Cytogenetic Damage from E-cigarette Use: Buccal Micronucleus Frequencies and Policy Implications in the Philippines

Reality Araojo[1] and Norvie Jalani[2]

[1]*Ateneo De Zamboanga University-School of Medicine, Philippines*
[2]*Zamboanga City Medical Center, Philippines*

ABSTRACT

The rapid rise of e-cigarettes and vapes in the Philippines, especially after Republic Act No. 11900, has raised health concerns among youth. Though marketed as safer alternatives, their aerosols have been shown to cause harm. By measuring buccal micronucleus frequencies, this study found significantly higher counts in e-cigarette users compared to non-users, with secondhand smoke exposure independently associated with elevated genotoxic damage (adjusted OR 11.8; $p = 0.035$). The findings support stricter regulations and broader smoke-free policies to safeguard public health amid the growing use of electronic nicotine delivery systems.

Key words: e-cigarettes, buccal micronucleus, genotoxicity, youth vaping, tobacco regulation, Philippines

ISSN 2507-8364 (Online)
Printed in the Philippines.

Received: 21 April 2026.
Accepted: 16 May 2026.
Published online first: 25 June 2026.
https://doi.org/10.21141/PJP.2026.599

Corresponding author: Norvie T. Jalani, MD
E-mail: norviejalani@gmail.com
ORCiD: https://orcid.org/0000-0002-1642-4698

The human genome is constantly exposed to environmental and lifestyle-related genotoxins, making accessible biomarkers essential for early detection of chromosomal damage. The buccal mucosa, consisting of stratified squamous epithelial cells, is the first tissue to contact inhaled and ingested toxicants, making it a relevant site for monitoring aerodigestive exposures. The buccal micronucleus cytome (B-MNcyt) assay is a validated tool in molecular epidemiology for assessing chromosomal instability and early genotoxic damage. Micronuclei (MN) are formed from entire chromosomes or acentric fragments that do not incorporate into daughter nuclei during cell division. Their presence in exfoliated buccal cells indicates DNA damage in the basal epithelial layer that occurred 5-14 days prior to sampling. Although international research reports increased MN frequencies among e-cigarette users, there is limited local cytogenetic evidence in the Philippines. This study aimed to compare MN frequency between adult e-cigarette users and non-users in Southern Philippines and identify factors associated with elevated MN counts.

A study in the Southern Philippines, involving 62 adults (31 e-cigarette users and 31 non-smokers), examined buccal cells stained with Papanicolaou for micronuclei (MN). Micronuclei were identified and counted manually using a 5-headed electric light microscope by two independent raters blinded to group allocation, following the morphological criteria of Tolbert et al.[1] Inter-rater reliability was good (ICC = 0.770), and discrepancies were resolved through consensus review. Elevated MN was defined as ≥203 per 1,000 cells (Figure 1). This threshold was determined empirically as the 85th percentile of the combined cohort MN distribution (n = 62), since standard reference values were not suitable given the notably elevated baseline MN frequencies observed in both groups, likely reflecting shared environmental exposures in this urban population.[2] The dichotomized outcome (elevated vs not elevated) served as the dependent variable in the regression analyses. Binary logistic regression

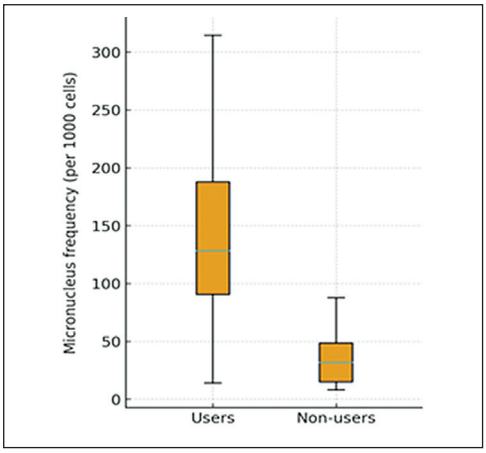

Figure 1. Boxplot of micronucleus frequencies among e-cigarette users and non-users.

Table 1. Regression analysis predictors of elevated micronucleus counts (≥203/1000 cells, n = 30)

Variable	Crude OR (95% CI)	*p*-value	Adjusted OR (95% CI)	*p*-value
Age (20-29)	3.3 (0.6-19.5)	0.551	1.2 (0.1-86.6)	0.934
Male sex	13.5 (1.4-128.3)	0.023*	8.5 (0.2-638.1)	0.178
Islamic faith	7.0 (1.3-37.9)	0.024*	1.7 (0.07-24.2)	0.704
Ethnicity	3.3 (0.6-19.5)	0.192	5.9 (0.2-221.8)	0.340
Socioeconomic status	0.5 (0.1-2.5)	0.402	3.9 (0.2-135.3)	0.432
Alcohol consumption	0.6 (0.1-3.3)	0.544	0.6 (0.003-10.7)	0.821
Secondhand smoke	16.0 (2.4-106.7)	0.004**	11.8 (2.2-72.0)	0.035*
Tooth brushing	0.7 (0.1-5.1)	0.730	0.6 (0.002-6219.8)	0.882
Daily flossing	0.6 (0.1-3.3)	0.544	0.7 (0.002-57.4)	0.877
Mouthwash use	1.9 (0.4-9.6)	0.432	2.5 (0.03-376.2)	0.695
Vegetable consumption	1.3 (0.2-6.4)	0.784	2.8 (0.07-21811)	0.655
Fruit consumption	2.7 (0.4-16.0)	0.283	0.8 (0.02-13.1)	0.865

*p <0.05; **p <0.01
Crude analysis: Binary logistic regression.
Adjusted analysis: Firth's bias-reduced logistic regression.

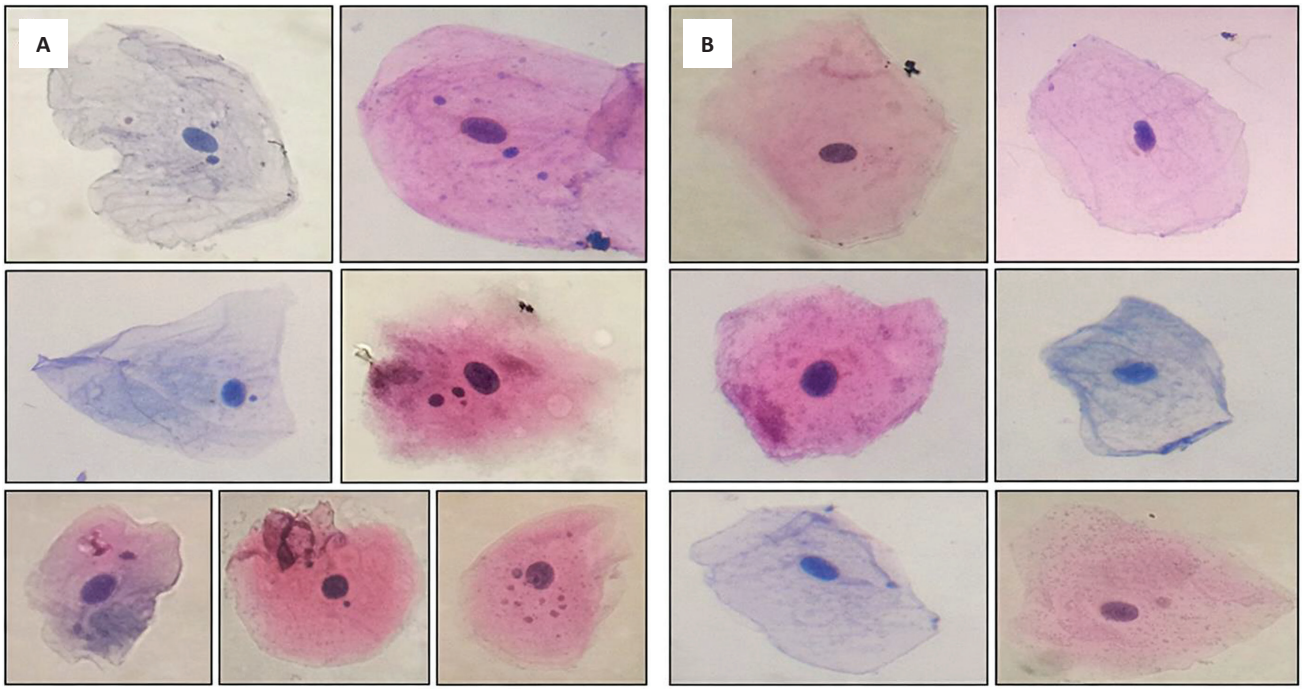

Figure 2. Buccal epithelial cells showing micronuclei among **(A)** e-cigarette users and **(B)** non-users (Papanicolaou stain, 400x).

was used for crude estimates, and Firth's bias-reduced logistic regression for adjusted estimates, selected to address potential complete or quasi-complete separation and ensure reliable parameter estimates given the small case-control subsample (n=30, 10 cases and 20 controls). Results indicated that e-cigarette users had significantly higher MN levels (152.3 ± 102.6 versus 34.9 ± 28.5; p <0.001). Regression analysis showed that secondhand smoke exposure was associated with elevated MN (adjusted OR 11.8; p = 0.035) (Table 1). Pearson's correlation found no significant relationships between continuous MN counts and vaping duration, frequency, device type, puff topography, or nicotine concentration among users (all p-values >0.05). These null findings should be interpreted cautiously, given the limited sample size (n = 31), which may have been insufficient to detect weak-to-moderate dose-response relationships. The possibility that genotoxic injury follows a threshold model warrants investigation in larger, adequately powered studies.[3,4]

A key finding was the independent association between secondhand smoke exposure and elevated MN counts. Vapers exposed to environmental tobacco smoke faced nearly twelve times the risk of higher MN counts compared to those without exposure. This association might be due to the inflamed state of the buccal mucosa in e-cigarette users, which reduces the cellular threshold for reacting to additional toxicants in combustible tobacco smoke. These findings have important public health implications, emphasizing that strict enforcement of smoke-free laws is necessary to protect individuals already experiencing baseline genotoxic stress from vaping.[5-7]

The rise of EVALI cases in the Philippines coincides with the surge in youth vaping, underscoring the urgent need for product safety monitoring. Data indicate a 110% increase in e-cigarette prevalence among Filipino youth between 2015 and 2019, and this trend has only accelerated with the recent legislative changes.[8] Experts from the Philippine Pediatric Society warn that 1 out of every 7 Filipino youths aged 13-15 is now using e-cigarettes.[7] Adolescents are particularly vulnerable to the genotoxic effects of aerosols because their tissues are still undergoing rapid growth and differentiation. Furthermore, the high prevalence of daily use among youth, often driven by fruit and candy flavors, prolongs exposure to carbonyls and metals during a critical window of biological development.[9]

The enactment of Republic Act No. 11900 in 2022 significantly reshaped the regulation of electronic nicotine delivery systems (ENDS) and heated tobacco products (HTPs) in the Philippines. A key feature of the law is the transfer of regulatory authority from the Food and Drug Administration (FDA) to the Department of Trade and Industry (DTI), shifting oversight from a health-based to a trade-oriented framework. This change has raised concerns regarding the adequacy of toxicological and genotoxic evaluation of vaping products.[10] RA 11900 also reduced the minimum age for purchase and use of vaping products from 21 to 18 years, expanding access to adolescents and young adults whose respiratory and neurological systems remain developmentally vulnerable. Although the law restricts youth-oriented flavor descriptors, it does not prohibit flavored products themselves, allowing the continued availability of fruit, dessert, and menthol variants, which are strongly associated with youth initiation. Local buffer-zone regulations around schools further face enforcement challenges, with retail proximity and point-of-sale marketing remaining common. Given emerging biological evidence of vaping-associated genotoxicity and compounded risk from secondhand smoke exposure, these regulatory gaps warrant reassessment. Incorpo-rating cost-effective biomarkers, such as the buccal micronucleus cytome assay, into community surveillance may provide early warning of harm.[11] The present findings support strengthening aerosol-free public space policies, reinforcing age protections, and aligning regulations with health-centered risk assessment.[12]

The study of buccal micronucleus levels among e-cigarette users and non-users in the Southern Philippines highlights the serious biological effects of vaping. Higher MN counts suggest that vapers' oral mucosa is experiencing early chromosomal instability, a known cancer precursor. The absence of a dose-response relationship raises the possibility that no level of vaping is entirely safe for genetic health, though this interpretation requires confirmation in larger, adequately powered studies. Secondhand smoke exposure adds to the risk, creating a double burden for those in shared environments. A limitation of this study is that the 203/1000 cells cut-off is population-specific, derived from local cohort data, and may not be applicable in other settings.

As the Philippines faces increasing EVALI cases and a significant surge in teen vaping, the current law, RA 11900, urgently calls for revision. Its focus on trade over toxicology and weaker protections for minors have contributed to an environment that may promote nicotine addiction and cellular damage. Replacing it with health-centered regulations, expanding aerosol-free policies, and adopting genomic monitoring tools like the B-MNcyt assay can foster a more science-driven public health approach. This strategy should prioritize the long-term biological health of Filipinos. The evidence of DNA damage in the buccal cells of young Filipinos highlights the urgent need for policymakers to treat health rights as a fundamental national priority.

STATEMENT OF AUTHORSHIP

Both authors certified fulfillment of ICMJE authorship criteria.

AUTHORSHIP DISCLOSURE

The authors declared no conflict of interest.

DATA AVAILABILITY STATEMENT

Datasets generated and analyzed are included in the published article.

FUNDING SOURCE

None.

REFERENCES

1. Tolbert PE, Shy CM, Allen JW. Micronuclei and other nuclear anomalies in buccal smears: methods development. Mutat Res. 1992;271(1):69-77. PMID: 1371831 DOI: 10.1016/0165-1161(92)90033-i
2. Ribeiro D. Evidence of genotoxicity and cytotoxicity of X-rays in the oral mucosa epithelium of adults subjected to cone beam computed tomography. Dentomaxillofac Radiol. 2019;48(6):20180299. PMID: 30285478 PMCID: PMC6747437 DOI: 10.1259/dmfr.20180299
3. Tadin A, Stazic V, Galic N, Zeljezic D. Evaluation of cytotoxic and genotoxic effects in buccal mucosal cells in non-smokers and users of traditional combustible tobacco products and non-combustible alternatives. J Xenobiot. 2024;14(1):154-65. PMID: 38249106 PMCID: PMC10801550 DOI: 10.3390/jox14010009
4. Toxicological Effects of Methylmercury. Toxicological effects of methylmercury. Washington, DC: National Academies Press; 2000. Chapter 5, Health effects of methylmercury. Bookshelf ID: NBK225765/
5. Salih MM, Tamr TA, Elmissbah TE, Hanafy SM, Dahlawi HA, Khalifa EH. Comparative analysis of cytological changes in the buccal mucosa among traditional cigarette and electronic cigarette users. Tob Induc Dis. 2025;23. PMID: 40552062 PMCID: PMC12184094 DOI: 10.18332/tid/203670
6. Szumilas P, Wilk A, Szumilas K, Karakiewicz B. The effects of e-cigarette aerosol on oral cavity cells and tissues: a narrative review. Toxics. 2022;10(2):74. PMID: 35202260 PMCID: PMC8878056 DOI: 10.3390/toxics10020074

7. Dai H. Exposure to secondhand aerosol from electronic cigarettes among US youth from 2015 to 2018. JAMA Pediatr. 2020;174(3):298-300. PMID: 31985771 PMCID: PMC6990747 DOI: 10.1001/jamapediatrics.2019.5665
8. Philippine News Agency. Experts warn youth lung injury crisis due to vaping. Published on April 12, 2024. Accessed January 27, 2026. https://www.pna.gov.ph/articles/1222493
9. Southeast Asia Tobacco Control Alliance (SEATCA). Philippines: 22-year-old's senseless death while denials on vape harms persist. TobaccoWatch. Published June 24, 2024. Accessed January 27, 2026. https://tobaccowatch.seatca.org/index.php/2024/06/25/philippines-22-year-olds-senseless-death-while-denials-on-vape-harms-persist/
10. House of Representatives of the Philippines. House Resolution No. 43: Resolution directing the appropriate committee to conduct an inquiry, in aid of legislation, on the effective implementation of Republic Act No. 11900, otherwise known as the Vaporized Nicotine and Non-Nicotine Products Regulation Act. Published 2025. Accessed January 27, 2026. https://docs.congress.hrep.online/legisdocs/basic_20/HR00043.pdf
11. Yadav AS, Jaggi S. Buccal micronucleus cytome assay - a biomarker of genotoxicity. J Mol Biomark Diagn. 2015;6(3):1-6. DOI: 10.4172/2155-9929.1000236
12. Republic of the Philippines. Republic Act No. 11900: Vaporized Nicotine and Non-Nicotine Products Regulation Act. Official Gazette of the Republic of the Philippines. Published July 25, 2022. Accessed January 27, 2026.