

# Vaping During Pregnancy in Northern Wisconsin

Jeffrey J. VanWormer, PhD; Richard L. Berg, MS; Aditya Joshi, MD

## ABSTRACT

**Introduction:** The use of electronic cigarettes during pregnancy is an emerging health risk. This study estimated use of electronic cigarettes and associated risk factors in pregnant women in a predominantly rural population.

**Methods:** Surveys on e-cigarette use and sociodemographics, linked to medical records, were administered to women in the third trimester of pregnancy. Participants were Marshfield Clinic Health System patients in northern and central Wisconsin.

**Results:** There were 391 respondents. The prevalence of e-cigarette use during pregnancy was 5% (95% CI, 2-8). Women who were younger, lower gestational age, unmarried, had lower education, lower income, and lower body mass index were more likely to use e-cigarettes.

**Discussion:** Use of e-cigarette in pregnant women in rural Wisconsin was 5 times greater than that observed nationally. Prenatal e-cigarette prevention interventions may need to focus on women who are younger, not married, and with lower education/income.

## INTRODUCTION

Electronic cigarettes (e-cig) are battery-powered devices that generate an inhaled aerosol (ie, vaping). These aerosols include nicotine and flavorings, as well as solvents and phenolic compounds, some of which are carcinogens.<sup>1</sup> Given their potential to cause adverse fetal outcomes in animal models,<sup>2</sup> the toxicity of these compounds is a concern during pregnancy. Research in humans is developing, but the principal risk is fetal size for gestational age. Compared to nonusers, the odds of delivering a low birthweight baby are over twice as high—both for pregnant mothers who con-

tinue to smoke conventional cigarettes or those who use e-cigs in late pregnancy.<sup>3</sup> Low birth weight is a strong risk factor for metabolic disorders in adulthood.<sup>4</sup> The US Surgeon General considers vaping a fetal risk factor.<sup>5</sup>

Vaping has increased widely in the US since 2007.<sup>5</sup> Some surveys found as many as 10% of mothers regularly vape just prior to pregnancy,<sup>6</sup> though more recent national estimates suggest vaping is lower in later pregnancy stages.<sup>7</sup> Most prior studies, however, represent primarily urban populations. There is a higher rate of conventional smoking in the rural US,

which is linked to rural sociodemographics, such as higher rates of unemployment, lower income, and decreased access to health care.<sup>8</sup>

Vaping is an emerging health risk during pregnancy. No known studies have examined vaping during pregnancy among women in rural Wisconsin, where the burden of many lifestyle risk factors (eg, smoking) is greater than more affluent areas. The purpose of this study was to estimate the prevalence of e-cig use in pregnant mothers in north-central Wisconsin and to identify sociodemographic and other factors associated with vaping.

## METHODS

### Design and Setting

A cross-sectional survey was used, with linkage of existing sociodemographic and clinical characteristics of pregnant women from Marshfield Clinic Health System (MCHS) electronic health records (EHR). The source population included adults with reasonably complete capture of their medical care within MCHS data systems, including patients who reside within a 20-county region of north-central Wisconsin and are members of Security

• • •

**Author Affiliations:** Center for Clinical Epidemiology and Population Health, Marshfield Clinic Research Institute, Marshfield, Wisconsin (VanWormer); Office of Research Computing and Analytics, Marshfield Clinic Research Institute, Marshfield, Wisconsin (Berg); Division of Neonatology, Department of Pediatrics, Marshfield Clinic, Marshfield, Wisconsin (Joshi).

**Corresponding Author:** Jeffrey J. VanWormer, PhD, Center for Clinical Epidemiology and Population Health, Marshfield Clinic Research Institute, 1000 N Oak Ave, Marshfield, WI 54449; phone 715.221.6484; email vanwormer.jeffrey@marshfieldresearch.org; ORCID ID 0000-0002-8733-8703

Health Plan of Wisconsin and/or residents of the Marshfield Epidemiologic Study Area.<sup>9</sup>

### Sample

Inclusion criteria for survey invitees were (1) living in the source population, (2) age  $\geq 18$  years, (3) female, (4) currently pregnant in the third trimester (per pregnancy diagnostic codes) or  $\geq 24$  weeks' gestation, (5)  $\geq 1$  encounter with an MCHS clinician over the previous year, and (6) ability to read the English language survey. Known institutional residents (eg, medical, penal) were excluded. The requirement of having a recent medical encounter helped ensure current study eligibility. Given the limited prior research on e-cig use in pregnant mothers, guidance on assumptions for precise sample size calculations was unavailable. Thus, all known pregnant mothers from the source population over a 1-year timeframe were invited to complete the study survey. Procedures were approved in advance by the MCHS Institutional Review Board, including a request to waive documentation of informed consent and HIPAA authorization.

### Recruitment

Contact information for study-eligible individuals was extracted from the EHR. For each enumerated individual, survey recruitment methods included (1) a mailed invitation packet, which included a cover letter, study information sheet, survey instrument, return mailer, and \$5 cash incentive; (2) a mailed reminder/thank you postcard; (3) follow-up telephone calls for nonrespondents (plus a verbal survey response option); and (4) final mailed follow-up packet, which included the same elements as the mailed invitation packet, sent to all remaining nonrespondents. By completing the survey, participants consented to have their survey data linked to their EHR data for analyses.

### Measures

The outcome was current use of e-cigs during third trimester pregnancy. This was assessed in the survey using validated questions from the Pregnancy Risk Assessment Monitoring System (PRAMS), with supplemental questions on e-cig use.<sup>6</sup> Clinical data, such as number of clinical encounters over the past year, medical comorbidities, and conventional cigarette smoking nearest to the date of pregnancy, were extracted from the EHR. In addition, self-report surveys (and EHR data if available) captured basic pregnancy characteristics (eg, gestation), knowledge/beliefs in e-cig risks, and sociodemographic measures, such as age, race/ethnicity, education, income, and health insurance coverage.

### Analyses

To assess possible respondent biases, available basic EHR characteristics were compared between survey respondents and nonrespondents. Univariate regression was used to examine associations between each sociodemographic/clinical exposure and e-cig use. The univariate model findings were considered hypothesis generat-

**Table 1.** Descriptive Characteristics of Pregnant Women in Northern and Central Wisconsin Who Were Invited to a Survey on Vaping, Including Propensity Score Weighted Characteristics of Survey Respondents

Characteristics	All Invitees (n=1199)	Respondents (n=391)	
		Unadjusted	Weighted
Age (years)	28.6±0.2	29.4±0.3	28.4±0.3
Gestational age (months)	31.2±0.1	30.4±0.2	31.2±0.3
Gravida			
$\geq 2$	131 (11%)	37 (9%)	9%
<2 or unknown	1068 (89%)	354 (91%)	91%
Race/Ethnicity			
White, non-Hispanic	975 (81%)	337 (86%)	81%
Non-White or Hispanic	224 (19%)	54 (14%)	19%
Health insurance			
Medicaid	485 (40%)	111 (28%)	42%
Not Medicaid	714 (60%)	280 (72%)	58%
Smoking status at start of pregnancy			
Smoker	360 (30%)	65 (17%)	32%
Non-smoker	839 (70%)	326 (83%)	68%
Medical encounters in prior 3 years (n)	69.1±1.6	66.3±2.2	69.5±2.9
Body mass index (kg/m <sup>2</sup> )	29.3±0.2	29.5±0.4	29.7±0.4
Depression			
Yes	402 (34%)	115 (29%)	37%
No	797 (66%)	276 (71%)	63%
Anxiety			
Yes	628 (52%)	172 (44%)	55%
No	571 (48%)	219 (56%)	46%

Values are reported as mean  $\pm$  SE or frequency (% of total). Among respondents, the unadjusted values are as-observed from the surveys. Weighted values reflect the rebalanced exposure characteristics after propensity score weighting (using inverse probability weights) was applied.

ing, as multivariable regression was not performed given the small sample size and exploratory nature of our study design. However, propensity score weighting (using inverse probability weights) was used to account for imbalances between survey respondents and nonrespondents. Regression analyses included propensity scores to better reflect the full target population, adjusting final estimates to help minimize the influence of imbalances in potentially confounding characteristics in survey respondents.

## RESULTS

There were 1199 individuals invited to take the survey over the 1-year study period. Of these, 423 (35%) responded. Thirty-two respondents were no longer pregnant at the time of survey completion and were excluded from analyses, yielding a final analytical sample of 391 participants. Descriptive characteristics of survey invitees and respondents are outlined in Table 1. The most notable differences were that respondents were less likely to be current smokers or on Medicaid, but the propensity score weighting adequately balanced the respondent sample to better reflect the underlying source population.

The model-estimated prevalence of current e-cig use during

**Table 2.** Univariate Associations Between Sociodemographic/Clinical Exposures and Current E-cig Use Among Pregnant Women in Northern and Central Wisconsin (n = 391)

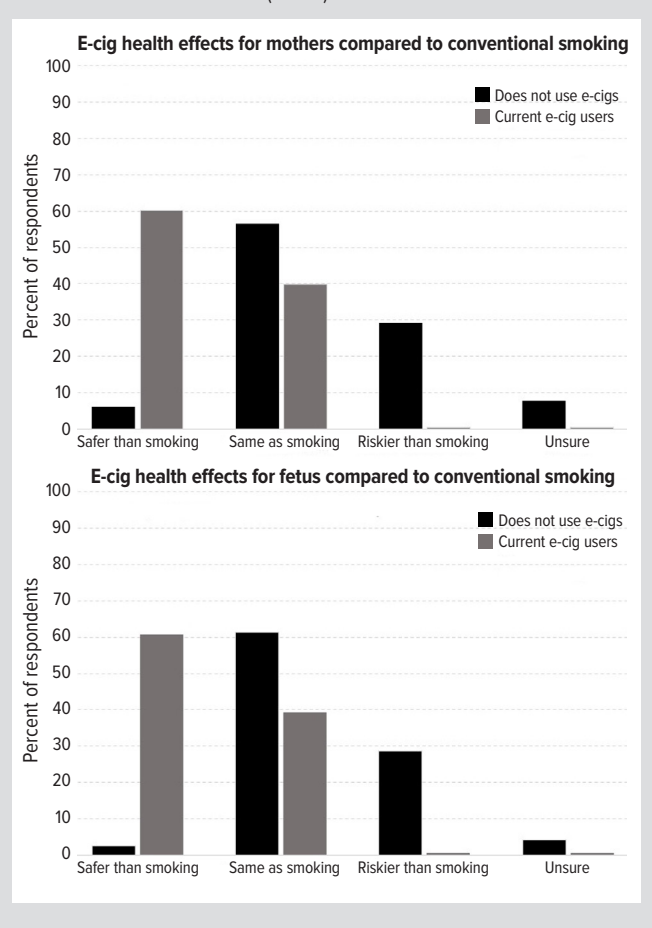
Exposures	Current E-cig Use (95% CI)	P value
Maternal age (years)	0.74 (0.64–0.90)	0.002
Gestational age (months)	0.87 (0.79–0.95)	0.002
Gravida		
≥2 vs <2 or unknown (ref)	0.53 (0.05–5.52)	0.594
Children in the household		
Any vs none (ref)	0.19 (0.05–0.68)	0.011
Marital status		
Married/living with partners vs not married (ref)	0.08 (0.02–0.28)	<0.001
Race/ethnicity		
White, non-Hispanic vs non-white or Hispanic (ref)	1.15 (0.31–4.27)	0.834
Health insurance		
Medicaid vs not Medicaid (ref)	0.83 (0.22–3.14)	0.784
Education		
College vs high school or less (ref)	0.10 (0.03–0.40)	0.001
Annual household income		
≥\$60 000 vs <\$60 000 (ref)	0.09 (0.01–0.92)	0.042
Smoking status at start of pregnancy		
Smoker vs nonsmoker (ref)	3.12 (0.75–13.01)	0.118
Medical encounters in prior 3 years (n)	0.99 (0.98–1.01)	0.484
Body mass index	0.84 (0.74–0.96)	0.008
Depression		
Yes vs no (ref)	0.69 (0.20–2.42)	0.559
Anxiety		
Yes vs no (ref)	3.09 (0.82–11.64)	0.095

Values are reported as odds ratio (95% CI, P value) of current E-cig use. Odds ratio values >1.0 indicate that the odds of e-cig use increase as compared to the reference group (or a 1-unit increase for continuous exposures). Odds ratio values <1.0 indicate that the odds of e-cig use decrease as compared to the reference group (or a 1-unit increase for continuous exposures). For example, the predicted odds of e-cig use was 0.74 (or 26% lower) for each 1 year increase in maternal age. Exposures with  $P < 0.05$  were considered to have a statistically significant association with e-cig use.

third trimester pregnancy was 5% (95% CI, 2.0–8.0), with 16% (95% CI, 11.4–19.6) reporting e-cig use within the 3 months prior to pregnancy. In the subset of respondents who reported ever using e-cigs (n = 119), the most-used brands were Juul (26%), Vuse (21%), and Blu (5%). The most common reasons cited for using e-cigs included initial curiosity (54%), pleasing flavors (36%), and to help reduce use of conventional tobacco products (27%).

As outlined in Table 2, seven exposure variables were significantly associated with current e-cig use. Pregnant women who were younger, at a lower gestational age, not married, without other children in the home, had lower education, lower income, and lower body mass index (BMI) were significantly more likely to report current use of e-cigs (all  $P$  values < 0.05). In addition, compared to pregnant women who did not use e-cigs, significantly more current e-cig users viewed e-cigs as just as safe or safer than

**Figure.** Beliefs in the Health Effects of Electronic Cigarettes for (a) Mother and (b) Fetus, as Compared to Conventional Smoking, in Pregnant Women in Northern and Central Wisconsin (n = 391).



conventional cigarettes, both for the mother and the fetus (all  $P$  values < 0.00, see Figure).

## DISCUSSION

This was the first known study to examine the basic epidemiology of e-cig use in pregnant women in this predominantly rural area of Wisconsin. About 1 of every 20 pregnant women in this region used e-cigs during their third trimester of pregnancy. This was considerably higher than national estimates, where just 1% of pregnant women reported e-cig use in the third trimester.<sup>7</sup> This may reflect differences in the underlying characteristics of our source population, including a higher proportion of non-Hispanic White respondents—a group that was more likely to use e-cigs in the national study. Several other exposures that predicted e-cig use in our study also were observed in national data,<sup>7</sup> including individuals who were younger, lower income, and not married.

Cigarette smoking just prior to pregnancy, while trending in the expected direction in that e-cig use was somewhat more common among cigarette smokers, was not as strong of a risk factor for current e-cig use in our study as has been observed nationally.<sup>7</sup> This was somewhat surprising, as 27% of (ever) e-cig users in our

study still indicated e-cigs were used to help reduce use of conventional tobacco products, and current e-cig users near-uniformly believed that e-cigs were just as safe or safer for the mother and fetus relative to cigarettes. Despite evidence that smokers who also use e-cigs are less likely to quit smoking compared to those who do not use e-cigs,<sup>10</sup> beliefs that e-cigs are a safer alternative to tobacco and/or can help with smoking cessation seem to persist in pregnant e-cig users.

Strengths of this study included the linkage of EHR and survey data to identify e-cig risk factors in an understudied population of rural pregnant mothers, as well as use of a propensity score method to help control for imbalances in the respondent sample. Limitations included the small sample size, which precluded multi-variable modeling, as well as the cross-sectional design, which limits causal conclusions. In addition, the e-cig use outcome from the PRAMS and several exposure variables were self-reported. Other limitations included the racially homogenous sample, which limits generalizability. In addition to addressing these limitations, future research should examine both maternal and child outcomes of e-cig use after pregnancy in rural populations.

Findings from this study indicate the prevalence of e-cig use in pregnant women in north-central Wisconsin could be 5 times greater than that observed nationally.<sup>6</sup> Several influential social, economic, and demographic risk factors for e-cig use were confirmed, namely younger age, low education and income, and unmarried status. If confirmed in larger studies, this could inform better targeted screening, education, and e-cig prevention strategies during the course of prenatal care in rural areas.

**Funding/Support:** This project was funded by philanthropic support of the Marshfield Clinic Research Institute's General Medical Research Fund.

**Financial Disclosures:** None declared.

## REFERENCES

1. England LJ, Aagaard K, Bloch M, et al. Developmental toxicity of nicotine: A transdisciplinary synthesis and implications for emerging tobacco products. *Neurosci Biobehav Rev.* 2017;72:176-189. doi:10.1016/j.neubiorev.2016.11.013
2. Orzabal MR, Lunde-Young ER, Ramirez JI, et al. Chronic exposure to e-cig aerosols during early development causes vascular dysfunction and offspring growth deficits. *Transl Res.* 2019;207:70-82. doi:10.1016/j.trsl.2019.01.001
3. Wang X, Lee NL, Burstyn I. Smoking and use of electronic cigarettes (vaping) in relation to preterm birth and small-for-gestational-age in a 2016 U.S. national sample. *Prev Med.* 2020;134:106041. doi:10.1016/j.ypmed.2020.106041
4. Liao L, Deng Y, Zhao D. Association of low birth weight and premature birth with the risk of metabolic syndrome: a meta-analysis. *Front Pediatr.* 2020;8:405. doi:10.3389/fped.2020.00405
5. U.S. Department of Health and Human Services. *E-cigarette use among youth and young adults. A report of the Surgeon General.* Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2016.
6. Kapaya M, D'Angelo DV, Tong VT, et al. Use of electronic vapor products before, during, and after pregnancy among women with a recent live birth – Oklahoma and Texas, 2015. *MMWR Morb Mortal Wkly Rep.* 2019;68(8):189-194. doi:10.15585/mmwr.mm6808a1
7. Liu B, Du Y, Wu Y, Sun Y, Santillan MK, Santillan DA, Bao W. Prevalence and distribution of electronic cigarette use before and during Pregnancy among women in 38 states of the United States. *Nicotine Tob Res.* 2021;23(9):1459-1467. doi:10.1093/ntr/ntab041
8. Buettner-Schmidt K, Miller DR, Maack B. Disparities in rural tobacco use, smoke-free policies, and tobacco taxes. *West J Nurs Res.* 2019;41(8):1184-1202. doi:10.1177/0193945919828061
9. DeStefano F, Eaker ED, Broste SK, et al. Epidemiologic research in an integrated regional medical care system: the Marshfield Epidemiologic Study Area. *J Clin Epidemiol.* 1996;49(6):643-652. doi:10.1016/0895-4356(96)00008-x
10. Weaver SR, Huang J, Pechacek TF, Heath JW, Ashley DL, Eriksen MP. Are electronic nicotine delivery systems helping cigarette smokers quit? Evidence from a prospective cohort study of U.S. adult smokers, 2015-2016. *PLoS One.* 2018;13(7):e0198047.

advancing the art & science of medicine in the midwest

**WMJ**

*WMJ* (ISSN 1098-1861) is published through a collaboration between The Medical College of Wisconsin and The University of Wisconsin School of Medicine and Public Health. The mission of *WMJ* is to provide an opportunity to publish original research, case reports, review articles, and essays about current medical and public health issues.

© 2024 Board of Regents of the University of Wisconsin System and The Medical College of Wisconsin, Inc.

**Visit [www.wmjonline.org](http://www.wmjonline.org) to learn more.**