commonly in menthol-flavored products. Ethyl maltol, ethyl vanillin, and vanillin were detected alone or in combination in the vape cartridges labeled to have flavors associated with fruit, ice-cream, cola or other sweets. Interestingly, the *NJOY* brand, with few exceptions, was labeled as menthol but levomenthol was detected much less frequently than with other brands. With the exception of one product, none of these additives were detected in the *SMOK* products.

None of the 141 tested nicotine products were found to contain synthetic cannabinoids, natural cannabinoids, or any other drug substances. Other substances of unknown purpose were frequently detected, including piperidinol, 1-ethyl (n = 81); benzoic acid (n = 67); and triacetin (n = 25); however, these substances were not confirmed but rather identified based on external database matching.

Table 1: Frequency of Cannabinoids Identified in Cannabis Product Sub-groups.

Note: Delta-9 THC was a minor component when it was identified in products of the “CBN” and “d8THC” sub-groups.

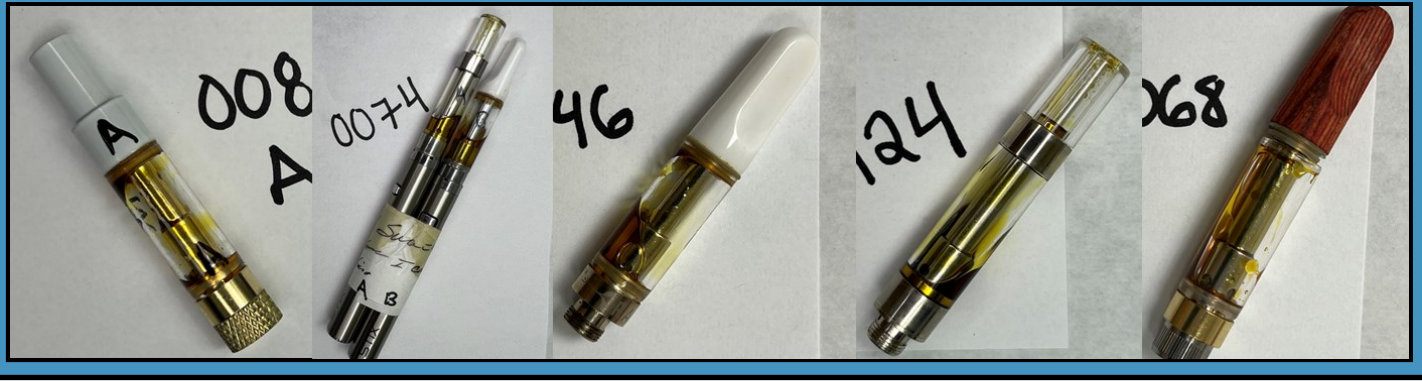
Sub-Group ▶	1:1	CBN	d8THC	d9THC
Cannabinoid ▼	n = 3	n = 4	n = 7	n = 15
Cannabichromene	100%	25%	43%	60%
Cannabicitran	33%	0%	29%	87%
Cannabicyclic acid	100%	75%	0%	80%
Cannabidiol (CBD)	33%	0%	29%	67%
Cannabigerol	33%	0%	43%	53%
Cannabinol (CBN)	100%	100%	100%	100%
Delta-8 Tetrahydrocannabinol	0%	0%	29%	0%
Delta-8 THC	0%	0%	100%	13%
Delta-9 Tetrahydrocannabinol	0%	0%	14%	67%
Delta-9 THC	100%	75%	57%	100%

Cannabis Products:

The cannabis products tested (n=29) were divided into sub-groups based on the cannabinoids identified and their relevant proportions. Products with approximately even proportions of delta-9 THC and cannabinol (CBN) as the primary components were classified as “1:1”. Products with a predominant CBN component and little or no delta-9 THC were classified as “CBN”. Products with a predominant delta-8 THC component and little or no delta-9 THC were classified as “d8THC”. Products with a predominant delta-9 THC component were classified as “d9THC”. All tested samples fit well within these sub-groups, but it is not known what these products were purported to be when originally sold and/or consumed.



Figure 4: Cannabis Vape Cartridges Containing Vitamin E Acetate



Cannabis Products (Continued):

None of the cannabis products contained synthetic cannabinoids, novel psychoactive substances, or other drugs. However, 20.6% (n=6) of the samples contained vitamin E acetate, a substance that has been strongly associated with lung injury caused by vape product (primarily cannabis product) use, also known as “EVALI”.^{2,3} Deaths and serious lung illnesses have been reported with EVALI.⁴ The cannabis products containing vitamin E acetate were indistinguishable from other cannabis products. Vitamin E acetate was found in all sub-groups of the cannabis products (one of the “1:1”, one of the “CBN”, one of the “d8THC”, and three of the “d9THC” sub-groups). The distribution of vitamin E acetate in cannabis product sub-groups mirrors the overall distribution of cannabis products received; therefore, no correlation was noted.

Counterfeit (or “homemade”) cannabis vape operations have been in the news over the past few years.⁵ Professionals have linked some of these types of bootleg operations to vape products with vitamin E acetate. Yet, the true prevalence of vitamin E acetate in cannabis vape products is largely unknown due to most crime laboratories not including this substance in their scope of testing and/or reporting. Counterfeit vape products (i.e., those containing vitamin E acetate) are not produced under quality control measures, nor do they undergo chemical and safety testing—which is not the case for cannabis vape products produced for the recreational/medical cannabis industry.

Cannabis-containing products all resemble the cartridges shown in Figure 4, with only one exception, which is shown in Figure 5. In general, apart from the *PAX ERA* device, the cartridges are intended to be disposable and used interchangeably with an external battery. The battery itself is intended to be reusable, in most cases. However, it is possible to remove the mouth piece from the cartridge and directly access the liquid, making adulteration, substitution, and/or refilling possible. Item #0074 in Figure 4 shows two cartridges attached to external batteries.

The prevalence of delta-8 THC products (e.g., vapes, edibles) on the market has been increasing, largely due to confusing legal status and hemp origins. This has created what some would characterize as a “quasi-legal” market space for the drug, which means youth, parents and school administrators must be aware of delta-8 THC and the unknown dangers or side effects associated with its use. Delta-8 THC-containing vape products are not regulated, so the extent of quality and safety testing is questionable to non-existent. It may be important to emphasize to youth that items or drug products sold from “legitimate” sources or businesses are not universally safe and may come with unanticipated harm. The safety profile of delta-8 THC vs. delta-9 THC is unknown, especially in adolescents.

One unusual observation from this study was the abundance of CBN in a number of cannabis products. The authors hypothesize that the CBN observed is due to the degradation of delta-9 THC and/or CBD.⁶ No sources could be found for any online retailer advertising CBN as the primary component of their vaping products. Over time, external factors, such as exposure to heat, humidity, ultra-violet light, or variations in pH, may contribute to the formation of CBN through the degradation of CBD and THC. Shelf-life and stability under various storage conditions should be further evaluated.

Figure 5: PAX ERA

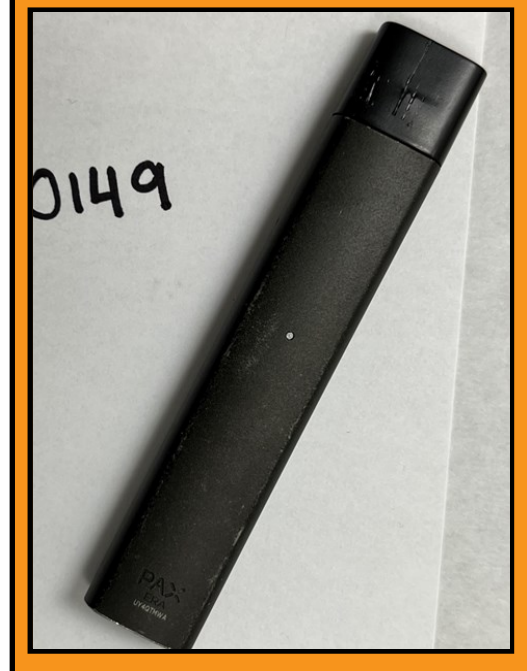




Figure 6: General Differences in Physical Appearance of Nicotine vs. Cannabis Products

Nicotine Products

1. Cartridges that are fully sealed with no easy access to the vape liquid generally contain nicotine.
2. Disposable nicotine cartridges are typically constructed using plastic with a magnetic base.
3. When visible, nicotine vape liquid is much less viscous (i.e., more runny).
4. Nicotine vaping liquid can be purchased in bulk (>20mL) and used to refill a vape cartridge.
5. Nicotine vape products are often labeled with a flavor, such as mint, menthol, ice cream, or strawberry.
6. A person using a nicotine vape product often produces a thick, white cloud of vapor due the glycerin/glycol condensing agent.

Examples of Nicotine Products:



Cannabis Products

1. Cannabis vape products almost always consist of a liquid-containing cartridge to be used with a separate battery.
2. Disposable cannabis cartridges are typically constructed from glass, with a metal threaded base.
3. Cannabis vape liquid is usually visible, and is considerably more viscous (i.e., thick, slow flowing).
4. Cannabis refill liquid, though somewhat uncommon, can be purchased in smaller amounts, usually in 1cc (1mL) syringes.
5. In this study, cannabis products were not marketed with a flavoring profile.
6. A person using a cannabis vape product tends to exhale vapor that is more similar to smoke or steam in visual appearance.

Examples of Cannabis Products:



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