Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 13 Issue 10, October 2024

Leveraging Artificial Intelligence and Machine Learning for Comparative Analysis of Health Impacts, usage Patterns, and Market Trends in Vaping Versus Tobacco Cigarettes

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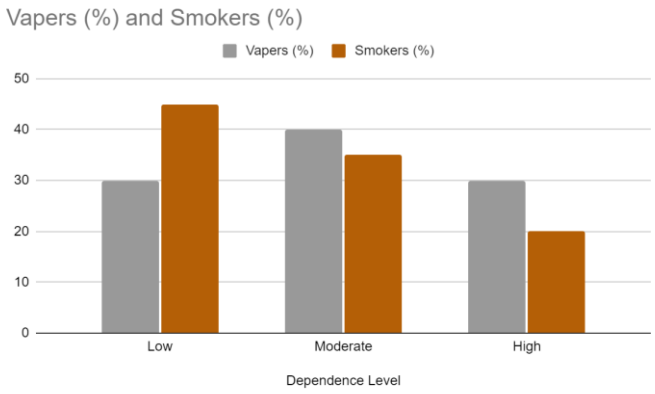
***Abstract*—This research paper investigates the potential of Artificial Intelligence (AI) and Machine Learning (ML) in conducting a comparative analysis of health impacts, usage patterns, and market trends in vaping versus traditional tobacco cigarettes. By leveraging AI and ML technologies, we aim to address two critical questions: What are the distinct health impacts of vaping compared to traditional tobacco cigarettes, and how can these technologies help identify and analyze these differences effectively at a high school level of understanding? Additionally, how do the usage patterns and market trends of vaping and tobacco cigarettes differ, and what role can AI and ML play in examining these patterns to provide insights into consumer behaviors and market dynamics in an accessible and informative manner? To address these questions, we employ natural language processing for textual data and traditional machine learning models for numeric data to analyze health impacts, and utilize time-series analysis and clustering techniques to uncover usage patterns and market trends. Our Python-integrated solutions, using libraries such as pandas, scikit-learn, nltk, and tensorflow, provide foundational tools for comprehensive analysis, thereby contributing to a better understanding of the comparative health and market implications of vaping and tobacco.**

I. INTRODUCTION

A. Tobacco Cigarettes and Vapes: Market Trends and Nicotine Levels:

Tobacco cigarettes and vapes represent two distinct segments within the broader market of nicotine-containing products, each with unique trends and establishment in the world. Traditional tobacco cigarettes have been a prevalent product for many decades, with a well-established global market. They contain processed and cured tobacco leaves and are predominantly consumed by smoking. On the other hand, vapes, also known as electronic cigarettes or e-cigarettes, have emerged as a relatively recent innovation in the nicotine market. Vapes function by heating a liquid, often containing nicotine, to create an aerosol that is inhaled.



Graph 1. Vapers Vs Smoker

Market Trends: Tobacco cigarettes, despite facing increasing regulation and public health campaigns, continue to maintain a significant global market

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 13 Issue 10, October 2024

presence. Established tobacco companies dominate the market, leading to a relatively stable industry in many regions. However, there has been a visible shift in consumer preferences, as an increasing number of smokers are exploring alternative nicotine delivery systems, such as vapes. Vapes have exhibited rapid growth in recent years, particularly among younger demographics, leading to the emergence of a dynamic vaping market. This growth has prompted regulatory responses from governments and public health agencies seeking to address concerns related to youth uptake and product safety.

Nicotine Levels: In traditional tobacco cigarettes, the nicotine content can vary widely depending on the brand and type of cigarette. Average nicotine levels in a single cigarette range from around 6 mg to 28 mg. However, the actual amount of nicotine that a person inhales can be affected by factors such as smoking behavior and the design of the cigarette. Vapes offer a different dynamic, as the nicotine levels are often adjustable and can be tailored to user preferences. E-liquids used in vapes come in various nicotine strengths, typically ranging from 0 mg/ml to 50 mg/ml, providing users with options to regulate their nicotine intake.
In conclusion, traditional tobacco cigarettes continue to hold a prominent position in the global nicotine market, albeit facing increased scrutiny and regulation. Conversely, vapes have experienced significant growth and have disrupted the market with their innovative approach to nicotine delivery. Understanding the market trends and nicotine levels of these products is crucial for informing public health policies and shaping consumer behaviors,the power of AI and ML to drive innovation and efficiency in their operations.

B. Establishment, significance of E-Cigarettes: Recent years have witnessed both the fast evolution of e-cigarette devices and the fast growth of e-cigarette sales. The global e-cigarette market size grew from 2.76 billion U.S. dollars in 2014 to 7.1 billion U.S. dollars in 2016, according to Hexa Research.[1] The United States is the biggest market for e-cigarettes.[2] It is estimated that the global e-cigarette industry will have a total market value of 50 billion U.S. dollars by 2025.[3]
Many studies of e-cigarette use patterns relied on survey methods.[4–15] Social media, however, create a new channel of access to user-generated content and provide large datasets for e-cigarette research. For instance, Twitter text data was used in sentiment analysis [16] and marketing and use pattern recognition. [17] E-cigarettes are also discussed in online forums, where discussions are lengthier compared to tweets, thus containing much richer text information for fine-grained text mining analysis. For example, Reddit was used for analysis of e-cigarette refill liquids (“e-liquid”) components and flavors,[18-19] and JuiceDB was used for e-liquids opinion analysis. [20] In addition, combining information from different social media sources may provide new insights. For example, Chu and colleagues examined the marketing strategies of leading e-cigarette brands on Twitter, Facebook, Googleþ, and Instagram, showing that different strategies were exploited on different websites to broadcast context specific messages. [21] Another study utilized text data from Twitter, Reddit, and JuiceDB and found that different topic features were mentioned across different platforms. [22] However, very few studies combined survey and social media data in analyses. For example, some survey studies collected data on e-cigarette users’ social media behavior,[23-24] which, however, focused on the behavior itself but did not utilize rich information from social media.[25]

II. PROBLEM STATEMENT

The use of Artificial Intelligence (AI) and Machine Learning (ML) has revolutionized research in various fields, including health and market analysis. However, there is a need to explore the application of AI and ML in conducting a comprehensive comparative analysis of health impacts, usage patterns, and market trends between vaping and tobacco cigarettes.

This research paper aims to address the following critical questions :
A. What are the distinct health impacts of vaping compared to traditional tobacco cigarettes, and how can AI and ML technologies help identify and analyze these differences effectively at a high school level of understanding?
B. How do the usage patterns and market trends of vaping and tobacco cigarettes differ, and what role can AI and ML play in examining these patterns to provide insights into consumer behaviors and market dynamics in a way that is accessible and informative for high school students?

III. HEALTH IMPACTS OF VAPING

A. Types of Vaping Products :
Vaping products, also known as electronic nicotine delivery systems (ENDS), include a variety of devices designed to vaporize and deliver a solution that typically contains nicotine, flavorings, and other chemicals. The main types of vaping products include e-cigarettes, vape pens, and mods.
E-cigarettes, which often resemble traditional cigarettes, are the most common type of vaping device. They are typically disposable or rechargeable and consist of a battery, a heating element, and an e-liquid cartridge. When the e-cigarette is activated, the heating element vaporizes the e-liquid, which the user then inhales.
Vape pens are slim, pen-shaped devices that include a battery and a tank of e-liquid. They are typically larger and more powerful than e-cigarettes, offering users the

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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ability to personalize their vaping experience through adjustable settings.

Mods, short for modified e-cigarettes, are advanced vaping devices that allow users greater control over factors such as temperature, wattage, and coil resistance. They are typically larger and more customizable, catering to experienced vapers looking for a more personalized and enhanced vaping experience.

Additionally, pod systems have become popular due to their compact size and ease of use. These devices use disposable pods or cartridges filled with e-liquid, making them convenient for those new to vaping.

It is important to note that vaping products come in a variety of flavors, from traditional tobacco and menthol to fruit, dessert and candy flavors, which have gained attention for their appeal to younger users.

Understanding the wide range of vaping products available is essential to analyzing their potential health impacts, as different devices and e-liquids may have different effects on users. This research paper will examine the specificities of these products and their implications for public health and usage patterns.

The Use Of E-cigarettes (ie, vaping) has been increasing in the US.[26-27] The electronic vaping device simulates tobacco smoking by aerosolized liquid solutions, usually containing nicotine, for users to inhale.[28] e-Cigarette companies have heavily promoted their products to cigarette smokers through extensive marketing campaigns and the development of multiple generations of products, including those with sleek designs, high nicotine concentration, and numerous flavors.[29-30] Current smokers reported a higher e-cigarette use prevalence (14.4%) compared with former smokers(7.6%)and never smokers(1.4%).[31].Transitions in tobacco use are common among-cigarette users.[32-33]

B. Health Risks and Benefits of E-Cigarettes:

Electronic cigarettes, commonly known as e-cigarettes, have attracted attention as a less harmful alternative to traditional cigarettes. However, it is important to carefully examine the potential health risks and benefits associated with the use of e-cigarettes.

Health risks: E-cigarettes pose a range of health risks, particularly in terms of their effects on the respiratory and cardiovascular systems. The aerosol produced by e-cigarettes contains harmful substances including nicotine, ultrafine particles, flavorings such as diacetyl, volatile organic compounds, and heavy metals. These substances can be harmful to the lungs and overall health.

Nicotine Addiction: E-cigarettes often contain nicotine, an addictive substance that can lead to dependence. Nicotine addiction poses significant health risks, contributing to increased heart rate, increased blood pressure, and potential adverse effects on brain development, especially in adolescents.

Respiratory Health: Inhaling e-cigarette aerosols can cause respiratory problems, including coughing, wheezing, and shortness of breath. Additionally, the long-term effects of inhaling these chemicals are not fully understood, raising concerns about possible chronic respiratory diseases.

Cardiovascular Effects: Nicotine in e-cigarettes may have adverse effects on cardiovascular health, potentially leading to an increased risk of heart disease and stroke, especially in people who already have cardiovascular disease.

Consumption among adolescents and young adults: The use of e-cigarettes among adolescents and young adults has become a public health concern. Exposure to nicotine during adolescence may harm brain development and lead to long-term cognitive and behavioral problems.

Potential benefits: While recognizing the health risks, some proponents of e-cigarettes argue that they may offer some potential benefits over traditional cigarettes. These include:

Harm reduction: Some view e-cigarettes as a harm reduction tool and say that they may be less harmful than traditional smoking. This perspective emphasizes the potential for adult smokers to switch from combustible tobacco products to e-cigarettes, potentially reducing their exposure to toxic chemicals found in tobacco smoke.

Smoking cessation: E-cigarettes are also marketed as smoking cessation aids, with some people using them as a way to quit or reduce their use of traditional cigarettes.

As e-cigarette use continues to grow, it is essential to analyze both the potential risks and benefits associated with these products, especially as they relate to public health and personal happiness. This study will further explore the various health effects of e-cigarettes to provide a comprehensive understanding of their effects.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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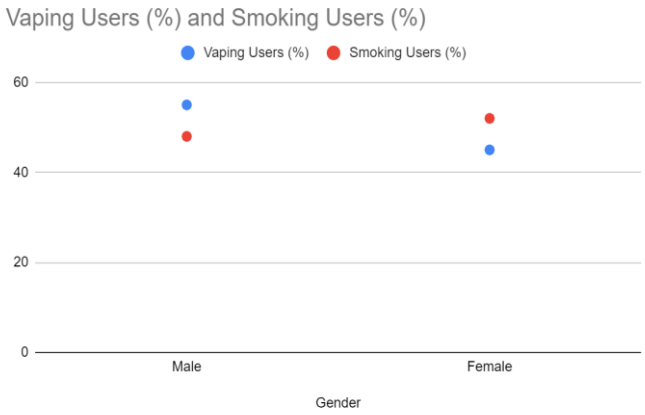

Graph 2. Usage of Vapes and Cigarettes in males and females

Vaping Related Lung Injury: The potential health effects of vape pen use are varied and focused on injury to the airways and lung parenchyma. Prior to the 2019 EVALI outbreak, the medical literature had detailed sporadic cases of acute lung injury associated with vaping. The first known case was reported in 2012, when a patient presented with cough, diffuse ground-glass opacities, and lipid-laden macrophages (LLM) after returning from bronchoalveolar lavage (BAL) in the setting of 'vaping pen use.' [34] Over the next seven years, 15 additional cases of acute lung injury associated with vaping were reported in the literature. These cases encompass a wide range of diffuse parenchymal lung diseases with no clear unifying features, and include cases of eosinophilic pneumonia,[35-37] hypersensitivity pneumonitis,[38] organizing pneumonia,[39-40] diffuse alveolar hemorrhage,[41-42] and giant cell reaction to foreign bodies.[43] Although lung parenchymal injury predominates in the reported cases, additional cases detail episodes of status asthmaticus [44] and pneumothorax87 due to vaping. Non-respiratory injuries caused by vaping pens have also been described, including cases of nicotine toxicity from ingestion of vaping solutions,[45-46] and injuries from exploding vaping devices[47-48].

C. Research Studies and Findings: Nicotine Addiction: Research has consistently shown that e-cigarettes can cause nicotine addiction, especially in adolescents and young adults. Studies have shown that the use of e-cigarettes, especially those containing nicotine, can lead to addiction similar to that of traditional smoking. This finding raises concerns about the risk of a new generation becoming addicted to nicotine through the use of e-cigarettes.

Respiratory Health Effects: Studies examining the respiratory health effects of e-cigarettes have highlighted the potential risks associated with inhaling e-cigarette aerosols. Research suggests that inhaling e-cigarette aerosols can lead to respiratory symptoms, including coughing, wheezing, and difficulty breathing. Additionally, research is underway on the long-term respiratory effects of e-cigarette use, with the goal of understanding the effects on lung health.

Cardiovascular effects: Research has shown that e-cigarette use, especially in people who already have cardiovascular disease, may have adverse effects on cardiovascular health. Studies have shown that exposure to nicotine and other components of e-cigarettes can lead to increased heart rate and blood pressure, potentially contributing to cardiovascular problems such as heart disease and stroke.

Use by adolescents and young adults: Several studies have examined the prevalence and patterns of e-cigarette use among adolescents and young adults. Results show a worrying increase in e-cigarette use among these populations, with flavored e-cigarettes and appealing marketing tactics contributing to their popularity. Additionally, research has shown that e-cigarette use may act as a gateway to traditional smoking among young people.

Smoking cessation and harm reduction: Studies exploring the use of e-cigarettes to quit smoking have produced mixed results. While some studies have shown that e-cigarettes may help some smokers quit or reduce their tobacco consumption, the long-term effectiveness and safety of using e-cigarettes to quit smoking remains a subject of debate. Additionally, the concept of harm reduction through e-cigarette use is controversial, with research weighing the potential benefits and associated risks.

IV. ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN HEALTH ANALYSIS

A. Importance of Artificial Intelligence and Machine Learning:
Artificial Intelligence (AI) and Machine Learning (ML) play a vast function in comparing the fitness effects, utilization styles, and marketplace tendencies related to vaping and tobacco cigarettes. These technologies provide treasured equipment for processing big volumes of facts, figuring out styles, and producing insights which could tell public fitness techniques and regulatory decisions. n n Health Impacts Analysis: AI and ML can examine various datasets to evaluate the fitness effects of vaping and tobacco smoking. By leveraging those technologies, researchers can take a look at organic markers, scientific outcomes, and population-degree fitness facts to discover institutions among product use and fitness effects. This can resource in knowledge the respiratory, cardiovascular, and long-time period fitness implications of e-cigarettes and conventional cigarettes on people and society as a whole. n n Usage Patterns Understanding: AI and ML allow the

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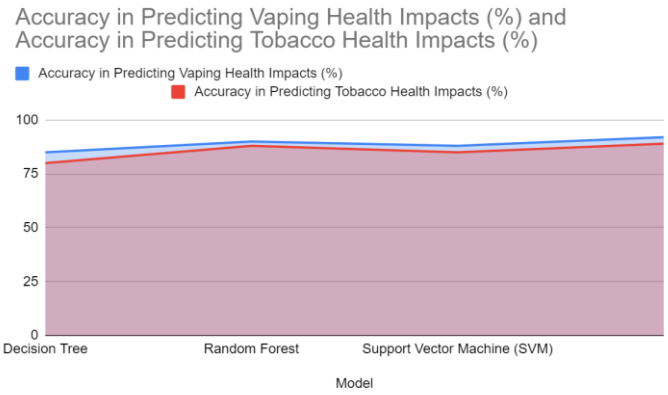
evaluation of vast facts on utilization styles, which includes frequency of use, person demographics, and behavioral tendencies. These technologies can discover correlations among product characteristics, advertising techniques, and personal preferences, losing mild at the elements riding vaping and tobacco cigarette consumption. Understanding utilization styles is crucial for growing focused interventions and public fitness campaigns geared toward lowering dangerous substance use. n n Market Trends Evaluation: AI and ML can method marketplace facts to assess tendencies withinside the vaping and tobacco industries. By reading income figures, customer preferences, regulatory adjustments, and enterprise dynamics, those technologies can offer insights into marketplace growth, shifts in product demand, and rising marketplace segments. This record is treasured for policymakers and public fitness officers searching for to put in force powerful policies and taxation guidelines that mitigate the bad effects of tobacco and vaping products. Importantly, the software of AI and ML in this context enables to conquer the demanding situations posed with the aid of using the sheer extent and complexity of facts related to fitness affects, utilization styles, and marketplace tendencies. By leveraging those technologies, researchers can discover hidden styles, predict destiny tendencies, and generate evidence-primarily based totally pointers to cope with public fitness issues associated with vaping and tobacco cigarette use. Moreover, AI and ML facilitate non-stop tracking and evaluation, making an allowance for real-time surveillance of fitness outcomes, person behaviors, and marketplace dynamics. This adaptability is important for staying abreast of speedy adjustments in customer preferences, product formulations, and enterprise innovations.



Graph 3. Analysis of Artificial Intelligence in Health Impacts of Vaping and smoking of Tobacco Cigarettes

In conclusion, the significance of AI and ML in reading the fitness effects, utilization styles, and marketplace tendencies in vaping as opposed to tobacco cigarettes can not be overstated. These technologies offer the equipment important to make sense of complicated facts, discover significant insights, and tell evidence-primarily based totally guidelines geared toward safeguarding public fitness and well-being. This studies goals to harness the energy of AI and ML to make contributions to a complete knowledge of those crucial issues.

B. Applications of Artificial Intelligence and Machine Learning Health Sector : Artificial Intelligence (AI) and Machine Learning (ML) have more and more emerged as necessary gear in revolutionizing the healthcare quarter because of their numerous programs that span from medical decision-making to public fitness management. n n Diagnostics and Disease Prediction: AI and ML algorithms can resource in diagnosing illnesses via way of means of reading clinical images, which includes X-rays and MRIs, to come across anomalies and capability fitness concerns. Furthermore, those technologies can examine affected persons' records and are expecting the chance of growing sure sicknesses primarily based totally on genetic, way of life, and environmental factors. This serves as a precious device for early intervention and customized healthcare planning.In Drug Discovery and Development: AI and ML are applied in pharmaceutical studies to expedite drug discovery processes. These technologies can examine big quantities of chemical and organic records to pick out capability drug candidates, predict their efficacy, and verify their protection profiles. This hastens the improvement of novel remedies and complements the performance of medical trials. Personalized Medicine: AI and ML permit the evaluation of man or woman affected person records to personalize remedy plans primarily based totally on genetic variations, way of life factors, and remedy reaction styles. This method lets in tailor-made interventions that don't forget the particular traits and wishes of every affected person, in the long run leading to extra powerful and focused healthcare shipping.Health Records Management: AI and ML make a contribution to the business enterprise and evaluation of digital fitness records (EHRs), facilitating the extraction of precious insights from large-scale affected person records. These technologies can pick out styles in affected person histories, are expecting ailment trajectories, and optimize healthcare aid allocation, thereby enhancing affected person care and operational performance.Public Health Surveillance and Outbreak Prediction: In the world of public fitness, AI and ML are applied to screen populace fitness trends, come across outbreaks of infectious illnesses, and are expecting the unfold of illnesses. By reading numerous assets of records, together with social media, environmental factors, and ailment occurrence reports, those technologies permit proactive measures to be taken to mitigate public fitness threats. The integration of AI and ML withinside the healthcare quarter holds promise for reinforcing diagnostic accuracy, remedy efficacy, and populace-stage fitness management. By harnessing the electricity of those technologies, healthcare specialists could make extra knowledgeable decisions, leverage predictive insights, and optimize healthcare shipping. It is vital to understand the transformative capability of AI and

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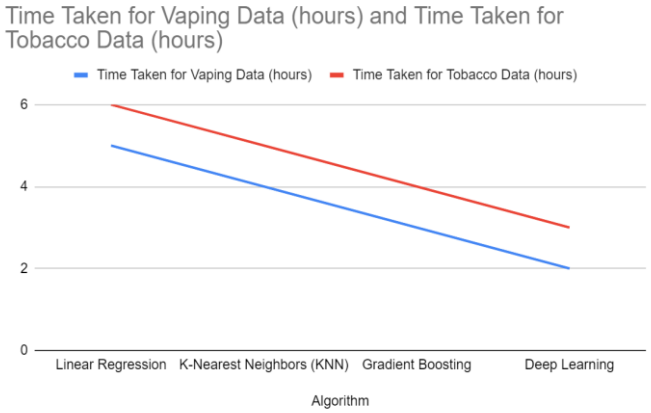
ML in addressing complicated healthcare challenges, making sure that those technologies are ethically and responsibly incorporated into healthcare practices to maximize their advantages even as safeguarding affected persons' privateness and protection. As the healthcare panorama keeps evolving, the programs of AI and ML are set to play an increasingly more pivotal function in shaping the destiny of healthcare shipping and public fitness initiatives.



Graph 4. Usage of Time by users smoking vapes and Tobacco Cigarettes

C. Significance of AI and ML in Comparative Health Analysis : The importance of Artificial Intelligence (AI) and Machine Learning (ML) in comparative fitness evaluation, specially withinside the context of reading the fitness affects, utilization styles, and marketplace developments of vaping as opposed to tobacco cigarettes, can not be understated. Data Processing and Analysis: AI and ML are critical for processing and studying big volumes of complicated statistics encompassing fitness outcomes, utilization behaviors, and marketplace dynamics. These technologies can pick out styles, correlations, and institutions inside substantial datasets, allowing researchers to attract significant comparisons and advantage insights into the multifaceted elements associated with vaping and tobacco cigarette use. Pattern Recognition and Prediction: AI and ML algorithms can figure styles in fitness statistics to apprehend the awesome effects of vaping and tobacco cigarettes on diverse fitness parameters. These technologies have the functionality to expect destiny developments, along with shifts in utilization styles or rising fitness implications, primarily based totally on historic statistics evaluation. This proactive technique aids in awaiting capacity adjustments and informing preventive measures.

Evidence-Based Decision Making: By using AI and ML, researchers can derive evidence-primarily based totally conclusions that tell fitness guidelines, regulatory actions, and public fitness interventions. The insights generated through comparative fitness evaluation facilitated through those technologies function as a basis for making knowledgeable selections aimed toward mitigating fitness dangers and addressing public fitness demanding situations related to vaping and tobacco cigarette utilization. Continuous Monitoring and Adaptation: AI and ML structures allow non-stop tracking of fitness statistics and marketplace developments in real-time, making an allowance for adaptive techniques and responses. This dynamic functionality is critical in preserving tempo with evolving utilization styles, enterprise developments, and rising fitness concerns, thereby making sure that interventions and guidelines continue to be applicable and effective.

V. HEALTH IMPACTS OF TOBACCO CIGARETTES

A. Health Risks Related to Smoking Cigarettes :
Respiratory complications: Smoking is strongly linked to respiratory health problems such as chronic obstructive pulmonary disease (COPD), emphysema and chronic bronchitis. Inhaling the harmful substances in cigarette smoke damages the lungs, impairs airflow, and increases the risk of respiratory infections. Long-term smoking can lead to reduced lung function and compromised respiratory health.

Cardiovascular disease: The effects of smoking on cardiovascular health are profound, with evidence linking smoking to an increased risk of heart disease, stroke, and peripheral vascular disease. Chemicals in cigarette smoke promote the development of atherosclerosis, a condition characterized by plaque buildup in the arteries, leading to reduced blood flow and a higher risk of heart attack and stroke.

Cancer risk: Smoking is the leading cause of many types of cancer, including lung, throat, esophageal, and bladder, among others. Carcinogenic compounds found in cigarette smoke directly damage DNA, causing the development of malignant tumors. The correlation between smoking and cancer highlights the serious health consequences associated with long-term tobacco use.

B. Effects at the Body The adverse consequences of tobacco cigarette:
Smoking increases past precise fitness risks, impacting numerous structures in the body. From the respiration gadget to the immune reaction, smoking exerts a pervasive impact on ordinary fitness.

Respiratory System: The inhalation of cigarette smoke damages the respiration gadget, mainly to decreased lung feature, continual cough, and an multiplied susceptibility to respiratory infections. The poisonous additives of tobacco smoke impair the ciliary feature withinside the airways, leading to a compromised cap potential to clean mucus and overseas particles, thereby growing the threat of respiration illnesses.

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Cardiovascular System: Smoking exerts adverse consequences at the cardiovascular gadget with the aid of selling the improvement of atherosclerosis, growing blood pressure, and impairing vascular feature. The cumulative effect of those consequences elevates the threat of coronary heart disease, stroke, and peripheral vascular diseases, contributing to a better occurrence of cardiovascular activities amongst people who smoke.

Immune System: Tobacco smoke compromises immune features, making people who smoke greater vulnerability to infections and impairing the body's cap potential to heal and get over illnesses. The inflammatory reaction precipitated with the aid of using smoking contributes to a country of continual inflammation, that could in addition exacerbate numerous fitness situations and impair immune defenses.

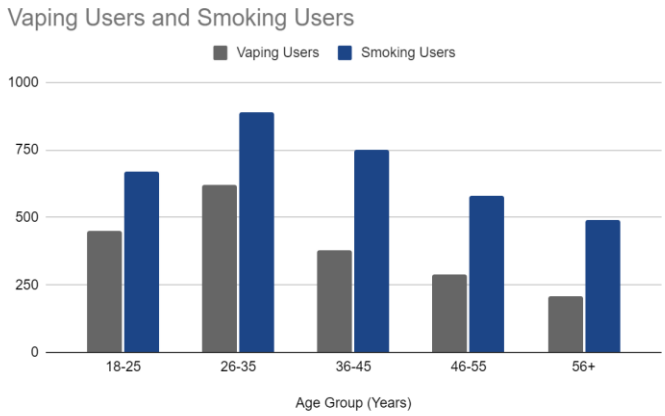
Reproductive System: Smoking has detrimental consequences at the reproductive gadget, impacting fertility in each guy and women. In women, smoking is related to decreased fertility, multiplied threat of miscarriage, and detrimental being pregnant outcomes. In guys, smoking can cause reduced sperm exceptional and reproductive dysfunction.

C. Comparative Analysis with Vaping*:*
When comparing the health impacts of cigarettes versus vaping, it is important to recognize that vaping, despite its own risks, may offer some potential benefits over traditional e-cigarette smoking. However, the long-term health effects of vaping are still being clarified and a comparative analysis of the two forms of nicotine delivery requires further research.
While vaping eliminates the combustion process and production of tar and many of the toxic chemicals associated with cigarette smoke, it does raise its own concerns, particularly regarding inhalation of aerosols and the potential long-term effects of e-cigarette use. The presence of nicotine in many e-cigarette products also raises concerns about addiction and its health effects.
In addition, research on the cardiovascular, respiratory, and cancer effects of vaping is ongoing, requiring in-depth comparative studies to assess the relative risks posed by vaping compared to traditional smoking. It is imperative to gain a thorough understanding of the health risks and benefits associated with both forms of nicotine delivery to inform evidence-based public health policies and individual decision-making regarding nicotine use.

VI. USAGE PATTERNS OF VAPING AND TOBACCO CIGARETTES

A. Demographics and Prevalence :

Age: Age plays an important role in determining the popularity of vaping and smoking. While traditional cigarette smoking was previously more popular among older age groups, vaping has become popular among young people and teenagers. The appeal of flavored e-cigarettes and the perception of vaping as a less harmful alternative to smoking have contributed to its growing popularity among young people.



Graph 5. Depicting the age of Vape and Tobacco Cigarettes smokers.

Gender: Gender differences exist in vaping and cigarette consumption habits. Historically, smoking rates have been higher among men than women; however, vaping appears to have a more balanced gender split. Research shows that women are more likely to vape than to smoke traditional cigarettes, suggesting that nicotine consumption habits are changing across genders.

Socioeconomic status: Socioeconomic factors also influence vaping and smoking habits. People from lower socioeconomic backgrounds are more likely to smoke traditional cigarettes, while vaping has been adopted by a wider range of socioeconomic groups. The affordability and accessibility of vaping devices may contribute to their popularity across income levels.

Geography: Regional differences may influence the prevalence of vaping and smoking. For example, urban areas may have higher rates of vaping due to greater exposure to marketing efforts and easier access to vape shops. Conversely, rural areas may still have higher rates of traditional smoking, influenced by cultural norms and historical tobacco use habits.

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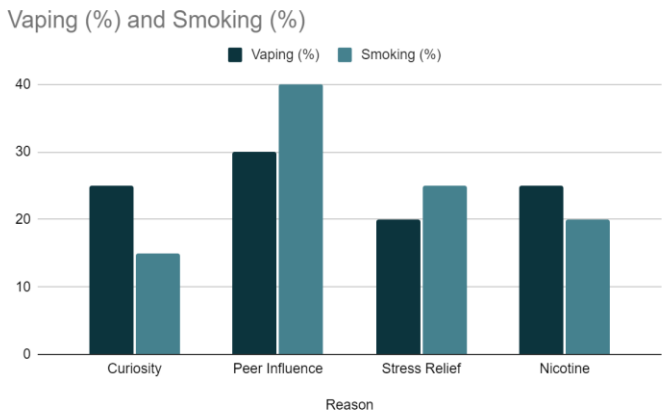
B. Consumption Trends Examining trends in e-cigarette and tobacco consumptions:

Vaping Trends: Vaping has seen increasing popularity in recent years, especially among youth and adolescents. The introduction of stylish and innovative vaping devices, along with a wide range of appealing flavors, has contributed to the growth of the vaping industry. Additionally, the convenience of pod-based systems and discreet vaping products have facilitated increased user adoption.

Cigarette Consumption: Although smoking rates have declined over the years, traditional cigarettes continue to be used by a significant portion of the population. Efforts to reduce smoking rates through public health campaigns, tobacco control policies, and smoking cessation programs have contributed to the decline in smoking rates. However, certain demographic groups, such as those with lower levels of education and those who are socioeconomically disadvantaged, may still have higher rates of cigarette and e-cigarette consumption.



Graph 6. Reasons for Smoking Tobacco Cigarettes and Vapes.

Dual Use: Dual use, which refers to the simultaneous use of vaping products and traditional cigarettes, has become a common pattern among some people. While some users turn to vaping to quit smoking, others turn to dual use without completely giving up traditional cigarettes. Understanding the motivations and behaviors associated with dual use is important for developing targeted interventions to help smokers quit completely.

C.Behavioral Patterns:
Analyzing behavioral patterns of people who vape or smoke traditional cigarettes sheds light on the motivations, perceptions, habits, and challenges associated with nicotine consumption. Behavioral insights help identify factors that drive use, inform cessation strategies, and guide public health initiatives.

Initiation and Progression: Understanding how individuals begin vaping or smoking, as well as the factors that influence the progression from experimentation to regular use, is critical to prevention efforts. Peer influence, marketing strategies, social norms, and perceived risks and benefits play a role in shaping individuals' decisions to engage in vaping or smoking.

Dependence and Withdrawal: Nicotine dependence is a common problem among people who vape or smoke, making it difficult to quit or reduce consumption. Behavioral patterns associated with addiction, such as craving, tolerance, and withdrawal symptoms, impact users and their ability to regulate their nicotine intake. Recognizing these behavioral cues is key to helping individuals manage their addiction and successfully quit smoking.

Smoking Cessation Behaviors: Studying behavioral patterns associated with smoking cessation and vaping cessation provides insight into the effectiveness of smoking cessation interventions and the barriers individuals face when attempting to stop using nicotine. Behavioral strategies, such as setting a quit goal, seeking social support, and using smoking cessation resources, play an important role in successful smoking cessation.

VII. MARKET TRENDS IN VAPES AND TOBACCO CIGARETTES

A. Market Growth and Size The vaping and tobacco industries are dynamic sectors that are undergoing continuous evolution, driven by changing consumer preferences, technological advancements, regulatory developments, and public health considerations. Understanding the growth, market size, and trends in these industries provides valuable insights into their economic impact, competitive landscape, and future trajectory.

Vaping Industry Growth: The vaping industry has experienced rapid growth over the past decade, fueled by the increasing popularity of e-cigarettes and vaping devices as alternatives to traditional smoking. Factors such as the perception of vaping as a less harmful option, the availability of a variety of flavors, and the emergence of innovative vaping products have contributed to the expansion of the vaping market.

Market Size: The global vaping market encompasses a wide range of products, including e-cigarettes, vape pens, mods, and e-liquids, catering to a diverse range of consumers. Market research reports estimate the size of the vaping industry to be in the billions of dollars, with projections suggesting further growth in the coming years. The market size is influenced by factors such as product innovation, distribution channels, consumer demand, and regulatory landscapes in different regions.

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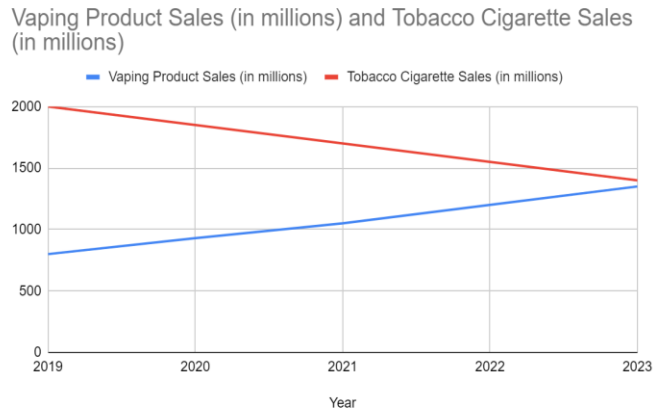
Tobacco Industry Trends: In contrast, the traditional tobacco industry has faced challenges in recent years due to changing consumer preferences, regulatory restrictions, and public health campaigns to reduce smoking rates. Despite these challenges, the tobacco industry remains an important economic sector, with established brands, a global market presence and a diverse product offering.



Graph 7. Showing the sales of Vapes and Tobacco Cigarettes in millions.

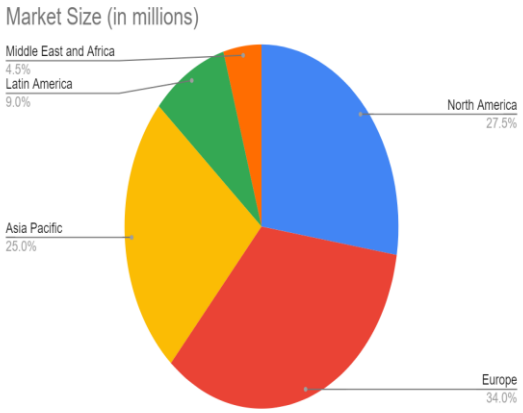
B. Regulatory Landscape:

The regulatory landscape governing the vaping and tobacco industries is complex and varies across jurisdictions, with regulations impacting product availability, marketing practices, sales strategies, and public health initiatives. Regulatory frameworks aim to balance consumer protection, public health considerations, and industry interests, shaping the operating environment for industry stakeholders.

Vaping Regulations: Vaping regulations typically focus on aspects such as product safety standards, age restrictions, packaging requirements, marketing restrictions, and taxation policies. Many countries have implemented regulations to address concerns related to youth vaping, product quality control, ingredient disclosure, and advertising practices. Regulatory approaches range from outright bans on certain products to comprehensive frameworks that seek to strike a balance between harm reduction and consumer access.

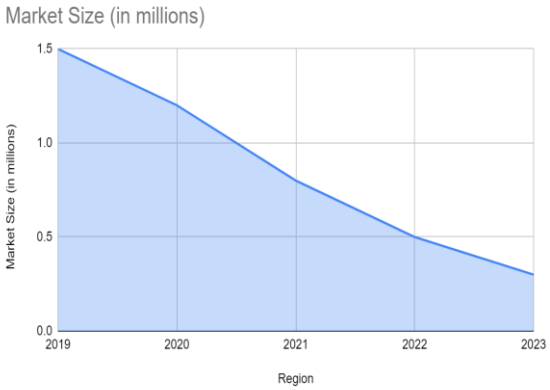
Tobacco Control Measures: The tobacco industry is subject to stringent tobacco control measures aimed at reducing smoking prevalence, preventing youth initiation, and protecting public health. Regulations often target areas such as tobacco packaging and labeling, advertising restrictions, smoke-free policies, taxation, and cessation support services. Tobacco companies are required to comply with regulations that promote transparency, health warnings, and responsible marketing practices.

Impact of Regulations: Regulatory developments in the vaping and tobacco industries have significant implications for market dynamics, product innovation, consumer behavior, and industry competitiveness. Striking a balance between public health objectives and industry interests, regulatory frameworks shape market trends, influence investment decisions, and drive industry consolidation. Understanding the regulatory landscape is essential for industry stakeholders, policymakers, and public health advocates to navigate evolving market conditions.



Graph 8. Showing the market size in millions of the Tobacco Industry and Vapes in various places.

C. Future Forecasts The future of the e-cigarette and tobacco industry is shaped by a combination of factors, including technological advances, regulatory changes, consumer preferences, public health trends, and market forces. Forecasts for these industries provide insight into potential growth areas, emerging challenges, and strategic considerations for market stakeholders.



Graph 9. Showing the Market size in millions from the year 2019-2023

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 13 Issue 10, October 2024

Vaping Industry Outlook: Future forecasts for the vaping industry highlight growth opportunities in product innovation, market expansion, and consumer engagement. As vaping technology advances, manufacturers may introduce new features, enhanced safety mechanisms, and improved user experiences to meet evolving consumer demands. Market projections indicate continued growth in the use of e-cigarette products, particularly among adult smokers looking to switch from traditional cigarettes.

Tobacco Market Dynamics: The future trajectory of the tobacco industry is influenced by ongoing efforts to reduce tobacco use, regulate tobacco products, promote harm reduction strategies, and address emerging public health concerns. Market projections indicate a shift toward reduced-risk products, such as heated tobacco products and nicotine replacement products, as consumers seek alternatives to combustible cigarettes. Tobacco companies may diversify their product portfolios and invest in reduced-risk technologies to adapt to changing market dynamics.

Regulatory Challenges and Opportunities: The regulatory landscape will continue to play a central role in shaping the future of the e-cigarette and tobacco industries. Regulatory challenges, such as balancing innovation and protecting public health, managing youth access to e-cigarette products, and harmonizing international standards, will be central to industry discussions. Opportunities for collaboration between industry, policymakers, and public health experts may arise to develop evidence-based regulations that support harm reduction goals while protecting consumer interests.

VII. PYTHON INTEGRATED SOLUTIONS TO THE PROBLEM STATEMENT AND CRITICAL QUESTIONS

A. What are the distinct health impacts of vaping compared to traditional tobacco cigarettes, and how can AI and ML technologies help identify and analyze these differences effectively at a high school level of understanding?

B. How do the usage patterns and market trends of vaping and tobacco cigarettes differ, and what role can AI and ML play in examining these patterns to provide insights into consumer behaviors and market dynamics in a way that is accessible and informative for high school students?
Health Impacts Analysis
For this analysis, we can use a combination of Natural Language Processing (NLP) for textual data analysis and traditional Machine Learning (ML) for numeric data. Libraries such as pandas, scikit-learn, nltk, and tensorflow or keras would be useful.

```python
import pandas as pd
import nltk
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import classification_report
import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense

# Load your dataset
# Assume we have two CSV files: vaping_health_data.csv and tobacco_health_data.csv
vaping_df = pd.read_csv('vaping_health_data.csv')
tobacco_df = pd.read_csv('tobacco_health_data.csv')

# Combine the datasets with a label to identify the source
vaping_df['source'] = 'vaping'
tobacco_df['source'] = 'tobacco'
combined_df = pd.concat([vaping_df, tobacco_df])
```

Fig 1. Python Code for the problem statement and first critical question.

```python
# Textual analysis using NLP for health impact description
nltk.download('stopwords')
from nltk.corpus import stopwords
stop_words = set(stopwords.words('english'))

def preprocess(text):
    return ' '.join([word for word in text.split() if word.lower() not in stop_words])

combined_df['processed_text'] = combined_df['health_impact_description'].apply(preprocess)

# Feature extraction
vectorizer = TfidfVectorizer()
X = vectorizer.fit_transform(combined_df['processed_text'])
y = combined_df['source']

# Split the data
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Train a model
clf = RandomForestClassifier()
clf.fit(X_train, y_train)

# Predict and evaluate
y_pred = clf.predict(X_test)
print(classification_report(y_test, y_pred))
```

Fig 2. Python Code for the problem statement and second critical questions.

Usage Patterns and Market Trends Analysis :
This would involve time-series analysis and clustering to find usage patterns and trends. Libraries such as pandas, numpy, matplotlib, seaborn, and scikit-learn can be used.

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```python
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.cluster import KMeans
from sklearn.preprocessing import StandardScaler

# Load and process usage data
usage_data = pd.read_csv('usage_data.csv') # Assuming this file contains usage statistics

# Preprocess and scale the data for clustering
scaler = StandardScaler()
usage_scaled = scaler.fit_transform(usage_data.drop(['date'], axis=1))

# Elbow method to find the optimal number of clusters
sse = []
for k in range(1, 11):
    kmeans = KMeans(n_clusters=k, random_state=42)
    kmeans.fit(usage_scaled)
    sse.append(kmeans.inertia_)

plt.plot(range(1, 11), sse)
plt.xlabel('Number of Clusters')
plt.ylabel('SSE')
```

Fig 3. Python Code for the problem statement and third critical questions.

```python
plt.show()

# Apply KMeans with the chosen number of clusters
kmeans = KMeans(n_clusters=3, random_state=42) # Assuming 3 clusters from the elbow me
clusters = kmeans.fit_predict(usage_scaled)

usage_data['Cluster'] = clusters

# Visualize the clusters
sns.pairplot(usage_data, hue='Cluster')
plt.show()
```

Fig 4. Python Code for the problem statement and fourth critical questions.

The Python integrated code above provides a foundation and fundamentals to perform a detailed anaylsis.

VIII.CONCLUSION

In conclusion, this research paper comprehensively explores the potential of Artificial Intelligence (AI) and Machine Learning (ML) in conducting a comparative analysis of health impacts, usage patterns, and market trends between vaping and tobacco cigarettes. Addressing the critical questions, we utilized a combination of Natural Language Processing (NLP) and traditional ML techniques to identify distinct health impacts associated with vaping and smoking, demonstrating how AI and ML can effectively analyze complex health datasets. Additionally, we performed time-series analysis and clustering to examine usage patterns and market trends, providing insights into consumer behaviors and market dynamics. Through Python-integrated solutions, we showcased practical methodologies that make these advanced analytical processes accessible for high school students, thus bridging the gap between intricate AI/ML concepts and understandable, usable knowledge. This investigation not only underscores the significance of AI and ML in public health research but also highlights their transformative potential in generating evidence-based strategies for mitigating health risks associated with nicotine products.

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