

# Vaping, lung injury, and mental health in Minnesota 2018–2019

BY CORY COLE, MPH; TERRA WIENS, MPH; JOANNE TAYLOR, PHD; RICHARD DANILA, PHD; PAIGE D'HEILLY, MPH; JAMIE MARGETTA, MPH; MARIA BYE, MPH; ERICA MUMM, MPH; LAUREN SCHWERZLER, MPH; ROON MAKHTAL; STACY HOLZBAUER, DVM; AND RUTH LYNFIELD, MD

This report describes and contextualizes the high prevalence of mental health conditions (MHC) among Minnesota 2019 EVALI patients by examining the prevalence of MHC and associations between MHC and e-cigarette or vaping product (EVP) use in Minnesota population surveys.

Investigators reviewed medical records for 140 EVALI patients to determine history of MHC. History of MHC and EVP use in the general population was estimated using self-reported measures and screening tools from two population-based surveys, the 2019 Minnesota Student Survey (MSS) and the 2018 Minnesota Behavioral Risk Factor Surveillance Survey (MN-BRFSS).

Some 64.3% of EVALI patients had an MHC. In both Minnesota population surveys, MHCs were common among people who used EVP. The odds of MHC among youth aged <18 were higher among those who reported current EVP use compared with those who did not report EVP use. Similarly, the odds of depression were higher among adults who reported current EVP use compared with those who did not.

Clinicians treating patients with EVALI should consider evaluating the need for, and providing indicated referrals to, post-discharge mental health services for their patients.

## Introduction

A multistate outbreak of e-cigarette, or vaping, product-use associated lung injury (EVALI) was identified in the United States in summer 2019. During their investigation of the outbreak, Minnesota Department of Health (MDH) epidemiologists noted a high prevalence of underlying mental health conditions (MHC), including anxiety, depression, and other psychiatric diagnoses among confirmed and probable EVALI patients. Additionally, some of these patients noted during interview that they had been using e-cigarette, or vaping, products (EVP) with the intention of alleviating MHC symptoms. Finally, language about alleviating MHC symptoms was noted on packaging (Figure) of some EVP that EVALI patients had submitted to MDH's Public Health Laboratory for testing. All three of these observations from the outbreak investigation process raised questions not only about a potential association between MHC and EVALI, but about a potential association between MHC and EVP use in the general Minnesota population.

In order to better describe the prevalence of MHC among Minnesota EVALI patients, medical records for all 140 confirmed and probable patients were reviewed. In order to contextualize these findings with observations from the general Minnesota population, two population-based surveys, the 2019 Minnesota Student Survey (MSS) and the 2018 Minnesota Behavioral Risk Factor Surveillance Survey (MN-BRFSS), were used to estimate the prevalence of MHC and EVP use among youths and adults.

## Methods

### *EVALI patients*

EVALI became reportable to MDH on August 12, 2019. During August 15–December 23, 2019, MDH interviewed EVALI patients or their proxies for cases reported by clinicians to MDH during August 8–December 16, 2019.<sup>1</sup> Patients were identified as confirmed or probable EVALI cases using the standardized case definition provided by the Centers for Disease Control and Prevention.<sup>2</sup> MDH also reviewed patient medical records to ascertain his-

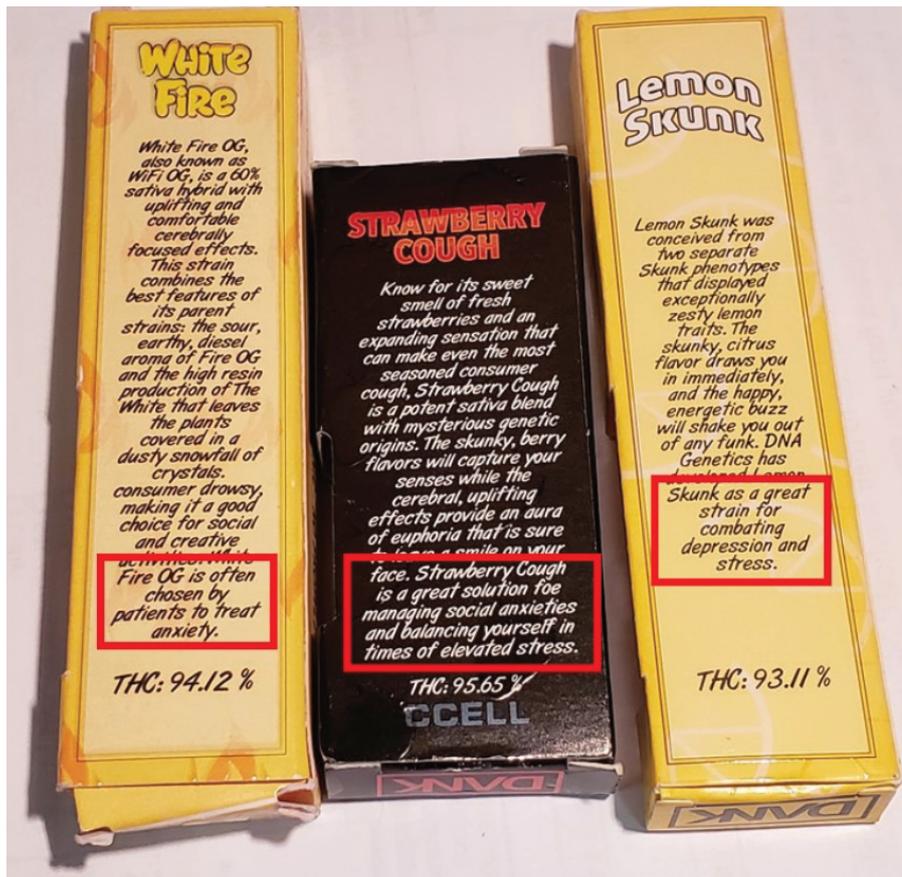
tory of MHC, including anxiety, depression, and other psychiatric diagnoses, and history of medication commonly indicated for MHC. Other psychiatric diagnoses included attention-deficit/hyperactivity disorder, attention deficit disorder, specified and unspecified eating disorders, adjustment disorder, borderline personality disorder, post-traumatic stress disorder, bipolar disorder, panic disorder, obsessive-compulsive disorder, psychotic disorder, schizoaffective disorder, unspecified personality disorder, and schizophrenia. To reduce potential confounding, substance-use disorders were not counted as MHC.

### *Population surveys*

Prevalence estimates of MHC and current EVP use (defined as an answer of “every day,” “most days,” or “some days” to the question, “during the past 30 days, on how many days did you use an e-cigarette or electronic vaping product?”) among Minnesota school-attending adolescents were obtained from the 2019 Minnesota Student Survey (MSS).<sup>3</sup> MSS is a census-style statewide computer survey of fifth-, eighth-,

FIGURE

Examples of labels



Illicit tetrahydrocannabinol-containing e-cigarette, or vaping, product packaging submitted to the Minnesota Department of Health by e-cigarette, or vaping, product-use associated lung injury patients that specifically reference symptoms associated with mental health conditions.

ninth-, and 11th-graders conducted every three years in the spring. Survey responses from 125,228 students (response rate 64%) from grades 8, 9, and 11, who were between the ages of 12 and 19 years, were analyzed, including 624 (0.5%) students aged 18–19 years. Respondents were identified as having “any” MHC if they answered “yes” to the question, “Have you ever been diagnosed with a long-term mental health problem?” Anxiety and depression symptoms were assessed using the 2-Item Generalized Anxiety Disorder questionnaire (GAD-2) and 2-Item Patient Health Questionnaire (PHQ-2).<sup>4,5</sup> Anxiety or depression was defined as a score of  $\geq 3$  on the GAD-2 and PHQ-2, respectively.

Prevalence estimates of depression and current EVP use among adults were obtained from the 2018 Minnesota Behavioral Risk Factor Surveillance Survey (MN-BRFSS), an annual, state-based telephone survey of noninstitutionalized U.S.

adults aged  $\geq 18$  years.<sup>6</sup> In 2018, a total of 16,990 people responded to MN-BRFSS (51.0% combined landline and cell phone weighted response rate). Current EVP use was defined as an answer of “every day,” “most days,” or “some days” to the question, “during the past 30 days, on how many days did you use an e-cigarette or electronic vaping product?” Respondents were identified as having depression if they answered “yes” to the question, “Have you ever been told you have a depressive disorder?” Appropriate indicators for “any” MHC and anxiety were not available.

Statistical analysis

Proportions of any MHC, anxiety, and depression by sex among EVALI patients were compared using Pearson’s chi-square test ( $\alpha = 0.05$ ). For both MSS and MN-BRFSS surveys, percentages and odds ratios (ORs) of self-reported MHC diag-

noses and symptoms were calculated. MN-BRFSS data were weighted to account for the complex sampling design. We tested associations for effect modification by sex. For associations with evidence of effect modification ( $\alpha = 0.05$ ), sex-stratified ORs were calculated. For associations without evidence of effect modification, ORs were adjusted for sex. All statistical analyses were performed using SAS<sup>®</sup> (version 9.4; SAS Institute, Cary, North Carolina).

Results

EVALI patients

During August 8–December 16, 2019, a total of 140 confirmed and probable EVALI patients were reported to MDH; median age was 22 years (interquartile range: 18–32.5 years), and 89 (63.6%) patients were male. Ninety (64.3%) EVALI patients had a history of any MHC; 75 (83.3%) of these 90 EVALI patients were prescribed at least one medication commonly indicated for MHC before seeking care for EVALI. Among 34 EVALI patients aged  $< 18$  years (range: 13–17), 61.8% had any MHC, including 58.8% who had anxiety, and 35.3% who had depression. Among these 34 adolescent patients, prevalence of any MHC, anxiety, and depression did not significantly differ between female and male patients (75.0% vs 50.0%,  $p = 0.13$  [prevalence of any MHC]; 75.0% vs 44.4%,  $p = .07$  [anxiety]; and 43.8% vs 27.8%,  $p = 0.33$  [depression]) (Table 1).

Among 106 EVALI patients aged  $\geq 18$  years (range 18–75), 65.1% had any MHC, 54.7% had anxiety, and 50.9% had depression. Prevalence of any MHC was higher among adult women than adult men (85.3% vs 54.9%;  $p < 0.01$ ), as was anxiety (76.5% vs 43.7%;  $p < 0.01$ ), and depression (70.6% vs. 40.8%;  $p < 0.01$ ) (Table 1).

Population surveys

Among all MSS respondents, prevalence of any self-reported MHC diagnosis, anxiety, and depression was 30.3%, 35.3%, and 27.6%, respectively, for females; and was 15.9%, 16.2%, and 16.8%, respectively, for males (Table 2). Among MSS respondents reporting current EVP use, prevalence of any self-reported MHC diagnosis, anxiety,

TABLE 1

**Mental health conditions (MHCs) among 140 Minnesota patients with e-cigarette, or vaping, product-use associated lung injury, by sex and age — August-December 2019**

	ANY MHC, INCLUDING ANXIETY, DEPRESSION, AND OTHER PSYCHIATRIC DIAGNOSES* (%)	ANXIETY (%)	DEPRESSION (%)
TOTAL	90/140 (64.3)	78/140 (55.7)	66/140 (47.1)
Prescribed medication commonly indicated for MHC, total	75/90 (83.3)	67/78 (85.9)	56/66 (84.9)
Prescribed MHC meds, male	48/89 (53.9)	39/89 (43.8)	34/89 (38.2)
Prescribed MHC meds, female	41/50 (82.0)	38/50 (76.0)	31/50 (62.0)
Prescribed MHC meds, other	1/1 (100)	1/1 (100)	1/1 (100)
Aged <18 years, total	21/34 (61.8)	20/34 (58.8)	12/34 (35.3)
Aged <18 years, male	9/18 (50.0)	8/18 (44.4)	5/18 (27.8)
Aged <18 years, female	12/16 (75.0)	12/16 (75.0)	7/16 (43.8)
Aged ≥18 years, total	69/106 (65.1)	58/106 (54.7)	54/106 (50.9)
Aged ≥18 years, male	39/71 (54.9)	31/71 (43.7)	29/71 (40.8)
Aged ≥18 years, female	29/34 (85.3)	26/34 (76.5)	24/34 (70.6)
Aged ≥18 years, other	1/1 (100)	1/1 (100)	1/1 (100)

and depression was 50.8%, 45.5%, and 52.9%, respectively, for females; and was 26.6%, 27.9%, and 26.5%, respectively, for males (Table 2). Among MSS respondents, 16% of male and 18% of female students reported current EVP use. Odds of any MHC diagnosis, depression, and anxiety were significantly higher among those who reported current EVP use (Table 2). ORs were higher among female students [any MHC: 2.97 (2.85, 3.11); depression: 2.46 (2.35, 2.57); anxiety: 2.73 (2.61, 2.86)] than among male students [any MHC: 2.22 (2.10, 2.35); depression: 2.26 (2.14, 2.39); anxiety: 2.21 (2.09, 2.33)] (Table 2).

Among all adult MN-BRFSS respondents, prevalence of depression was 17.6% (Table 2). Among adult MN-BRFSS respondents who reported current EVP use, the prevalence of depression was 32.5% (Table 2). Among MN-BRFSS respondents, 5% of male and 2% of female adults reported current EVP use. Adjusting for sex, odds of self-reported depression were significantly higher [OR = 2.75 (2.20, 3.43)] among respondents who reported current EVP use, compared with those who did not (Table 2).

### Discussion

Approximately two-thirds of Minnesota EVALI patients had evidence of a past

medical history of any MHC. Among adult EVALI patients, MHC prevalence was higher among females than males. The majority of EVALI patients with MHC had been prescribed at least one medication commonly indicated for MHC before seeking care for EVALI. These findings reinforce CDC's guidance to clinicians that EVALI patients might benefit from evaluations for MHC to determine post-discharge support needs, including assuring social support and access to mental health and substance-use disorder services.<sup>7</sup>

Among respondents to the 2019 MSS and 2018 MN-BRFSS, both youth and adults who reported current EVP use were significantly more likely to report history or symptoms of MHC than those who did not report current EVP use. These findings align with those of other cross-sectional analyses that have investigated MHC and EVP use in large, population-based samples.<sup>8,9</sup> For example, among respondents to the 2016 National Health Interview Survey, those who self-reported MHC were 2–3 times more likely to report EVP ever use and current use, compared with respondents who did not report MHC.<sup>7</sup> In another large, nationally representative adult sample, Cummins et al. found that regardless of smoking status, respondents with self-reported MHC were



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approximately twice as likely to have tried e-cigarettes as those without MHC.<sup>8</sup> The survey data collection tools referenced in these studies do not ask respondents to distinguish between nicotine-containing EVP use and tetrahydrocannabinol (THC)-containing EVP use.

An important limitation of this study is the inability of the 2019 MSS and 2018 MN-BRFSS survey instruments to distinguish between use of nicotine-containing EVP and THC-containing EVP.<sup>1</sup> Although the majority of EVALI patients reported using THC-containing EVP, MSS and MN-BRFSS respondents could have used mostly nicotine- or cannabidiol (CBD)-containing EVP. Therefore, we are unable to determine whether the high prevalence of MHC among EVALI patients and the association between EVP and MHC in the general population represent the same association. To more fully understand this association and its implications for population health, more research is needed to examine the role that specific EVP substances (e.g., illicit THC-containing EVPs vs nicotine-containing EVPs) play in the association with MHC. Additionally, because the study samples and data collection methods differ fundamentally from each other, prevalence of MHC should not be directly compared between samples.

However, the similarity of findings within each of these disparate samples makes a strong case for an association between MHC and EVP use. Another limitation is the use of self-reported data to estimate the population prevalence of MHC. Because of social stigma around MHC, MSS respondents and MN-BRFSS respondents might have been less likely to report MHC. Similarly, EVALI patients may not have volunteered history of MHC to their physicians during lung-injury treatment.

**Conclusions**

Clinicians treating patients with EVALI should consider evaluating the need for post-discharge mental health services for their patients, especially if the patient reports having used EVP intending to manage MHC-related symptoms. These post-discharge mental health services could include assuring social support and access to mental health and substance-use disorder services. Further research is warranted to examine underlying factors driving the observed association between EVP use and MHC among the general population youth and adults. **MM**

Cory Cole, MPH, is applied epidemiology fellow, MDH, through the Council of State and Territorial Epidemiologists Applied Epidemiology Fellowship Program, Atlanta. Terra Wiens, MPH, is an epidemiologist, MDH.

Joanne Taylor, PhD, is with the Epidemic Intelligence Service, Division of Scientific Education and Professional Development, CDC, and MDH. Richard Danila, PhD, is epidemiology program manager, MDH. Paige D’Heilly, MPH, is an epidemiologist, MDH. Jamie Margetta, MPH, is health economics and outcomes researcher, Medtronic. Maria Bye, MPH, is healthcare worker monitoring interview team lead, MDH. Erica Mumm, MPH, is applied epidemiology fellow, MDH, through the Council of State and Territorial Epidemiologists Applied Epidemiology Fellowship Program, Atlanta. Lauren Scherzler, MPH, RDN, is an epidemiologist, MDH. Roon Makhtal is data abstractor, MDH. Stacy Holzbauer, DVM, MPH, is epidemiology field officer, MDH and Center for Preparedness and Response, CDC. Ruth Lynfield, MD, is state epidemiologist, MDH.

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TABLE 2  
**Prevalence of mental health conditions (MHCs) and odds of MHC by e-cigarette or vaping (EVP) use 2019 Minnesota Student Survey (MSS)<sup>†</sup> and 2018 Minnesota Behavioral Risk Factor Surveillance Survey<sup>§</sup> (MN-BRFSS)**

MHC VARIABLE	SURVEY	AGE GROUP (YEARS)	PREVALENCE OF MHC AMONG ALL RESPONDENTS (%)	PREVALENCE OF MHC AMONG RESPONDENTS REPORTING CURRENT EVP USE (%)	PREVALENCE OF MHC AMONG RESPONDENTS NOT REPORTING CURRENT EVP USE (%)	CURRENT EVP USE Odds ratio (95% CI)
Any MHC	2019 MSS	12–19	Male: 15.9	Male: 26.6	Male: 13.7	2.22 (2.10, 2.35)
			Female: 30.3	Female: 50.8	Female: 25.8	2.97 (2.85, 3.11)
Anxiety	2019 MSS	12–19	Male: 16.2	Male: 27.9	Male: 14.0	2.21 (2.09, 2.33)
			Female: 35.3	Female: 45.5	Female: 31.3	2.46 (2.35, 2.57)
Depression	2019 MSS	12–19	Male: 16.8	Male: 26.5	Male: 14.6	2.26 (2.14, 2.39)
			Female: 27.6	Female: 52.9	Female: 23.4	2.73 (2.61, 2.86)
Depression	2018 MN-BRFSS	18–65+	Overall: 17.6	Overall: 32.5	Overall: 17.0	2.75 (2.20, 3.43) (Adjusted for sex)

<sup>†</sup> MSS is a statewide computer survey of fifth, eighth, ninth, and 11th grade students conducted every three years. Fifth graders were not asked about EVP use and not included in this analysis.

<sup>§</sup> MN-BRFSS is an annual, state-based telephone survey of noninstitutionalized U.S. adults aged ≥18 years.

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