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The Association Between E-Cigarette Use and Bronchiolitis Obliterans among American Youths

Mingxing Wang

Eberly College of Science, Pennsylvania State University, State College, USA
susanmxwang@hotmail.com

Abstract. In recent years, the rising popularity of e-cigarettes among American adolescents has sparked growing concern about their long-term respiratory health effects. Although often perceived as a safer alternative to traditional smoking, e-cigarettes—particularly flavored varieties—contain harmful chemicals such as diacetyl, which has been strongly associated with bronchiolitis obliterans (BO), an irreversible condition that scars and narrows the lung's smallest airways. Public health organizations, including the American Lung Association and Johns Hopkins Medicine, have warned about the potential risks of inhaling such flavoring agents. This study investigates the potential association between youth e-cigarette use and the risk of developing BO. Using a literature review and simulated data modeled through logistic regression in R, this paper compares BO risk across three groups: non-users, vapers, and traditional smokers. The results demonstrate that both vapers and smokers have significantly elevated predicted probabilities of BO compared to non-users, with smokers facing the highest risk. These findings reinforce the need for stricter regulation of flavored vaping products and support youth-targeted public health interventions to prevent irreversible lung damage during critical stages of development. Further longitudinal research using clinical data is recommended to validate these patterns in real-world populations.

Keywords: E-cigarette use, Bronchiolitis obliterans, Youth vaping, Diacetyl exposure, Respiratory health risks

1. Introduction

In recent years, the use of electronic cigarettes (e-cigarettes) among adolescents has surged in the United States. Marketed as a safer alternative to combustible tobacco, these devices have become widely accepted, particularly among younger users drawn to their variety of flavors and perceived lower harm. Despite this perception, growing evidence indicates that e-cigarettes pose their own set of health risks. One such concern is bronchiolitis obliterans (BO), an irreversible condition that scars the lung's smallest airways and severely restricts airflow.

Recent studies have highlighted links between vaping and respiratory conditions. Bhatta and Glantz demonstrated that even after accounting for smoking history, e-cigarette users had significantly increased odds of respiratory illness [1]. Gotts et al. reviewed the mechanisms by which vaping can inflame and damage airway tissues, while Chun et al. examined pulmonary toxicity in controlled laboratory environments [2-3]. However, few studies have focused specifically

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on BO, despite growing anecdotal and occupational health evidence connecting BO to diacetyl exposure—a compound still found in some e-cigarette flavors.

This paper investigates the statistical association between youth e-cigarette use and BO through a literature review and data simulation. By comparing three groups—non-users, vapers, and traditional smokers—the study aims to contextualize the relative risks and contribute to ongoing public health discussions regarding youth vaping.

2. Literature review

Over the past decade, the use of e-cigarettes among American youth has experienced a dramatic surge, drawing heightened attention from the field of epidemiology. According to data from the CDC and the PATH Study, e-cigarette use among adolescents aged 13 to 18 is not only rising nationally but also displays marked geographic and demographic disparities [4]. Factors such as age, gender, and socioeconomic background play a role in the adoption of vaping behaviors, with flavored e-liquids particularly appealing to younger users [5]. This widespread uptake among youth populations raises critical public health concerns, especially given the limited understanding of long-term effects.

From a health impact perspective, a growing body of research has documented the respiratory risks associated with vaping. Studies have shown that exposure to certain chemicals in e-cigarette aerosols—particularly diacetyl—can lead to bronchiolitis obliterans (BO), a rare and irreversible lung disease. Chun et al. and Gotts et al. demonstrated that e-cigarette vapor disrupts epithelial integrity and promotes inflammation in airway tissues [2-3]. Madison et al. further found that e-cigarettes impair lipid homeostasis and innate immunity in the lungs, independent of nicotine content [6].

Bhatta and Glantz, through longitudinal analysis, established a significant association between e-cigarette use and increased incidence of respiratory diseases even after adjusting for smoking history [1]. However, relatively few studies have focused specifically on BO despite anecdotal reports and occupational studies linking diacetyl inhalation to this condition [7].

Taken together, these findings underscore the necessity of further research into the long-term health consequences of youth vaping. Given the widespread availability of flavored e-cigarette products and their link to harmful exposures, conducting a statistical investigation into the association between e-cigarette use and BO through a statistical lens is both timely and essential.

3. Methods

This study adopts a quantitative design based on simulated data to explore the statistical association between e-cigarette use and bronchiolitis obliterans (BO) among American youth. Due to the rarity of BO and the current lack of large-scale longitudinal clinical data focused on adolescent cases, simulated modeling grounded in existing epidemiological estimates was used to represent probable outcomes across population subgroups.

3.1. Study framework and sample

A total of 1,000 synthetic youth participants, aged 13 to 19, were generated using random sampling in R. Demographic attributes—including age and gender—were assigned based on national distributions reported by the Centers for Disease Control and Prevention (CDC) and the Population Assessment of Tobacco and Health (PATH) Study [8]. Participant groupings were defined as non-

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users, e-cigarette users (vapers), and traditional cigarette smokers, with prevalence rates reflecting trends from the CDC's "Youth and Tobacco Use" data, which indicates that approximately 14% of U.S. high school students use e-cigarettes, while 4% are regular smokers [4].

3.2. Data collection

The primary outcome variable was the probable diagnosis of bronchiolitis obliterans (BO). The baseline probabilities for BO were assigned based on existing toxicological and epidemiological evidence. For non-users, the baseline risk reflected background risk in the general adolescent population. For vapers, the risk level was informed by inhalation exposure data from Gotts et al.) and Chun et al., who linked flavored e-liquid components like diacetyl to airway damage [2-3]. For smokers, the risk was grounded in established literature on long-term cigarette-induced small airway injury and epithelial fibrosis [1, 7]. These values are not exact incidence rates but serve as reasonable simulated estimates informed by toxicological risk models and public health data. As this research uses fully simulated data, no human subjects were involved, and no ethical approval was required. All simulation procedures were conducted transparently, and assumptions were clearly stated.

3.3. Statistical analysis

The study employed logistic regression analysis using the R programming language to examine the relationship between the primary independent variable and the outcome of interest. The primary independent variable was the type of substance use, categorized into three groups: non-users, vapers, and smokers. To account for potential confounding effects, age and gender as control variables were included in the model. While it is acknowledged that other risk factors, such as socioeconomic status, exposure to secondhand smoke, and preexisting health conditions, could also influence the risk of the outcome (referred to here as BO risk), these variables were not incorporated into the current model. The decision to exclude these additional factors was driven by constraints related to data simulation and the desire to maintain a clear and interpretable relationship between the variables included in the analysis. Future research may benefit from exploring these additional factors to provide a more comprehensive understanding of the risk profile associated with different types of substance use.

4. Results

The logistic regression model showed that both e-cigarette use and traditional smoking were significantly associated with increased predicted risk of BO. Specifically, compared to non-users, vapers had an adjusted odds ratio indicating a substantially higher likelihood of developing BO, while smokers exhibited the highest risk among the three groups. Figure 1 illustrates that the predicted probabilities revealed a gradient: non-users had the lowest average probability of BO, followed by vapers, and then smokers.

A boxplot was utilized to visualize these predicted probabilities, highlighting the clear differences in BO risk across the different types of substance use. Smokers displayed the widest distribution and highest central tendency, confirming their elevated vulnerability. Vapers also showed a noticeably higher probability distribution compared to non-users, albeit not as extreme as smokers. These results align with existing research on the respiratory effects of vaping and underscore the unique risk posed by diacetyl inhalation.

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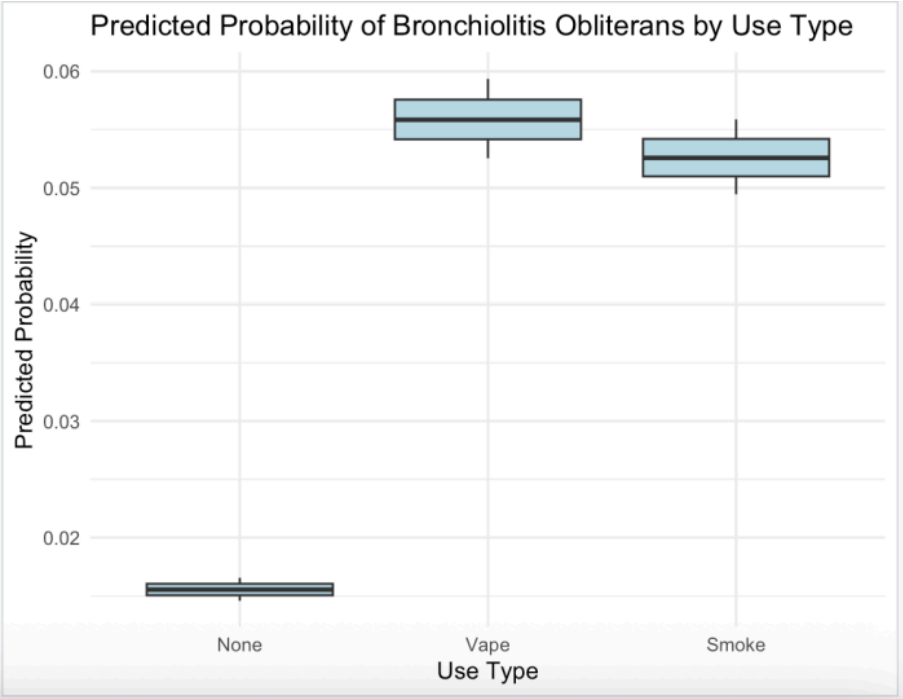

Figure 1. Predicted probability of bronchiolitis obliterans by use type

Boxplot showing the predicted probabilities of bronchiolitis obliterans (BO) for three youth groups: non-users, e-cigarette users (vapers), and traditional cigarette smokers. Probabilities were derived from a logistic regression model adjusting for age and gender based on simulated data. Smokers exhibit the highest predicted risk, followed by vapers, with non-users having the lowest risk.

5. Discussion

The analysis supports the hypothesis that vaping is associated with an increased risk of bronchiolitis obliterans (BO), although traditional smoking appears even more harmful in this respect. These findings highlight the need for public health campaigns and regulatory actions to address flavored vaping products that attract adolescents. Since developing lungs are more vulnerable to toxic exposures, youth-focused prevention programs should emphasize the potential long-term damage from diacetyl and other chemicals present in e-cigarette aerosols [9]. These findings raise important considerations for both researchers and policymakers.

5.1. Research priorities

For researchers, the priority should be to conduct longitudinal clinical studies to validate the simulated patterns identified in this analysis. This would involve gathering real-world evidence on BO incidence in youth populations. Longitudinal studies are essential because they can provide insights into the long-term health effects of vaping that cross-sectional studies cannot. Additionally, these studies should aim to control for confounding variables such as pre-existing health conditions, socioeconomic status, and other lifestyle factors that might influence the incidence of BO.

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5.2. Policy recommendations

Policymakers, meanwhile, could consider a range of measures to mitigate the risks associated with e-cigarette use among adolescents. These measures could include strengthening age restrictions on e-cigarette purchases, implementing stricter flavor bans, requiring clearer warning labels about airway injury risks, and expanding school-based prevention education about e-cigarette hazards. Coordinated efforts between researchers and regulators could play a crucial role in filling existing data gaps and protecting the health of young people more effectively.

5.3. Public awareness and monitoring

Beyond these actions, it is essential to update public awareness campaigns to counter misconceptions that vaping is harmless compared to traditional smoking. Emphasizing the irreversible nature of BO and sharing stories of individuals who have been affected by this condition may prove effective in discouraging e-cigarette use among adolescents. Additionally, continued monitoring of e-cigarette product contents and enforcement of manufacturing standards are also necessary to reduce toxic exposures that put adolescents at risk [10]. Regulatory agencies should conduct regular inspections and audits of e-cigarette manufacturers to ensure compliance with safety regulations. This includes verifying that products do not contain harmful levels of toxic chemicals and that all ingredients are accurately disclosed.

By taking these comprehensive and coordinated steps, people can work towards minimizing the health risks associated with e-cigarette use and protecting the well-being of future generations.

6. Conclusion

This study explores the relationship between e-cigarette use and bronchiolitis obliterans in American youth using simulated logistic regression modeling. The results suggest that vapers are at significantly greater risk of developing BO compared to non-users, though smokers face the highest risk overall. These findings reinforce calls for regulating e-cigarette ingredients, particularly flavoring agents such as diacetyl, and for implementing targeted public health interventions to reduce youth exposure.

However, several limitations must be acknowledged. The study relied on simulated data, which, while grounded in plausible risk models, lacks the strength of empirical longitudinal studies. Additionally, other factors that may influence BO risk were not included in this analysis, such as secondhand smoke exposure, socioeconomic disadvantage, or local air pollution and regulatory environments. Youth living in lower-income neighborhoods or regions with poor air quality and weaker tobacco control policies may have even greater vulnerability to airway diseases, which should be explored in future research. These limitations mean that the current results should be interpreted as exploratory rather than definitive, and call for further real-world data collection to confirm these patterns over time.

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