

M₃ MathWorks Math Modeling Challenge 2019

A CONTEST FOR
HIGH SCHOOL STUDENTS
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One is too many and a thousand not enough: *Substance Use and Abuse*

Substances such as tobacco, alcohol, and narcotics can affect the physical and mental health of users. The consequences of substance abuse, both financial (health care, the criminal justice system, workplace productivity, etc) and non-financial (divorce, domestic abuse, etc), ripple through society and affect more than just the user. The effects of substance abuse on individuals and society have come to the forefront recently as opioid addiction has become prominent¹.

Efforts, such as taxes and regulations on cigarettes and the Drug Abuse Resistance Education program, have been made at the local, state, and national level to educate, control, and/or restrict the consumption of such substances. Such efforts need to start with an understanding of how substance abuse spreads and affects some individuals more than others.

- Darth Vapor**—Often containing high doses of nicotine, vaping (inhalation of an aerosol created by vaporizing a liquid) is hooking a new generation that might otherwise have chosen not to use tobacco products. Build a mathematical model that predicts the spread of nicotine use due to vaping over the next 10 years. Analyze how the growth of this new form of nicotine use compares to that of cigarettes.
- Above or Under the Influence?**—Like nicotine, the abuse of most substances is correlated with numerous internal and external factors that affect the likelihood of an individual becoming addicted. Create a model that simulates the likelihood that a given individual will use a given substance. Take into account social influence and characteristic traits (e.g., social circles, genetics, health issues, income level, and/or any other relevant factors) as well as characteristics of the drug itself. Demonstrate how your model works by predicting how many students among a class of 300 high school seniors with varying characteristics will use the following substances: nicotine, marijuana, alcohol, and un-prescribed opioids.
- Ripples**—Develop a robust metric for the impact of substance use. Take into account both financial and non-financial factors, and use your metric to rank the substances mentioned in question #2.

Your submission should include a one-page executive summary with your findings, followed by your solution paper—for a maximum of 20 pages. If you choose to write code as part of your work to be eligible for the technical computing prize, please include it as an appendix. Cite your sources, including those in the provided data files if you use them. Any code appendix or reference page(s) will not count toward your 20-page limit.

[1] [https://www.npr.org/2019/01/14/684695273/report-americans-are-now-more-likely-to-die-of-an-opioid-overdose-than-on-the-ro](https://www.npr.org/2019/01/14/684695273/report-americans-are-now-more-likely-to-die-of-an-opioid-overdose-than-on-the-road)

MORE ON REVERSE

DATA STATEMENT

Various organizations and agencies collect a data on a regular basis. A small amount of data has been compiled and provided. You are not required to use this data; that is, you may choose to use none, some, or all of this data and/or any additional data sources you may identify while working on this problem. Be sure to cite all resources used. The data files (names below) are linked from this page: <https://m3challenge.siam.org/node/439>.

- High_school_vaping_data
- NIH-DrugTrends-Data Sheet
- A figure is also provided for historical context of cigarette consumption

MATLAB Users: If you are trying to use this or any other spreadsheet data in MATLAB, you can import the data by double-clicking the files in MATLAB's "Current Folder" browser or use the [Import Data Button](#) at the top of the Toolbar. Watch this quick MATLAB [video tutorial](#) about importing spreadsheet data. See how the [MATLAB Import Tool](#) was used in a previous year's problem to import and analyze data.

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Problem statement: This problem is based on the following scenario: In 2016, the U.S. Centers for Disease Control and Prevention (CDC) released a report showing that approximately 11.7% of high school students in the United States reported using e-cigarettes in the past month. This is up from 2013, when 6.9% of high school students reported using e-cigarettes. The report also found that 1 in 5 high school students who used e-cigarettes also smoked traditional cigarettes. The CDC also found that e-cigarette use was more common among boys than girls. The report concluded that e-cigarettes were a significant concern for public health because they pose risks to health and can lead to addiction. The report recommended that more research be conducted to better understand the health effects of e-cigarettes and to develop policies to prevent their use among young people.

Background: E-cigarettes are electronic devices that heat a liquid to produce an aerosol that is inhaled through a tube. They are often referred to as "vape pens" or "e-cigs". E-cigarettes contain nicotine, which is a highly addictive substance. Nicotine is a stimulant that can cause increased heart rate, blood pressure, and breathing rate. It can also affect the brain and nervous system, leading to mood swings, anxiety, and depression. E-cigarettes also contain other chemicals, such as flavorings and preservatives, which can be harmful to health. The use of e-cigarettes is becoming increasingly popular among young people, particularly teenagers. This is due to the availability of e-cigarettes in schools and convenience stores, as well as the marketing of e-cigarettes as a "safe" alternative to traditional cigarettes. However, there is growing concern about the health risks associated with e-cigarette use, particularly among young people.

Objectives: The purpose of this problem is to analyze data from the CDC report to answer the following questions:

- 1. What is the percentage of high school students who reported using e-cigarettes in the past month? Is this percentage higher or lower than the percentage in 2013?*
- 2. Are there any differences in e-cigarette use between boys and girls? If so, what are they?*
- 3. Is there a correlation between e-cigarette use and smoking traditional cigarettes? If so, what is it?*
- 4. What are the most common flavors of e-cigarettes used by high school students?*
- 5. How many e-cigarettes are sold per month in the United States?*

Note: The data provided in the problem statement is for illustration purposes only and does not reflect actual data from the CDC report.

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