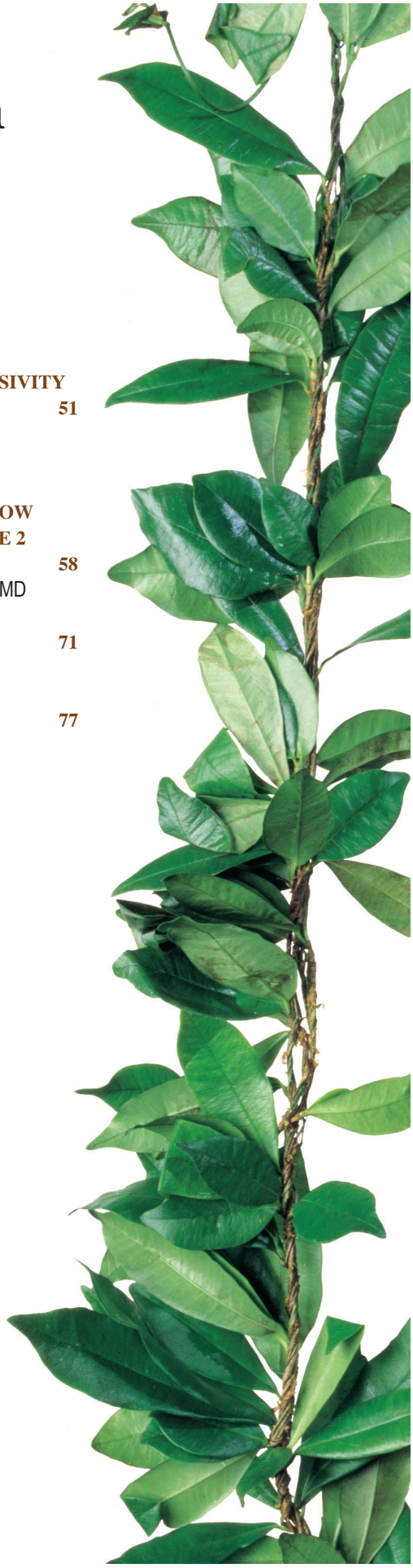
Hawai‘i Journal of Health & Social Welfare

A Journal of Pacific Health & Social Welfare

March 2022, Volume 81, No. 3, ISSN 2641-5216



Hawai‘i Journal of Health & Social Welfare

ISSN 2641-5216 (Print), ISSN 2641-5224 (Online)

Aim:

The aim of the Hawai‘i Journal of Health & Social Welfare is to advance knowledge about health and social welfare, with a focus on the diverse peoples and unique environments of Hawai‘i and the Pacific region.

History:

In 1941, a journal then called The Hawai‘i Medical Journal was founded by the Hawai‘i Medical Association (HMA). The HMA had been incorporated in 1856 under the Hawaiian monarchy. In 2008, a separate journal called the Hawai‘i Journal of Public Health was established by a collaborative effort between the Hawai‘i State Department of Health and the University of Hawai‘i at Mānoa Office of Public Health Studies. In 2012, these two journals merged to form the Hawai‘i Journal of Medicine & Public Health, and this journal continued to be supported by the Hawai‘i State Department of Health and the John A. Burns School of Medicine.

In 2018, the number of partners providing financial backing for the journal expanded, and to reflect this expansion the name of the journal was changed in 2019 to the Hawai‘i Journal of Health & Social Welfare. The lead academic partners are now the six units of the UH College of Health Sciences and Social Welfare, including the John A. Burns School of Medicine, UH Public Health, the Thompson School of Social Work & Public Health, the Nancy Atmospera-Walch School of Nursing, the UH Cancer Center, and the Daniel K. Inouye College of Pharmacy. Other partners are the Hawai‘i State Department of Health and the UH Office of the Vice Chancellor for Research. The journal is fiscally managed by University Health Partners of Hawai‘i.

The HJH&SW Today:

The Hawai‘i Journal of Health & Social Welfare is a monthly peer-reviewed journal. Full-text articles are available on PubMed Central. The HJH&SW cannot be held responsible for opinions expressed in papers, discussion, communications, or advertisements. The right is reserved to reject editorial and advertising materials that are submitted. Print subscriptions are available for an annual fee of $250. Please contact the journal for information about subscriptions for locations outside of the US.

The HJH&SW is financially supported by the academic units within the UH College of Health Sciences and Social Welfare, the UH Office of the Vice Chancellor for Research, the Hawai‘i State Department of Health, and by advertising. However, the journal’s editorial board maintains editorial independence from these entities for the acceptance and publication of research articles. All editorial decisions regarding the selection and editing of research articles are made by the members of the journal’s editorial board. The decisions of the editorial board are not influenced by nor subject to the approval of these entities.

The aim of the columns of the HJH&SW is to provide a space for the entities that financially support the HJH&SW to diseminate information regarding their research, programs, goals, or current issues facing their respective fields. Columns are edited by the HJH&SW contributing editors, who are employees of the agencies that support the HJH&SW.

The aim of the Hawai‘i Journal Watch is to highlight recent research of the entities that finacially support the HJH&SW. The research articles that are covered in the Hawai‘i Journal Watch are selected by both the HJH&SW and by researchers in the units that support the HJH&SW. The researchers whose articles are covered in the Hawai‘i Journal Watch are given the opportunity to fact check the news brief.

Journal Contact Information:

Mailing Address: Hawai‘i Journal of Health & Social Welfare
University of Hawai‘i John A. Burns School of Medicine
Medical Education Building, 224F
651 Ilalo St., Honolulu, HI 96813
Website: http://hawaiijournalhealth.org/
Email: hjhsw@hawaii.edu

2020 Writing Contest Undergraduate Winner

Relationships Between Depressive Symptoms, Anxiety, Impulsivity and Cigarette and E-cigarette Use Among Young Adults

Kelly Masaki; Rachel M. Taketa BA; Mark K. Nakama MPH; Crissy T. Kawamoto BS; Pallav Pokhrel PhD, MPH

Kelly Masaki

Kelly Masaki is a 2020 graduate of St. Andrew's Priory School. She did this project during her Summer Internship in 2019 at the University of Hawai'i Cancer Center under the mentorship of Dr. Pallav Pokhrel. She is now a student at Santa Clara University's School of Engineering studying Computer Science and Engineering.

Abstract

Depression and anxiety have been associated with cigarette use among young people. Higher impulsivity has also been associated with increased smoking behavior. However, relatively less is known about the associations between depression, anxiety, impulsivity and e-cigarette use and how these associations compare with the associations between depression, anxiety, impulsivity and cigarette smoking. In addition, little is known about how impulsivity influences the relationships between depression, anxiety, cigarette, and e-cigarette use. This study tested the hypothesis that higher depression and anxiety symptoms are associated with higher e-cigarette use and cigarette smoking in a similar way, and that these associations would be stronger among those with higher impulsivity. A sample of 2,622 young adults (18-25 year olds; 54% women) enrolled in 4-year and 2-year colleges in Hawai'i participated in a cross-sectional survey. Approximately 68% of the sample reported no use of either e-cigarettes or cigarettes, 13% reported only e-cigarette use, 9% reported only cigarette smoking, and 11% reported use of both. The study found that higher depressive and anxiety symptoms and higher impulsivity were significantly associated with current cigarette and e-cigarette use. For example, one unit increases in depression, anxiety, and impulsivity were associated with 34%, 17%, and 38% increased odds of e-cigarette use versus non-use, respectively. Impulsivity was found to significantly moderate the association between higher anxiety and higher cigarette smoking, such that the association was stronger among those with higher impulsivity. Impulsivity was not found to moderate any other association. Results suggest that tobacco product use prevention education should target children and young adults with higher internalizing symptoms, with particular attention to those who show higher impulsivity.

Keywords

Depressive symptoms, Anxiety symptoms, Impulsivity, Cigarettes, E-Cigarettes, Young Adults

Introduction

Electronic or e-cigarettes are becoming more commonly used by United States (US) high and middle school students than combustible cigarettes,[1] despite having been marketed widely for only about a decade. The risks of cigarette smoking and second-hand exposure to cigarette smoke have been known for decades.[2] However, as e-cigarettes are a relatively new product on the market, little is known regarding their potential risks. E-cigarettes appear to be less harmful than cigarettes; as a result, some people perceive them to be safer or healthier alternatives to combustible cigarettes.[3] Unfortunately, however, now many young people are being introduced to nicotine use through e-cigarettes, especially in Hawai'i.[4] In 2017, more Hawai'i high school students reported themselves as current e-cigarette users (26%) than cigarette smokers (8%).[5] Nationally, approximately, 3.6 million youths are current e-cigarette users.[6] E-cigarettes are available in many different flavors, which young people tend to find highly attractive.[7]

Apart from flavors, young people find e-cigarettes attractive because e-cigarette aerosol is easier to inhale, does not smell bad, is considered less harmful, and yet is able to deliver nicotine.[8] For some young people, the motive of e-cigarette use is social enhancement, such as an increase in popularity among peers and an enhanced social image.[8] Although cigarette smokers commonly use e-cigarettes for help with smoking cessation, some do not find e-cigarettes to be helpful in managing their cigarette smoking behavior.[9] Another potential risk of e-cigarettes is that individuals who have never smoked cigarettes, or who are novice

smokers, may find e-cigarettes as a more appealing cigarette alternative for nicotine delivery.[8,9] Smokers consume cigarettes primarily because of nicotine, which is a psychostimulant and addictive. However, cigarette smoke smells relatively harsh and tastes bitter. These characteristics may deter never or novice smokers from smoking, even though they may like the pleasurable effects of nicotine. E-cigarette aerosol, on the other hand, is less harsh and bitter. Furthermore, because e-cigarette aerosol is usually flavored, it smells and tastes good. Hence, individuals who might have been deterred from smoking cigarettes for nicotine intake may find e-cigarettes as a better alternative for delivery of nicotine.

Cigarettes have been known to cause cancer (especially lung cancer), asthma, diabetes, gum disease, heart disease, and stroke.[2] However, the definite harms caused by e-cigarettes are not as well-known. E-cigarettes may cause asthma,[10] decreased lung function,[11] an increased innate immune response in the lung,[12,13] and cardiovascular disease.[14] Even though in smaller amounts than cigarettes, e-cigarettes are known to contain dangerous carcinogens such as nitric oxide, which when burned creates formaldehyde.[15] Second-hand exposure to e-cigarette aerosol may also be risky, although the level of risks are currently unknown.[16] In 2019, the CDC investigated a national outbreak of e-cigarette or vaping product use associated lung injury (EVALI).[17,18] As of October 2019, there were 1,604 reported cases of EVALI, and 34 EVALI-related deaths in 24 states.[17,18] Therefore, despite popular notions about e-cigarettes being safer than cigarettes, there are still many potential risks that e-cigarettes may pose.

An area of research that has been understudied is the use of e-cigarettes by youth and young adults with symptoms of poor mental health. Data from the 2016 National Survey of Children's Health (NSCH) found that among children aged 3-17 years in the US, 7.1% had been diagnosed with anxiety and 3.2% had been diagnosed with depression.[19,20] Thirteen percent of youth aged 12-17 years report having at least one major depressive episode in the past year.[21] Research shows that cigarette smoking and dependence are strongly associated with higher depression and anxiety.[22,23] Some evidence suggests that use of e-cigarettes is higher among people with psychiatric and substance use disorders.[24,25] Individuals with higher levels of depression and anxiety are more likely to smoke cigarettes because of the need to self-medicate, as nicotine is believed to alleviate the symptoms of anxiety and depression.[23] People with symptoms of poor mental health may be attracted to use e-cigarettes for similar reasons. In addition, higher impulsivity has also been associated with an increase in risky behaviors and undesirable outcomes. Impulsivity is a strong correlate of cigarette smoking.[26-28] This is because higher impulsivity is an indicator of poor self-control.[29]

Currently, findings from studies examining the associations between anxiety, depression, and e-cigarette use have been mixed. Some studies have found significant positive associations between depressive symptoms and e-cigarette use,[30,31] whereas others have not.[22] This study tested the associations between depression, anxiety, and e-cigarette use and cigarette smoking among young adults in Hawai'i. The study also examined impulsivity as a moderator of the association between mental health symptoms and cigarette and e-cigarette use. The hypotheses were: (1) higher depression and anxiety symptoms would be associated with higher cigarette smoking and e-cigarette use, and (2) the associations between depression and anxiety symptoms and cigarette smoking/e-cigarette use would be stronger among those who show higher impulsivity.

Methods

Procedures

This study was conducted in 2018-2020. The study protocol was approved by the University of Hawai'i (UH) Human Studies Program under CFR 46.110 and 21 CFR 56.110, Category (7) (CHS#23645). Students from two, 4-year and four, 2-year (community) colleges under the same university system in Hawai'i were approached with the opportunity to participate in the study. To be eligible to participate in the study, participants had to be 18-25 years old and enrolled in a 2- or 4-year program within the UH system. E-mail addresses were obtained for all 18-25 year olds enrolled across the college campuses. A link to the screener survey was e-mailed to 7000 randomly selected e-mail addresses, inviting potential participants to participate in the study, which was described in generic terms, as a study on marketing and young adult health behavior. The screener survey included questions on age, sex, tobacco, alcohol, and dietary behaviors. In addition, the survey collected potential participants' basic contact information such as phone number and university e-mail address. Of 7000 students invited to complete the screener survey, 60% completed the screener survey at baseline.

However, respondents to the e-mail invitation were predominantly women, never cigarette smokers. To increase the proportion of men in the sample and for adequate representation of cigarette smokers and experimenters in the sample (relative to nationally representative samples of 18-25 year olds), classroom-based recruitment was conducted. Participants were approached in the classroom with the assumption that more men and cigarette smokers would complete the screener survey. Since students are a captive audience in the classrooms, they are more likely to pay attention to the invitation to participate in a research study if the opportunity to do so is presented face-to-face by research staff.

For classroom-based recruitment, approximately 40 classes from each participating campus were randomly selected, and instructors of those classes were approached with requests for a classroom visit. On average, 25% of the instructors who were

approached (approximately 10 classes per college) either did not respond to the research team's request or actively denied participation. Hence, the research staff visited about 30 classrooms per college and presented the study and the opportunity to participate in the study to the students. Interested students (total 2700) completed the paper-and-pencil version of the screener survey. Participants provided consent either online or on paper before completing the screener survey.

Initially, the only eligibility criterion for participation was age: participants had to be 18-25 years old. However, as recruitment progressed and a higher percentage of females than males enrolled in the study, eligibility criteria was adjusted to ensure a more balanced men to women ratio. Similarly, once the predetermined percentage of non-cigarette smokers was fulfilled in the sample, eligibility criteria were adjusted to exclude further enrollment of nonsmokers going forward, in order to ensure that cigarette smokers were adequately represented in the sample. Of the students who completed the screener survey, either online or in the classroom, 3,664 students were eligible to participate in the study. Research staff explained the follow up survey procedure to the participants in person or by telephone. Participants were first e-mailed a link to the online consent form. After participants indicated their consent to participate in the study by clicking the "I agree to participate" button, they were sent unique links to the survey via e-mail. Of these, informed consent was obtained from 2,884 (79%) potential participants; the remainder could not be reached for consent procedure. A total of 2,622 participants completed the survey. The survey was programmed on Inquisit 4.0 computer software (Millisecond Software, Seattle, WA, 2015). No incentive was provided to complete the screener survey. Participants who completed the main survey received a $40 Amazon gift card.

Measures

Demographic Variables

Demographic variables assessed included age, sex, ethnicity, and annual household income. Age and sex were assessed both in the screener survey and the main study survey. Age, sex, and household income were assessed with single items. To determine ethnicity, participants were asked, "What is your ethnic background?" and were provided with a list of ethnicities common in Hawaii and the US. The question was asked in two different ways. The first question asked participants to refer to the list and "check all that apply." The second question asked participants to choose the ethnic background that they identify with most. The response to the second question was utilized to assign mixed-ethnicity individuals to a particular racial/ethnic category. These items have been used successfully in past research.[8]

E-Cigarette and Cigarette Use

Cigarette smoking was assessed in the screener survey and the main survey. E-cigarette use was assessed only in the main survey. As in most national surveys,[4,32] current e-cigarette use and cigarette smoking were assessed in terms of past-30-day use. For example, "During the last 30 days (1 month), on how many days did you use an electronic cigarette (e-cigarette) or a similar vaping device?" (8-point scale: "0 days," "1-2 days," "3-5 days," up to "All days"). For logistic regression analyses, the variables were dichotomized to use (1) vs non-use (0). In addition, different patterns of e-cigarette and cigarette use, namely cigarette-only smoking, e-cigarette-only use, dual use of cigarette and e-cigarette, and use of neither product were also compared (see Table 1).

Mental Health Symptoms

Depression was assessed using the Center for Epidemiological Studies Depression (CES-D) scale,[33] which asks 20 questions about feelings in the past week. Each question was scored from 0 to 3, and the scores were added with a total range from 0 to 60. A previously defined cut-point ≥16 was used for presence of depressive symptoms.[34,35] Anxiety symptoms were defined using the Generalized Anxiety Disorder 7-item (GAD-7) scale,[36] which asked 7 questions about feelings in the past 2 weeks. Each question was scored from 0 to 3, and the scores were added with a total range from 0 to 21. A previously defined cut-point ≥ 10 was used for presence of anxiety symptoms.[36]

Impulsivity

Impulsivity was defined using a modified version of the Kendall Wilcox Impulsivity Scale for Children (Self-Control Rating Scale),[37] which asked 7 questions about impulsivity, each rated on a 5-point scale (1=never, 2=a little, 3=sometimes, 4=pretty often, 5=usually), for a sum score ranging from 5 to 35. High impulsivity was defined using a cut-point ≥ 10 based on median score.

Data Analysis

Data were analyzed using SAS software, version 9.2 (SAS Institute Inc., Cary, NC).[38] General Linear Models (GLM) and chi-square tests were used to compare means and proportions of variables across the 4 smoking/e-cigarette use categories: "no use," "cigarette-only use," "e-cigarette-only use," and "dual use." GLMs were also used to examine the associations between 4 smoking categories and depressive symptoms, anxiety symptoms and impulsivity after adjusting for demographic variables such as age, sex, ethnicity, and family/household income. Logistic regression was used to test the associations between depression, anxiety, impulsivity and cigarette and e-cigarette use. The logistic regression models adjusted for demographic covariates (age, sex, ethnicity, and family/household income) and cigarette

Table 1. Demographic Characteristics of the Entire Sample and by Smoking and E-cigarette Use Status						
Variables	**Entire sample (N = 2,622, 100%)**	**No smoking/ No e-cigarette use (n=1,750, 67.9%)**	**E-cigarette use only (n=324, 12.6%)**	**Cigarette smoking only (n=233, 9.0%)**	**Dual use of e-cigarette and cigarette (n=271, 10.5%)**	***P* value**
Age: yrs (SD)	21.2 + (2.2)	21.0 + 0.05	20.9 + 0.12	22.4 + 0.14	21.6 + 0.13	*P* <.001
Sex						
Female	54.4%	56.5%	39.6%	64.0%	50.2%	*P* <.001
Male	45.6%	43.5%	60.4%	36.1%	49.8%	
Ethnicity						
Asian	26.0%	27.3%	23.2%	18.0%	26.2%	*P* <.001
White	24.3%	24.1%	18.2%	35.6%	24.4%	
NHPI	21.2%	19.9%	24.4%	22.3%	24.0%	
Filipino	17.9%	17.5%	24.7%	11.6%	18.5%	
Other	10.6%	11.2%	9.6%	12.5%	7.0%	
Annual Household Income						
Low (<$60K/yr)	40.1%	39.6%	42.9%	41.9%	40.3%	*P* =.126
Medium ($60 000-$99 999)	29.0%	29.2%	29.8%	21.8%	31.7%	
High (>$100K/yr)	30.9%	31.3%	27.3%	36.2%	28.0%	
Depressive Symptoms	38.5%	37.8%	41.4%	57.0%	58.0%	*P* <.001
Anxiety Symptoms	25.5%	23.2%	22.7%	35.6%	37.2%	*P* <.001
High Impulsivity	52.6%	48.6%	54.6%	61.2%	69.7%	*P* <.001

SD = standard deviation, NHPI = Native Hawaiian or Pacific Islander

smoking or e-cigarette use, depending on the outcome (ie, cigarette smoking for e-cigarette use outcome and vice-versa). Interaction effects of impulsivity on the associations between the mental health symptoms and cigarette and e-cigarette use were tested using GLMs as well. All continuous variables used in the regression analysis were standardized, centering the mean at zero. After standardization, Depression X Impulsivity and Anxiety X Impulsivity interaction terms were created. Next, the interaction terms were entered as independent variables along with depression/anxiety, impulsivity, and demographic covariates, with cigarette/e-cigarette use as the dependent variable.

Results

Participants

Table 1 shows participants' (N = 2622) characteristics. The mean age of the participants was 21.2 (SD = 2.2). There were 1423 females and 1194 males who completed the survey. Ethnically, participants included 26% Asians, 24% Whites, 21% Native Hawaiian and Pacific Islanders (NHPI), 18% Filipinos and 11% Other ethnicities. Overall, women were slightly more represented than men (55% vs 45%). Forty-three percent of the students were enrolled in 2-year or community colleges. Almost half of the participants were Asian or Pacific Islanders.

Table 1 shows differences between demographic and mental health variables across the following groups: no use, cigarette-only use, e-cigarette-only use, and dual use. No use of either e-cigarettes or cigarettes was reported in 68% of the sample, while 13% reported use of e-cigarette only, 9% reported use of cigarette only, and 11% reported use of both. Cigarette-only smokers were slightly older than other groups (P <.001). E-cigarette-only users were more likely to be men and cigarette-only smokers were more likely to be women, compared to other groups (P<.001). Household income was significantly different across the 4 categories.

After adjusting for age, sex, ethnicity and annual household income, multivariable analyses found significant stepwise associations between the 4 smoking categories and depressive symptoms (P <.001), anxiety symptoms (P <.001) and high impulsivity (P <.001) (see Figure 1). After stratifying into low and high impulsivity groups, the associations between depressive and anxiety symptoms and the 4 categories were stronger in the high impulsivity group (see Figure 2).

Table 2 shows the results of the logistic regression analysis. There were statistically significant associations found between depression, anxiety, impulsivity and cigarette and e-cigarette use, after adjusting for demographic covariates. The associations

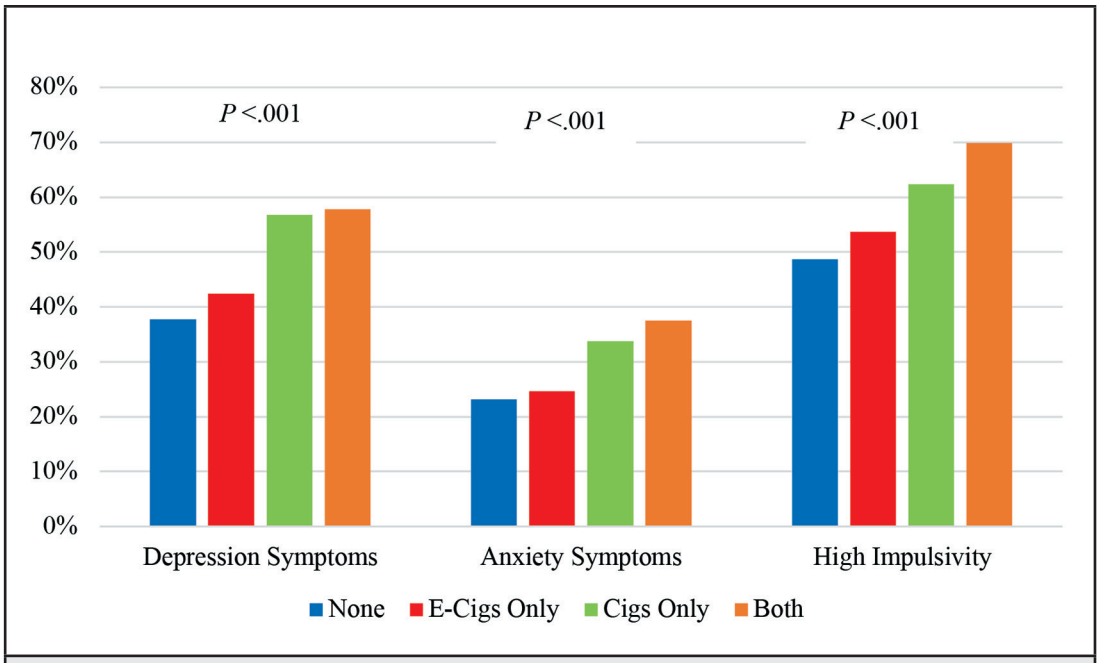


Figure 1. Adjusted Depression, Anxiety, and High Impulsivity by Tobacco Product Use[a]

[a] Adjusted for age, sex, ethnicity, and annual household income.

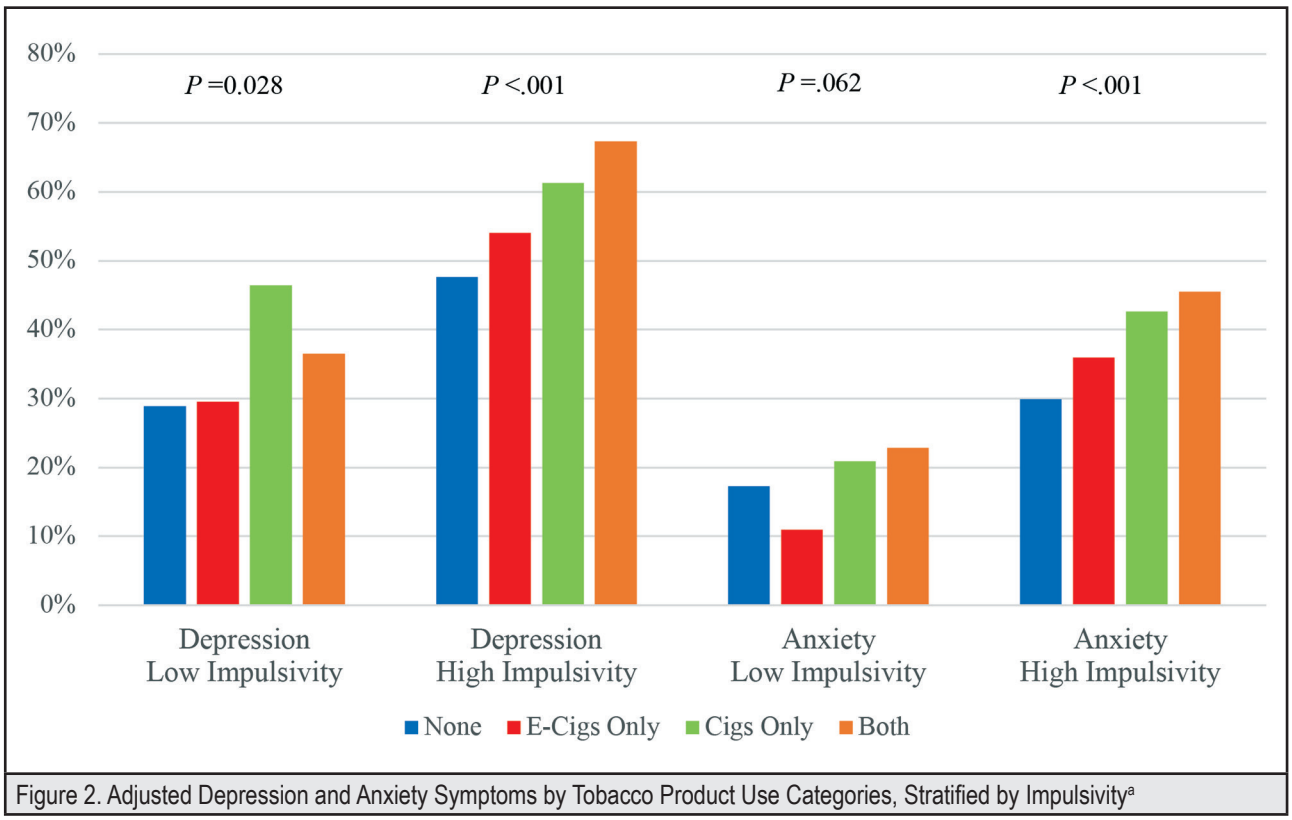


Figure 2. Adjusted Depression and Anxiety Symptoms by Tobacco Product Use Categories, Stratified by Impulsivity[a]

[a] Adjusted for age, sex, ethnicity, and annual household income.

of depression, anxiety, and impulsivity with cigarette use were stronger than with e-cigarette use. For example, a unit increase in depressive symptoms increased the odds of past-30-day cigarette smoking by 2.29 times compared with 1.34 times for past-30-day for e-cigarette use.

Table 3 shows the results of the interaction analysis. No statistically significant interaction effects of impulsivity on the associations between depression, anxiety, and past-30-day e-cigarette use were found. In addition, impulsivity was not found to moderate the effects of depression on past-30-day cigarette use. However, impulsivity was found to moderate the effects of anxiety on past-30-day cigarette smoking, such that the association between anxiety and cigarette smoking was stronger for those with higher impulsivity.

Table 2. Associations Between Depression, Anxiety, Impulsivity and Current Cigarette and E-cigarette Use (N = 2622)

	Cigarette smoking	E-cigarette use
	Adjusted Odds Ratio [95% Confidence Interval]	
Depressive Symptoms	2.29 (1.92-2.72)	1.34 (1.14-1.56)
Anxiety Symptoms	1.57 (1.39-1.78)	1.17 (1.05-1.31)
Impulsivity	1.51 (1.35-1.70)	1.38 (1.25-1.53)

Note. The regression models adjusted for age, sex, ethnicity, annual household income, and cigarette smoking or e-cigarette use (depending on the outcome variable).

Table 3. Interaction Effects of Impulsivity in the Association Between Depression, Anxiety, and Current Cigarette and E-cigarette Use (N = 2622)

		Cigarette	E-cigarette
		B (SE)	
Model 1			
	Depression	0.23 (0.04)***	0.08 (0.04)*
	Impulsivity	0.15 (0.03)***	0.13(0.04)***
	Depression X Impulsivity	0.04 (0.03)	0.05 (0.03)
Model 2			
	Anxiety	0.16 (0.04)***	0.04 (0.04)
	Impulsivity	0.17 (0.03)***	0.15 (0.04)***
	Anxiety X Impulsivity	0.06 (0.03)*	0.04 (0.03)

Note. * $P = .05$; ** $P < .01$, *** $P < .001$; The regression models adjusted for age, sex, ethnicity, annual household income, and cigarette smoking or e-cigarette use (depending on the outcome variable).

Discussion

The current findings are somewhat consistent with the existing literature. For example, a study among high school students found psychiatric co-morbidities among both cigarette-only and e-cigarette-only users.[39] Similarly, the French Constances cohort study found that depressive symptoms were associated with e-cigarette use in both cross-sectional and longitudinal analyses with a dose-dependent relationship.[31] A large study of 2460 adolescents (mean age at baseline 14.1 years), who had never previously used cigarettes or e-cigarettes found a bi-directional association between depressive symptoms and e-cigarette use. Those with higher depressive symptoms at baseline were more likely to start using cigarettes, e-cigarettes or both a year later. In addition, increase in depressive symptoms was associated with sustained use of e-cigarettes over 12 months' time.[40] However, another study of 5445 college students in Texas found that depressive symptoms predicted subsequent e-cigarette use, but e-cigarette use did not predict later increased depressive symptoms.[30] There are potential mechanisms to explain our findings. Nicotine use is believed to help cope with symptoms of depression and anxiety, and people with mental health conditions may choose to use nicotine for this reason. Higher impulsivity is an indicator of poor self-control and is associated with nicotine use behavior.[29]

The current study has many strengths. It was a large study and included use of both e-cigarettes and cigarettes among college students. The study included several ethnic groups that were representative of Hawai'i. Validated scales were used to measure depressive symptoms, anxiety symptoms, and impulsivity. Limitations of the current study are that the study is cross-sectional in design, so causal conclusions cannot be formed based on the statistically significant associations detected in the current data. Second, smoking behavior may be misclassified, because it was only documented over the past 30 days. Third, the study did not have access to longitudinal data about the negative effects on health of e-cigarette use or cigarette smoking. Finally, data were self-reported and were not verified against objective measures.

Future directions include a longitudinal replication of the current findings. Also needed are prospective studies on the negative outcomes of e-cigarette and cigarette use, especially among those with mental health symptoms. Currently, not much has been done in terms of e-cigarette use prevention. There is a need for e-cigarette use prevention programs and such programs need to address poor mental health symptoms. School-based smoking prevention programs have played a key role in reducing cigarette smoking prevalence among young people in the US over the past several decades.[41] The current data suggest that any school-based prevention program designed to address e-cigarette use may need to also address poor mental health symptoms. Our study suggests that smoking prevention education should target children and young adults, particularly those with high impulsivity scores.

Conflict of Interest

None of the authors identify a conflict of interest.

Acknowledgements

The first author (KM) would like to acknowledge the encouragement and help of Mr. Jay Hamura, science teacher at St. Andrew's Priory School, and her mentor Dr. Pokhrel and all the staff at the University of Hawai'i Cancer Center, that culminated in the completion of the current project. The current study was supported by funds from the National Cancer Institute (R01202277; R01228905).

Authors' Affiliation:
Population Sciences in the Pacific Program, University of Hawai'i Cancer Center, University of Hawai'i at Mānoa, Honolulu, HI

Corresponding Author:
Pallav Pokhrel PhD, MPH; University of Hawai'i Cancer Center, 701 Ilalo St., 4th Fl., Honolulu, HI 96813; Email: ppokhrel@cc.hawaii.edu

References

1. Park-Lee E, Ren C, Sawdey MD, et al. Notes from the field: e-cigarette use among middle and high school students - National Youth Tobacco Survey, United States, 2021. *MMWR Morb Mortal Wkly Rep*. 2021;70(39):1387-1389. doi.org/10.15585/mmwr.mm7039a4
2. US Department of Health and Human Services. The health consequences of smoking—50 years of progress. Centers for Disease Control and Prevention (CDC). Accessed October 17, 2020. https://www.cdc.gov/tobacco/data_statistics/sgr/50th-anniversary/index.htm.
3. Hartmann-Boyce J, McRobbie H, Lindson N, et al. Electronic cigarettes for smoking cessation. Cochrane Database Syst Rev. 2020:10(10), Cd010216. doi.org/10.1002/14651858.CD010216.pub4.
4. Centers for Disease Control and Prevention (CDC). (2020). Hawaii Behavioral Risk Factor Surveillance System (BRFSS). Accessed May 6, 2021. https://health.hawaii.gov/brfss/.
5. Tobacco use in Hawaii 2018. Truth Initiative website. Accessed July 27, 2019. https://truthinitiative.org/research-resources/smoking-region/tobacco-use-hawaii-2018.
6. Wang TW, Neff LJ, Park-Lee E, Ren C, Cullen KA, King BA. E-cigarette Use Among Middle and High School Students – United States, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(37):1310–1312.
7. Smoking and Tobacco Use: Youth and Tobacco Use. Centers for Disease Control and Prevention (CDC) website. Accessed July 27, 2019. https://www.cdc.gov/tobacco/data_statistics/fact_sheets/youth_data/tobacco_use/index.htm.
8. Pokhrel P, Lam TH, Pagano I, Kawamoto CT, Herzog TA. Young adult e-cigarette use outcome expectancies: Validity of a revised scale and a short scale. *Addict Behav.* 2018;78:193-199.
9. Pokhrel P, Herzog TA, Muranaka N, Fagan P. Young adult e-cigarette users' reasons for liking and not liking e-cigarettes: A qualitative study. *Psychol Health*. 2015;30(12):1450-69.
10. Schweitzer RJ, Wills TA, Tam E, Pagano I, Choi K. E-cigarette use and asthma in a multiethnic sample of adolescents. *Prev Med*. 2017;105:226-231.
11. Rowell TR, Tarran R. Will chronic e-cigarette use cause lung disease? *Am J Physiol Lung Cell Mol Physiol.* 2015;309(12):L1398-L1409.
12. Chen IL, Todd I, Fairclough LC. Immunological and pathological effects of electronic cigarettes. *Basic Clin Pharmacol Toxicol.* 2019;125(3):237-252.
13. Reidel B, Radicioni G, Clapp PW, et al. E-Cigarette Use Causes a Unique Immune Response in the Lung, Involving Increased Neutrophilic Activation and Altered Mucin Secretion. *Am J Respir Crit Care Med*. 2018;197(4):492-501.
14. Zhang G, Wang Z, Zhang K, et al. Safety Assessment of Electronic Cigarettes and Their Relationship with Cardiovascular Disease. *Int J Environ Res Public Health*. 2018; 15(1):75.
15. Meo SA, Ansary MA, Barayan FR, et al. Electronic Cigarettes: Impact on Lung Function and Fractional Exhaled Nitric Oxide Among Healthy Adults. *Am J Mens Health*. 2019; 13(1):1557988318806073.
16. Avino P, Scungio M, Stabile L, Cortellessa G, Buonanno G, Manigrasso M. Second-hand aerosol from tobacco and electronic cigarettes: Evaluation of the smoker emission rates and doses and lung cancer risk of passive smokers and vapers. *Sci Total Environ*. 2018;642:137-147.
17. Moritz ED, Zapata LB, Lekiachvili A, et al. Update: Characteristics of Patients in a National Outbreak of E-cigarette, or Vaping, Product Use-Associated Lung Injuries – United States, October 2019. *MMWR Morb Mortal Wkly Rep*. 2019;68(43):985-989.
18. Siegel DA, Jatlaoui TC, Koumans EH, et al. Update: Interim Guidance for Health Care Providers Evaluating and Caring for Patients with Suspected E-cigarette, or Vaping, Product Use Associated Lung Injury – United States, October 2019. *MMWR Morb Mortal Wkly Rep*. 2019;68(41):919-927.
19. Children's Mental Health – Anxiety and depression in children: Get the facts. Centers for Disease Control and Prevention (CDC) website. Accessed October 17, 2020. https://www.cdc.gov/childrensmentalhealth/features/anxiety-depression-children.html.
20. Ghandour RM, Sherman LJ, Vladutiu CJ, et al. Prevalence and Treatment of Depression, Anxiety, and Conduct Problems in U.S. Children. *J Pediatr* 2019;206:256-67.
21. 2020 Mental Health in America – Youth Data. MHA: Mental Health America website. Accessed October 17, 2020. https://mhanational.org/issues/2020/mental-health-america-youth-data#two.
22. Bierhoff J, Haardörfer R, Windle M, Berg CJ. Psychological Risk Factors for Alcohol, Cannabis, and Various Tobacco Use among Young Adults: A Longitudinal Analysis. *Subst Use Misuse*. 2019;54(8):1365-1375.
23. Tidey JW, Miller ME. Smoking cessation and reduction in people with chronic mental illness. *BMJ*. 2015;351:h4065.
24. Hefner KR, Sollazzo A, Mullaney S, Coker KL, Sofuoglu M. E-cigarettes, alcohol use, and mental health: Use and perceptions of e-cigarettes among college students, by alcohol use and mental health status. *Addict Behav.* 2019;91:12-20.
25. Cummins SE, Zhu SH, Tedeschi GJ, Gamst AC, Myers MG. Use of e-cigarettes by individuals with mental health conditions. *Tob* Control. 2014;23(Suppl 3):iii48-53.
26. Bourque J, Mendrek A, Dinh-Williams L, Potvin S. Neural circuitry of impulsivity in a cigarette craving paradigm. *Front Psychiatry*. 2013;4:67.
27. Grant JE, Lust K, Fridberg DJ, King AC, Chamberlain SR. E-Cigarette Use (Vaping) is Associated with Illicit Drug Use, Mental Health Problems, and Impulsivity in University Students. *Ann Clin Psychiatry*. 2019;31(1):27-35.
28. Soneji S, Barrington-Trimis JL, Wills TA, et al. Association Between Initial Use of e-Cigarettes and Subsequent Cigarette Smoking Among Adolescents and Young Adults: A Systematic Review and Meta-analysis. *JAMA Pediatr*. 2017;171(8):788-797.
29. Wills TA, Walker C, Mendoza D, Ainette MG. Behavioral and emotional self-control: relations to substance use in samples of middle and high school students. *Psychol Addict Behav*. 2006;20(3):265-78.
30. Bandiera FC, Loukas A, Li X, Wilkinson AV, Perry CL. Depressive Symptoms Predict Current E-Cigarette Use Among College Students in Texas. *Nicotine Tob Res.* 2017;19(9):1102-1106.
31. Wiernik E, Airagnes G, Lequy E, et al. Electronic cigarette use is associated with depressive symptoms among smokers and former smokers: Cross-sectional and longitudinal findings from the Constances cohort. *Addict Behav.* 2019;90:85-91.
32. The Centers for Disease Control and Prevention (CDC). Youth Risk Behavior Surveillance System (YRBSS). Accessed May 6, 2021. https://www.cdc.gov/healthyyouth/data/yrbs/index.htm.
33. Radloff LS. The CES-D scale: A self report depression scale for research in the general population. *Applied Psychological Measurements*. 1977(1)1:385-401.
34. Vilagut G, Forero CG, Barbaglia G, Alonso J. Screening for Depression in the General Population with the Center for Epidemiologic Studies Depression (CES-D): A Systematic Review with Meta-Analysis. *PLoS One*. 2016;11(5):e0155431.
35. Weissman MM, Sholomskas D, Pottenger M, Prusoff BA, Locke BZ. Assessing depressive symptoms in five psychiatric populations: a validation study. *Am J Epidemiol*. 1977;106(3):203-14.
36. pitzer RL, Kroenke K, Williams JBW, Löwe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. *Arch Intern Med.* 2006;166(10):1092-1097.
37. Kendall PC, Wilcox LE. Self-control in children: Development of a rating scale. *Journal of Consulting and Clinical Psychology*, 1979;47(6):1020–1029.
38. SAS software. Version 9.4, of the SAS system for Windows. Cary, NC, USA: SAS Institute Inc.
39. Leventhal AM, Strong DR, Sussman S, et al. Psychiatric comorbidity in Adolescent Electronic and Conventional Cigarette Use. *J Psychiatr Res.* 2016;73:71-78.
40. Lechner WV, Janssen T, Kahler CW, Audrain-McGovern J, Leventhal AM. Bi-directional associations of electronic and combustible cigarette use onset patterns with depressive symptoms in adolescents. *Prev Med*. 2017;96:73-78.
41. Lantz PM, Jacobson PD, Warner KE, et al. Investing in youth tobacco control: a review of smoking prevention and control strategies. *Tob Control*. 2000;9(1):47-63.

A Scoping Review on Gestational Diabetes in Hawai'i: A "Window of Opportunity" to Address Intergenerational Risk for Type 2 Diabetes Mellitus

Megan Y. Kawamura; Marjorie K. Mau MD, MS; Reni Soon MD, MPH; Kelly Yamasato MD

Abstract

The health of women over the entire span of their reproductive years is crucial — beginning in adolescence and extending through the postpartum period. This paper provides a scoping review of the relevant literature on risk factors for gestational diabetes mellitus (GDM) and progression from GDM to type 2 diabetes mellitus (T2DM), particularly among women of Native Hawaiian and Pacific Islander (NHPI) and Asian racial/ethnic backgrounds in Hawai'i, using the PubMed database (July 2010 to July 2020). NHPI and Asian populations have a greater likelihood of developing GDM compared to their White counterparts. Risk factors such as advanced maternal age, high maternal body mass index, and lack of education about GDM have varying levels of impact on GDM diagnosis between ethnic populations. Mothers who have a history of GDM are also at higher risk of developing T2DM. Common risk factors include greater increase in postpartum body mass index and use of diabetes medications during pregnancy. However, few studies investigate the progression from GDM to T2DM in Hawai'i's Asian and NHPI populations, and no studies present upstream preconception care programs to prevent an initial GDM diagnosis among Hawai'i's women. Thus, updated reports are necessary for optimal early interventions to prevent the onset of GDM and break the intergenerational cycle of increased susceptibility to T2DM and GDM in both mother and child. Further attention to the development of culturally sensitive interventions may reduce disparities in GDM and improve the health for all affected by this condition.

Keywords

gestational diabetes mellitus, Native Hawaiian or Pacific Islander, Asian, minority populations, health disparities, intergenerational prevention, scoping review

Acronyms

BMI = body mass index
GDM = gestational diabetes mellitus
NH = Native Hawaiian
NHPI = Native Hawaiian and Pacific Islander
PI = Pacific Islander
T2DM = Type 2 Diabetes Mellitus

Introduction

Gestational diabetes mellitus (GDM) refers to "any degree of glucose intolerance with onset or first recognition during pregnancy"[1] and increases the risk of adverse pregnancy outcomes for both mother (ie, preeclampsia, cesarean delivery, preterm delivery) and neonate (ie, shoulder dystocia, macrosomia, neonatal hypoglycemia, and birth trauma).[2–4] These issues are of increasing importance as GDM affects 5% to 9% of pregnancies in the United States (US), with the prevalence steadily increasing over the last 20 years.[5,6] As GDM incidence and prevalence increase, the racial/ethnic disparities gap continues to widen between Whites and non-White minority women diagnosed with GDM. Previous studies have shown that American Indians, Native Hawaiians (NH), Hispanics, Asians and African Americans experience higher rates of GDM compared to White women.[7]

GDM is also of particular concern because it is associated with an increased risk of developing type 2 diabetes mellitus (T2DM), obesity, and other adverse metabolic effects on metabolism later in a mother's lifetime.[8–10] T2DM is a major health concern in the US, especially among racial/ethnic groups such as Native Hawaiians and Pacific Islanders (NHPI) and Asians. In Hawai'i, 27% of the population self-identifies as NHPI and 24.2% as multiracial. Among Asians in Hawai'i, 37.6% self-identify as Asian only, although the state reports 56.4% of its 1.4 million residents are of diverse Asian backgrounds.[11] From 2017 to 2019, 14.4% of NH, 18.5% of Pacific Islander (PI), and 8.4%-13.0% of adults from various Asian races in Hawai'i reported a diagnosis of T2DM, and this prevalence has continued to increase.[12]

Furthermore, ample epidemiologic and experimental evidence supports the phenomenon of "fetal programming," in which the intrauterine environment predisposes the fetus to adult onset cardiometabolic conditions later in life.[13-16] Infants born to mothers with GDM are themselves at increased risk for T2DM as adults, in part due to epigenetic changes induced by the diabetic intrauterine environment.[13–16] Thus, existing health disparities in GDM in the current generation may exacerbate T2DM disparities in future generations. This lends urgency and importance to the prevention of GDM in today's women of reproductive age.

Given the increasing risk of both GDM and T2DM among racial/ethnic minority populations as well as the increased risk for T2DM in the offspring of pregnancies complicated by GDM, the need to understand how best to stop the intergenerational risk for developing GDM, and hence T2DM, is imperative to break this cycle (Figure 1). Thus, the purpose of this paper was to conduct a scoping review to evaluate the current literature relevant to Hawai'i's multi-ethnic women and adolescent females of NHPI and Asian (Chinese, Japanese, Korean, Vietnamese, Filipino) ethnic groups who are at highest risk of developing GDM and subsequent T2DM.

Methods

Database searches were performed in PubMed for the time period between July 1, 2010 and July 1, 2020 for English language publications. Two authors independently reviewed all articles' abstracts and discussed the selection until consensus was reached,

The search was conducted with two primary areas of focus. The first search aimed to include literature on GDM risk and risk factors among Asian and NHPI women. The search terms used included *gestational diabetes* combined with the following terms using an AND function: *Hawai'i, Pacific Islander,* and *Asian.* Articles were excluded if they (1) were reviews of previous literature, (2) did not distinguish between pre-gestational and gestational diabetes, (3) were limited either to neonatal outcomes/populations other than Asians and/or NHPIs, or (4) included a population exclusively outside of the US. After review of all retrieved articles and application of exclusion criteria, a final selection of 15 peer-reviewed papers were included (Figure 2a).

The second portion of the search included literature on the progression of GDM to T2DM. The following search terms were used: *gestational diabetes, type 2 diabetes, progression, Hawai'i, Pacific Islander,* and *Asian* (Figure 2b). Articles were excluded if they (1) were reviews of previous literature, (2) did not address the progression between GDM and T2DM, or (3) included a population exclusively outside of the US. All retrieved articles were reviewed and exclusion criteria were applied, yielding a selection of 14 papers. Thus, a total of 29 articles were included in this scoping review.

Results

Studies on Risk for Developing GDM and Characteristics of GDM Pregnancies (Table 1A)

The 15 studies highlighted racial disparities in GDM as well as differing associations between GDM and risk factors among Asian and NHPI women compared to other racial groups. Key findings include the following:

Epidemiology and Racial/Ethnic Disparities (Table 1.A.1)

Multiple studies from varying cohorts within the US demonstrated increased risk of GDM among Asian women.[17–21] For example, one study found that GDM prevalence was higher in Asian American subgroups (Filipino: 19.0%, Asian Indian: 19.3%, Chinese: 15.3%, Korean: 12.9%, Vietnamese: 18.8%) compared with non-Hispanic Whites (7.0%).[20] Similar findings of increased rates of GDM among Asian women were present in a Los Angeles cohort.[17] Also, Hunsberger et al found that Asian women had a 16.4% prevalence of GDM while PI women had an 11.7% prevalence, both of which were increased compared to White women (6.0%).[21] However, it is important to note that such comparisons may be affected by different diagnostic criteria used to diagnose GDM and/or variable access to care. Among women in Hawai'i in 2013, Tsai et al found the highest GDM prevalence to be among Filipino women (13.1%) and NHPI women (12.1%), with lowest prevalence in White women (7.4%). Overall, Asian and PI women had a 50% increased odds of developing GDM compared to their White counterparts.[22] In 2015, Chang et al looked at PI subpopulations and found that NHs (9.3%), Micronesians (8.5%), Samoans (11.8%), and other PIs (13.7%) had higher rates of GDM compared to Whites (5.8%).[3] Such findings also demonstrate the heterogeneity even within Asian and PI populations and speak to the need to disaggregate ethnic groups from larger racial classifications, especially if there are substantial differences within racial classifications that can inform interventions targeted to specific cultures.

Clinical, Lifestyle, Nutrition, and Environmental Factors (Table 1.A.2-3)

Several studies identified common risk factors for developing GDM, including advanced maternal age, high pre-pregnancy body mass index (BMI), a history of a GDM pregnancy, and non-White race.[17,21–25]

Despite the commonality among GDM risk factors, differences between and within racial/ethnic groups were observed. For example, Pu et al found the effects of advanced maternal age to be more significant for non-Hispanic Whites and Hispanics compared to Asian Americans, suggesting that the pathophysiology of GDM might differ by racial/ethnic group.[20] Similarly, BMI was less predictive for GDM among Asians,[19] and overweight/obese BMI contributed less to GDM risk in Asian and PI women compared to other racial groups.[23–25] Conversely, an inverse association between maternal height and GDM risk was strongest in Asian women.[26] Another study found that individuals of Asian or PI ancestry have a higher susceptibility to pancreatic beta cell dysfunction when exposed to volatile organic compounds.[27]

Associations between immigration and acculturation and GDM risk have been investigated with conflicting results.[17,20,28–30] Pu et al found that Chinese and Filipino women born outside the US had a higher risk of developing GDM compared to their US-born counterparts,[20] and Chen et al also found increased GDM among Asian women with less acculturation.[17] Likewise, in a California cohort, Pacific Islander, Filipina, and Chinese women born outside the US had higher rates of GDM compared to those born in the US. However, in that same cohort, Japanese and Korean women born outside of the US had decreased risks of GDM compared to those who were born in the US.[28] Other cohorts have not found GDM rates to change with country of birth or markers of acculturation.[29,30] These inconsistencies highlight the complexity of the relationships between immigration, acculturation, and GDM. Immigration from various Asian and Pacific Island locations to Hawai'i, both historical and current, highlights the need for careful ongoing evaluation of GDM disparities.[20]

Studies on Risk for Developing T2DM following GDM Pregnancy (Table 1B)

Women with a history of GDM pregnancy are at an increased risk of developing T2DM later in life. A clear limitation of those findings is the unknown rates of T2DM among those who do not receive postpartum testing. Key findings from the 14 reviewed articles include the following:

Clinical, Lifestyle, and Metabolic Signatures (Table 1.B.1-3)

Risk factors for the subsequent diagnosis of T2DM after GDM include low intensity and short duration of lactation, earlier gestational age at GDM diagnosis, use of insulin or oral diabetes medications during pregnancy, higher pre-pregnancy BMI (>25 kg/m^2), advanced age, lower physical activity, higher dietary consumption of animal fat, greater intakes of total iron, lack of healthy lifestyle behaviors, adverse newborn outcomes, and greater postpartum BMI increase.[31–37] For example, the Diabetes and Women's Health cohort study found that women who gained greater than 5 kg (11 lbs) after a GDM pregnancy had a 43-times higher risk of developing T2DM compared to those gaining less than 5 kg (11 lbs).[6] Other risk factors included lipid dysmetabolism and the presence of metabolic signatures such as certain amino acids, medium-chain acylcarnitines, and reduced levels of sphingolipid metabolism.[38–41]

Racial/Ethnic Disparities (Table 1.B.4)

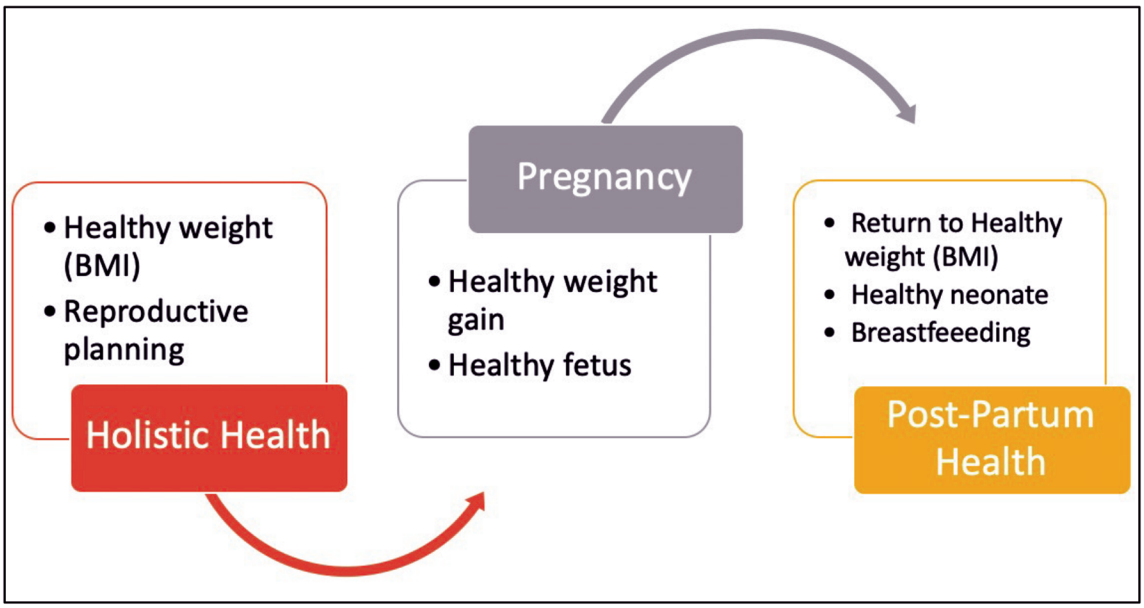
Racial/ethnic disparities have been observed in the development of T2DM after GDM. Gunderson et al reported that Hispanic (41%) and Asian (32%) women were at a higher risk for developing T2DM after a GDM pregnancy compared to non-Hispanic Whites (15%).[31] However, recent investigations regarding the progression from GDM to T2DM among Hawai'i's Asian and NHPI women were lacking.

Prevention Interventions and Postpartum Follow-up Care (Table 1.B.5)

GDM represents a strong risk factor for later development of T2DM. Despite the importance of screening, suboptimal follow-up prevents many women from obtaining T2DM screening and education.[42] Reasons for not obtaining postpartum T2DM screening include missed appointments, false assumptions about the low risk for T2DM, inconvenient or unpleasant tests, fear of a T2DM diagnosis, time constraints, and lack of physician awareness and communication.[38]

For those who do receive follow-up care, it was found that postpartum intervention implementation reduces the progression to T2DM. One study reported that diets consisting of fruits, vegetables, and low-fat dairy products, were associated with a 15-35% reduction in incidence of T2DM after GDM.[6] Other studies also found that intensive lifestyle interventions and metformin were highly effective in delaying and preventing subsequent T2DM.[10]

a) Holistic Health and Reproduction



b) Intergenerational risk of Gestational Diabetes Mellitus and Type 2 Diabetes Mellitus

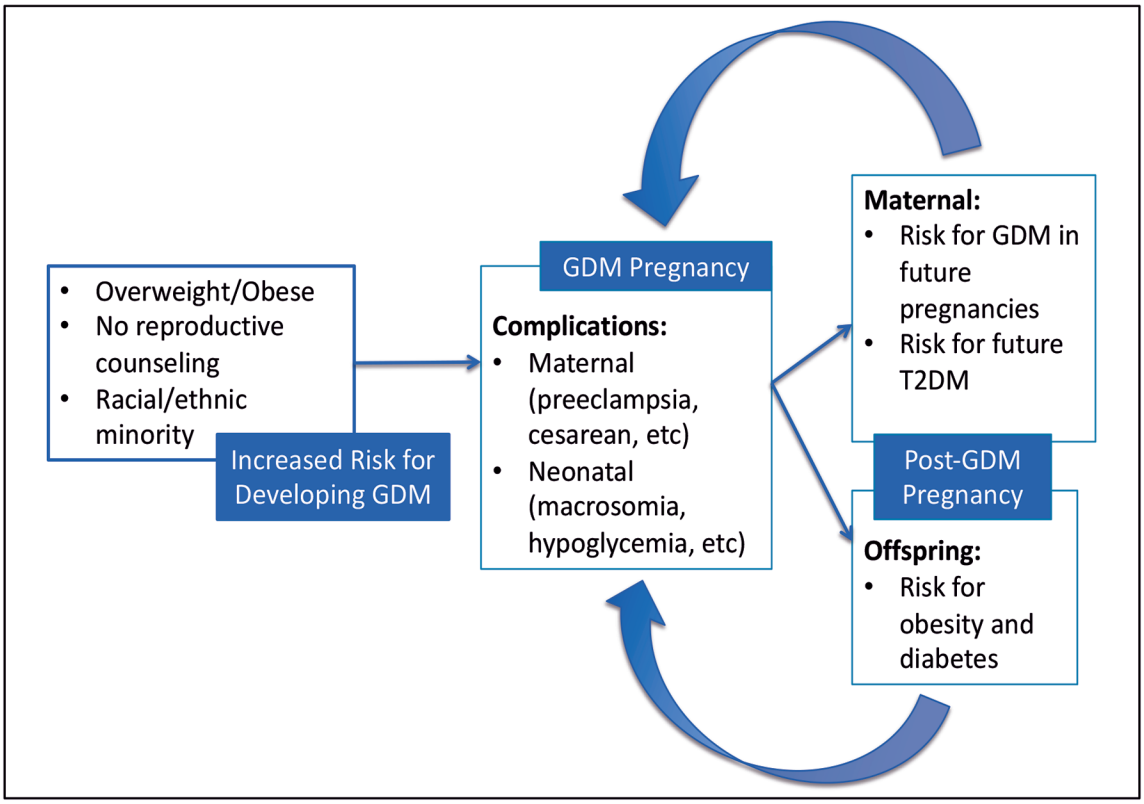


Figure 1. Proposed Concept of Holistic Health and Reproduction compared with Intergenerational Risk of Gestational Diabetes Mellitus for At-risk Women

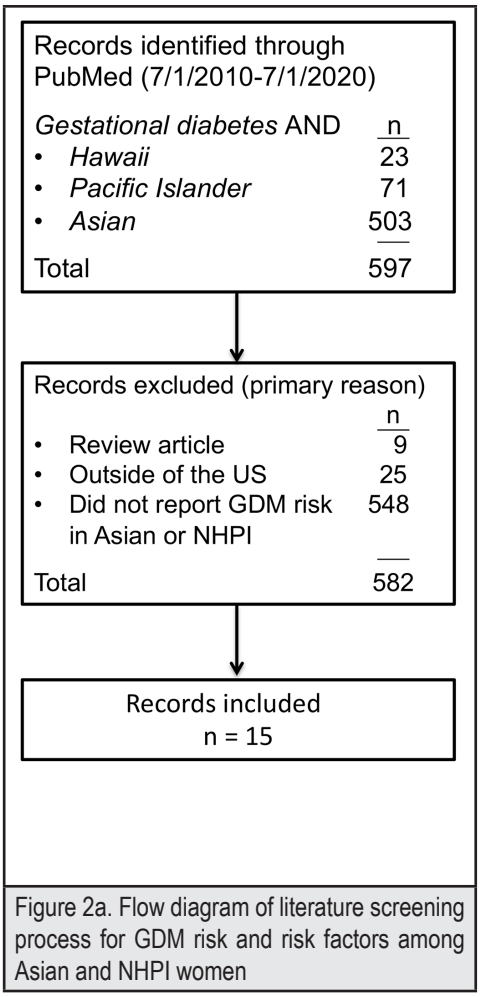


Figure 2a. Flow diagram of literature screening process for GDM risk and risk factors among Asian and NHPI women

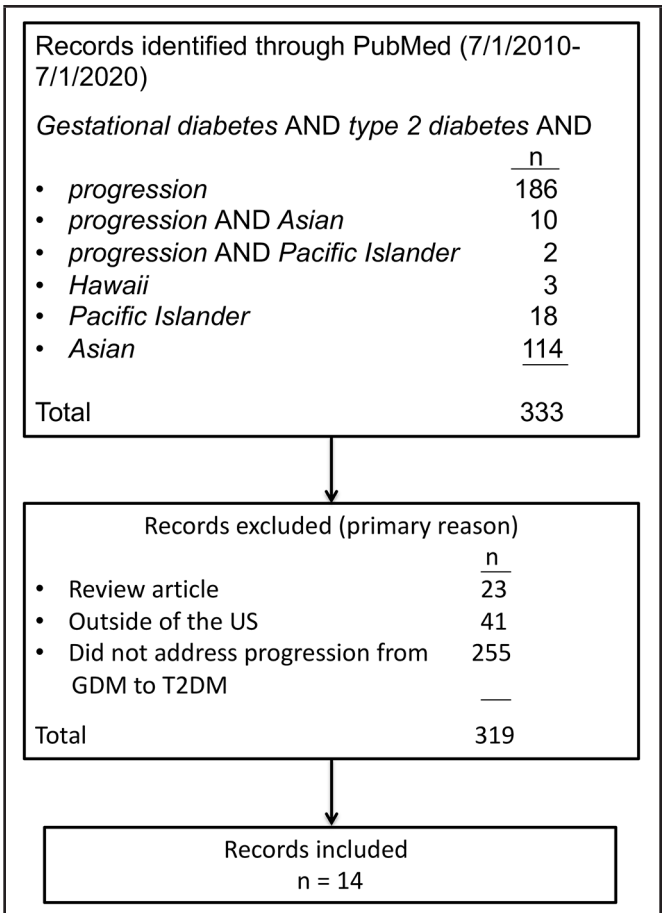


Figure 2b. Flow diagram of literature screening process for Progression of GDM to T2DM

Table 1. Summary of Scoping Review on Risk Associated with Developing Gestational Diabetes Mellitus and Subsequent Type 2 Diabetes Mellitus

Study Categories	Studies	Number of Participants	Study Time Period	Location	Purpose of Study	Methods	Key Findings Relevant to Hawai'i's Multi-ethnic Population
A) Studies on Risk for Developing GDM and Characteristics of GDM Pregnancies (n=15)							
1) Epidemiology and Racial/Ethnic Disparities	**Chang et al. (2015)**	n = 5,510 (Native Hawaiian=6,662, Micronesian=1,548, Samoan=897, Other Pacific Islanders=539)	2010-2011	Hawai'i	Quantify obstetric outcomes of Pacific Islander subgroups in Hawai'i	Retrospective cohort study	Outcome differences were observed between Pacific Islander subpopulations and when compared to White women. Of Pacific Islander subgroups, Micronesians had the highest risk of cesarean sections and Native Hawaiians had the highest risk of low-birthweight infants Samoans had a higher risk of macrosomia compared to Whites, while Native Hawaiians and Micronesians were significantly less likely to have an infant with macrosomia compared to Whites
	Chen et al. (2019)	n = 5,562	2007	Los Angeles, California	Assess GDM prevalence among Asian Americans and association with acculturation	Cross-sectional study	Compared to non-Hispanic White women, Asian women had a higher risk of GDM (OR 2.44 [95%CI 1.81-3.29]) Acculturation negatively associated with GDM
	Hunsberger et al. (2010)	n = 3,883 (API=617)	2004-2005	Oregon	Explore racial/ethnic disparities in the prevalence of GDM	Retrospective cohort study	Asian/Pacific Islander women (both normal and high BMI) had the highest prevalence of GDM (14.8%) among all women studied Asian women were more likely to have GDM compared to Pacific Islander women
	Liu et al. (2020)	16,258 (Asian n=620)	2010-2015	Detroit, Michigan	Investigate relationships between maternal race/ethnicity and age with GDM	Retrospective cohort study	Asian women had a significantly higher GDM risk compared to White women (OR 2.53 [95%CI 2.10-3.10]) Older maternal age increased GDM risk and affected risk interactively with race/ethnicity (smaller effect of age among African American compared to non-African American women)
	Pu et al. (2015)	n = 24,195 (Chinese=3,218), Filipino=1,088, Japanese=677, Korean=460, Vietnamese=460)	2007-2012	California	Assess racial/ethnic differences in risk factors for GDM	Retrospective cohort study	GDM was most prevalent among Asian American subgroups: Asian Indian (19.3%), Chinese (15.3%), Filipino (19.0%), Korean (12.9%) and Vietnamese (18.8%) Family history and foreign-born status were important risk factors for Asian subgroups Risk attributed to advanced maternal age was modified by race/ethnicity
	Tsai et al. (2013)	n = 4,735 (Native Hawaiian/Pacific Islander=20,851, Filipina=9,922, Other Asian=9,225)	2009-2011	Hawai'i	Examine the relationship between ethnicity, GDM, and macrosomia in Hawai'i	Retrospective cohort study	Overall prevalence of GDM in Hawai'i was 10.9% The highest prevalence of GDM was in Filipina (13.1%) and Native Hawaiian/Pacific Islander (12.1%) women, while the lowest prevalence was in White women (7.4%) Asian/Pacific Islander women had a 50% increased odds of having GDM compared to White women

Table 1. Summary of Scoping Review on Risk Associated with Developing Gestational Diabetes Mellitus and Subsequent Type 2 Diabetes Mellitus

Study Categories	Studies	Number of Participants	Study Time Period	Location	Purpose of Study	Methods	Key Findings Relevant to Hawai'i's Multi-ethnic Population
2) Clinical Risk Factors	**Brite et al. (2014)**	n=135,861 (Asian=4,190)	2002-2008	Consortium on Safe Labor study (11 states and District of Columbia)	Evaluate associations between maternal height and GDM across racial/ethnic groups	Retrospective cohort study	Maternal height was inversely correlated to GDM risk, with the strongest association among Asians
	Hedderson et al. (2012)	n=123,040 (Asian=18,497, Filipina=9,636)	1995-2006	Northern California	Examine associations between GDM and BMI by racial/ethnic groups	Retrospective cohort study	Asian and Filipina women had an increased risk of GDM at a lower BMI compared to non-Hispanic White and African American women
	Kim et al. (2012)	n=656,925 (API=16,799)	2004-2007	Florida	Evaluate percentages of GDM attributable to overweight and obesity across racial/ethnic groups	Cross-sectional study	API women had a higher GDM prevalence (9.9% vs 4.0% for Black women). API women had the lowest percentage of GDM attributable to overweight and obesity compared to other racial groups
	Kim et al. (2013)	n=1,228,265 (API=168,933)	2007-2009	California	Evaluate percentages of GDM attributable to overweight and obesity across racial/ethnic groups	Cross-sectional study	API women had a higher GDM prevalence (11.9% vs 5.4% for White women). API women had the lowest percentage of GDM attributable to overweight and obesity compared to other racial groups
	Shah et al. (2011)	24,325 (Asian n=7,404)	1988-2001	San Francisco, California	Examine body mass index as a screening tool for GDM among racial/ethnic groups	Retrospective cohort study	Asian women had increased risk of GDM compared to White women regardless of body mass index Body mass index had the poorest sensitivity for GDM among Asian women compared to other racial groups

Table 1. Summary of Scoping Review on Risk Associated with Developing Gestational Diabetes Mellitus and Subsequent Type 2 Diabetes Mellitus

Study Categories	Studies	Number of Participants	Study Time Period	Location	Purpose of Study	Methods	Key Findings Relevant to Hawai'i's Multi-ethnic Population
3) Lifestyle, Nutrition, and Environmental Factors	**Hedderson et al. (2010)**	n=216,089	1995-2004	Northern California	Compare GDM risk by country of birth (US or non-US) among racial/ethnic groups	Retrospective cohort study	Being born outside of the US associated with increased risk of GDM among Filipina, Chinese, and Pacific Islander women, but a decreased risk of GDM in Japanese and Korean women
	Janevic et al. (2014)	n=89,703 (Chinese=10,603)	2001-2002	New York City	Evaluate associations between living in an ethnic enclave and risk for GDM	Cross-sectional study	Among Chinese women, no association between living in an ethnic enclave and GDM risk
	Ramadhani et al. (2011)	n=6,463 (API=198)	1997-2005	National Birth Defects Prevention Study (10 states in the US)	Examine differences in pregnancy-related risk factors among US versus non-US born women across racial/ethnic groups	Retrospective cohort study	No difference in GDM between US and non-US born API women
	Williams et al. (2019)	n=220,065 (API=9,068)	2002-2008	Consortium on Safe Labor study (11 states and District of Columbia)	Understand racial/ethnic disparities in GDM by looking at exposure to volatile organic compounds (VOCs)	Retrospective cohort study	Exposure to high VOCs was associated with increased odds of GDM among whites and Asian/Pacific Islanders GDM risk was significantly higher for Asian/Pacific Islanders compared to whites for most compounds
B) Studies on Risk for Developing T2DM following GDM pregnancy (n=14)							
1) Clinical Factors	**Bao et al. (2015)**	n=1,695	1991-2001	Nurse's Health Study II cohort (14 states in US)	Examine how adiposity and weight change influences the long-term risk of developing T2DM after GDM	Prospective cohort study	Baseline BMI, most recent BMI, and weight gain after GDM pregnancy were significantly and positively associated with risk of progression from GDM to T2DM
	Gunderson et al. (2014)	n=1,007 (Asian=362)	2008-2011	SWIFT cohort; Northern California: Asian, Non-Hispanic White, Non-Hispanic Black, Hispanic, Other	Investigate whether higher lactation intensity is related to more favorable blood lipids, lipoproteins, and adipokines after a GDM pregnancy	Prospective cohort study	Higher lactation intensity was associated with more favorable biomarkers for T2DM except for lower plasma adiponectin after GDM delivery
	Zhang et al. (2019)	n=7,759	2012-2016	Denmark and US	Investigate the genetic and environmental factors that are implicated in the progression from GDM to T2DM	Hybrid Prospective cohort study combined with existing data	Progression from GDM to T2DM ranged from 23.1% to 27.2% of the study population Women with a history of GDM have a greater risk of hypertension and cardiovascular disease A healthful diet, lifestyle factors, and weight control correlated with a lower risk of T2DM, hypertension, and cardiovascular disease

Table 1. Summary of Scoping Review on Risk Associated with Developing Gestational Diabetes Mellitus and Subsequent Type 2 Diabetes Mellitus

Study Categories	Studies	Number of Participants	Study Time Period	Location	Purpose of Study	Methods	Key Findings Relevant to Hawai'i's Multi-ethnic Population
2) Lifestyle Factors	**Allalou et al. (2016)**	n=1,035 (Asian=340)	2008-2011	Non-Hispanic White, Non-Hispanic Black, Hispanic, Asian, Other	Identify early diagnostic biomarkers to predict risk and etiology of developing T2DM following GDM	Prospective cohort study	Several amino acids and all hexose sugars play important roles in T2DM development and impaired fasting glucose levels Women who developed T2DM had a more T2DM-like metabolite profile within 6-9 weeks postpartum and were more likely to have been treated with insulin or oral medication during pregnancy
	Bao et al. (2014)	n=4,554	1991-2007	Nurse's Health Study II cohort (14 states in US)	Examine the role of physical activity and sedentary behaviors in the progression from GDM to T2DM	Prospective cohort study	Increased physical activity may lower the risk of progression from GDM to T2DM
	Bao, Chavarro et al. (2016)	n=3976	1991-2009	Nurse's Health Study II cohort (14 states in US)	Examine the association of habitual iron intake with long-term risk of T2DM among women with previous GDM	Prospective cohort study	Greater intakes of total iron, dietary heme iron, dietary heme iron and supplemental iron were associated with increased risk for T2DM among women with a history of GDM
	Bao, Li et al. (2016)	n=4,502	1991-2011	Nurse's Health Study II cohort (14 states in US)	Examine the long-term effects of a low-carbohydrate diet on GDM to T2DM progression	Prospective Cohort Study	Low-carbohydrate diet with high protein and fat intake from animal-source foods is associated with higher risk of T2DM, while a low-carbohydrate diet with high protein and fat intake from plant-source foods is not significantly associated with risk of T2DM
	Brown et al. (2016)	n=1,463 (Chinese=168, Filipina=165, South Asian=144, Other Asian=153)	2011-2013	Northern California (Black, Latina, Non-Hispanic white, Chinese, Filipina, South Asian, Other Asian)	Examine whether strength of attachment to one's ethnic group could account for variation in lifestyle behaviors in women with previous GDM who are at high risk for T2DM	Cross-sectional study	Ethnic group attachment is associated with certain lifestyle behaviors that may promote behaviors associated with risk of developing T2DM

Table 1. Summary of Scoping Review on Risk Associated with Developing Gestational Diabetes Mellitus and Subsequent Type 2 Diabetes Mellitus

Study Categories	Studies	Number of Participants	Study Time Period	Location	Purpose of Study	Methods	Key Findings Relevant to Hawai'i's Multi-ethnic Population
3) Metabolic Signatures	**Batchuluun et al. (2018)**	n=24	Not specified	SWIFT cohort; Northern California: Asian, Non-Hispanic White, Non-Hispanic Black, Hispanic, Other	Investigate the link between acylC species and ß-cell dysfunction / onset of diabetes after GDM	Prospective cohort study	Serum medium-chain (M)-acylCs are associated with GDM and early TD2M onset, which directly impairs ß-cell function
	Khan et al. (2019)	n=1,035 (Asian=362)	2008-2011	SWIFT cohort; Northern California: Asian, Non-Hispanic White, Non-Hispanic Black, Hispanic, Other	Identify a predictive signature and early-stage pathophysiology of the transition from GDM to TD2M	Prospective cohort study	Predictive signature of reduced sphingolipids is associated with the pathophysiology of transition from GDM to T2DM
	Lai et al. (2020)	n=658 (Asian=196)	2008-2011	California: White, Black, Asian, Hispanic	Further the understanding of the pathology underlying the transition from GDM to T2DM	Nested case-control study	Amino acid and lipid dysmetabolism among women with a history of GDM can serve as a metabolic signature to predict the transition from GDM to T2DM in the early postpartum period
4) Racial/ Ethnic Disparities	**Gunderson et al. (2015)**	n=1,035 (Asian=362)	2008-2011	SWIFT cohort; Northern California: Asian, Non-Hispanic White, Non-Hispanic Black, Hispanic, Other	Evaluate lactation and 2-year incidence of T2DM after GDM pregnancy	Prospective observational cohort study	Lower lactation intensity and shorter duration; Hispanic/ Asian ethnicity, adverse newborn outcomes, use of insulin or oral medications during pregnancy, and higher dietary consumption of animal fat were associated with higher 2-year incidences of T2DM following a GDM pregnancy
5) Prevention Interventions and Postpartum Follow-up Care	**Aroda et al. (2015)**	n=350 (GDM) n=1,416 (no GDM)	1996-2009	Caucasian, African American, Hispanic, American Indian, and Asian American (n=47)	Evaluate the impacts of Intensive Lifestyle (ILS) and metformin interventions in women with and without a history of GDM using Diabetes Prevention Program (DPP) cohort	Randomized controlled clinical trial with observational follow-up	Among women with a history of GDM, both lifestyle and metformin interventions were effective in reducing the progression to diabetes over a 10-year period Among women without a history of GDM, lifestyle interventions only reduced the progression to T2DM
	Bernstein et al. (2019)	n=12,622 (Asian=123/1,091 women who conceived within 3 years of index pregnancy)	2006-2012	United States; Asian, Black, Hispanic, White	Assess the impact of GDM recurrence and/or delivery interval on follow-up care and T2DM onset	Secondary analysis	GDM severity in the index pregnancy was a strong predictor of subsequent T2DM onset Regardless of interval between deliveries, GDM reoccurs in 50% of subsequent pregnancies A short interval (<1 year, compared to >2 years) between the initial GDM delivery and subsequent pregnancy increased the likelihood of early onset T2DM, suggesting the importance of contraceptive counseling after a GDM pregnancy

Discussion

This scoping review confirms the disproportionate burden of risk factors leading to GDM or subsequent development of T2DM in NHPIs and Asians. These findings are supported by other studies in the literature, which demonstrate that GDM disproportionately affects Asian, African American, and Hispanic women compared to White women, and that the risk for developing GDM is 3-fold higher for Asian women: a trend that increases exponentially with increasing BMI.[4,43–45]

In addition to the 2 studies in this review that investigated GDM prevalence among Asian and NHPI populations in Hawai'i,[3,22] the most recent PRAMS data reported that 14.4% of new mothers in Hawai'i self-reported a GDM diagnosis in 2015, including 27.1% of Samoan and 20.2% of Filipino mothers, compared to 6.6% of White mothers. This review demonstrates the growing number of pregnancies complicated by GDM in Hawai'i, which is up from 4.8% in 1995. Work done prior to this scoping review found similar racial/ethnic disparities in GDM prevalence.[45] This further highlights the longstanding disparities in GDM prevalence that are still present today.

The time before and during pregnancy is an important time in a woman's life to prevent an initial GDM diagnosis, or to mitigate the risk of a future T2DM diagnosis for both herself and her offspring.[16,46] A substantial number of women, especially those of high-risk racial/ethnic groups, are unaware of the risk factors that could lead to the development of GDM and subsequent T2DM. For example, one study showed that 42% of a cohort of Samoan women were either unsure or not aware that diabetes could first occur during pregnancy. Furthermore, only 25% of participants identified pre-pregnancy obesity as a risk factor for GDM, which was the most widely identified risk factor in the study.[46] Another study interviewed American Indian and Alaska Native women who stated they wished they had been aware of the risk factors for GDM prior to pregnancy. Participants also voiced that intervention programs should be cognizant of cultural preferences when encouraging diet and lifestyle modifications.[47]

Therefore, culturally appropriate preconception planning programs are important to provide education counseling to women of reproductive age who may face language barriers when seeking reproductive health guidance.[5,8,9,47] Populations that may benefit from such programs include immigrants to higher-income countries, who are traditionally underweight or of normal weight, yet have higher rates of obesity and thus are at increased risk of developing GDM.[20,43,48,49] For example, a program for a disadvantaged Mexican-American cohort partnered coaches with diabetic patients based on language and ethnicity. These coaches helped to promote patient engagement during medical appointments.[9] Other studies proposed and implemented programs that educated women about GDM, GDM-associated risk factors, reproductive health, nutrition label interpretation, and how to include diabetes care amidst family and social situations.[8,9,28]

Prior work has reported success in preventative interventions for GDM during pregnancy. One study of high-risk Finnish women in early pregnancy using a lifestyle intervention was shown to reduce the development of GDM by 39%.[50] In addition, 2 meta-analyses found physical activity programs in pregnancy reduce the development of GDM.[51,52] While not all preventative interventions demonstrated such positive results,[16] these encouraging data suggest that modifiable risk factors can be effectively addressed to reduce GDM. Thus, based on our review findings highlighting disparities and challenges regarding GDM particular to NHPI and Asian women, preventative interventions targeted to these high-risk groups are warranted.

Because a recent meta-analysis found that women with previous GDM have a 10-fold increased risk of developing T2DM compared to women without a history of GDM,[53] and the prevalence of T2DM following GDM ranged from 26% to 36% with the risk of T2DM increasing linearly by 10% every 10 years in other cohorts, the necessity to manage care after an initial GDM diagnosis is critical to avoid long-term health complications.[54,55] A common theme across other reviews shows that early and consistent postpartum screening for T2DM plays an essential role in delaying and preventing the onset of T2DM after GDM.[56] However, similar to the reviewed literature, other sources cite inadequate GDM screening resources and inadequate training for staff, difficulty scheduling appointments or tests, and family-related practicalities as reasons why patients are unable to receive proper follow-up screening.[43,57]

While various risk factors have been established for the progression of GDM to T2DM, few studies focus on Asian and NHPI women, particularly in Hawai'i. As previous studies showed that PIs had the highest need for insulin to treat GDM, and the use of insulin, as a marker of greater hyperglycemia, is associated with a 3.5 times higher risk for postpartum T2DM. Similar investigation of disparities in other risk factors would offer the opportunity to develop a tailored-approach to preventative care for high-risk populations.[49]

Study Limitations

There were several common limitations that posed difficulties in reviewing and interpreting the published literature. First, inconsistent criteria used to clinically diagnose GDM hindered comparisons between, and possibly even within, cohorts.[17–21] GDM risk factors may also vary depending on the criteria used to diagnose the condition.

In addition, due to the large number of multiracial women in Hawai'i, classifying individuals into a single racial/ethnic group is challenging. Aggregating racial/ethnic groups and subgroups

may assist in classification, however, heterogeneity within racial/ethnic groups may obscure important differences between ethnic groups that are clinically relevant.[3,20–22]

Finally, many of the studies relied on retrospective data, such as birth certificate data, that may underestimate GDM prevalence and lack important variables.[3] On the other hand, GDM diagnoses in women prior to 20 weeks' gestation suggest the presence of pre-existing undiagnosed diabetes that was only identified when tested during pregnancy, thereby overestimating true GDM prevalence.[3] Other studies also used self-report data for variables such as GDM, BMI, and ethnicity, which may also be subject to bias.[22]

Conclusion

This review shows that there is a paucity of recent literature on the ethnic disparities in GDM and subsequent development of T2DM, particularly for Hawai'i's Asian and NHPI populations, despite these populations' known increased risk for GDM. Given the relationships between GDM, subsequent T2DM, and increased adult-onset metabolic disease in offspring exposed to in-utero GDM/T2DM, these disparities are likely to worsen without intervention. Periodic reviews of present disparities and the healthcare system's response to the increase of GDM and T2DM are necessary to help design upstream ethnic-specific intervention and education programs in order to stop the perpetual intergenerational cycle of GDM and T2DM in Asian and NHPI populations. Identifying high-risk women prior to and early in pregnancy offers unique advantages during a "window of opportunity" in women's reproductive lifecycles to implement interventions and educational programs aimed at healthy lifestyle behaviors that may reduce the risk of GDM and subsequent T2DM.

Future studies should also look at individuals who identify with a particular mix of races/ethnicities that independently are at increased risk for GDM or subsequent T2DM. This would provide a more accurate representation of Hawai'i's multi-ethnic population and could inform the development of ethnic-specific approaches to dietary preferences and cultural-based physical activities. In addition, it is critical to establish consistent screening with standard diagnostic criteria to better detect and compare the development of GDM in vulnerable populations.[5]

Lastly, several risk factors for GDM were shown to vary by race/ethnicity, such as high BMI and maternal age. Future studies should continue to investigate other modifiable and health system risk factors, such as follow-up screening and post-partum care of GDM pregnant mothers aimed at reducing the progression from GDM to T2DM that may vary between populations.

Conflict of Interest

None of the authors identify a conflict of interest.

Acknowledgements

This paper was supported, in part, by the Research Division, Department of Native Hawaiian Health (MKM, S21 MD 000228). The authors would like to thank Ms. Kim Spencer-Tolentino for bibliographic support and Ms. Mona-Ann Cardejon for coordination support.

Authors' Affiliations:
- Department of Native Hawaiian Health Summer 2020 Research Intern, John A. Burns School of Medicine, University of Hawai'i at Mānoa, Honolulu, HI (MYK)
- Department of Native Hawaiian Health, John A. Burns School of Medicine, University of Hawai'i at Mānoa, Honolulu, HI (MKM)
- Department of Obstetrics, Gynecology and Women's Health, John A. Burns School of Medicine, University of Hawai'i at Mānoa, Honolulu, HI (RS, KY)

Corresponding Author:
Marjorie K. Mau MD, MS; Email: mmau@hawaii.edu

References

1. American Diabetes Association. Diagnosis and classification of diabetes mellitus. *Diabetes Care*. 2012;35 Suppl 1(Suppl 1):S64-71. doi:10.2337/dc12-s064
2. Sugiyama MS, Cash HL, Roseveare C, Reklai R, Basilius K, Madraisau S. Assessment of gestational diabetes and associated risk factors and outcomes in the pacific island nation of Palau. *Matern Child Health J*. 2017;21(10):1961-1966. doi:10.1007/s10995-017-2313-0
3. Chang AL, Hurwitz E, Miyamura J, Kaneshiro B, Sentell T. Maternal risk factors and perinatal outcomes among pacific islander groups in Hawaii: a retrospective cohort study using statewide hospital data. *BMC Pregnancy Childbirth*. 2015;15:239. doi:10.1186/s12884-015-0671-4
4. Lee KW, Ching SM, Ramachandran V, et al. Prevalence and risk factors of gestational diabetes mellitus in Asia: a systematic review and meta-analysis. *BMC Pregnancy Childbirth*. 2018;18(1):494. doi:10.1186/s12884-018-2131-4
5. Deputy NP, Kim SY, Conrey EJ, Bullard KM. Prevalence and changes in preexisting diabetes and gestational diabetes among women who had a live birth - United States, 2012-2016. *MMWR Morb Mortal Wkly Rep*. 2018;67(43):1201-1207. doi:10.15585/mmwr.mm6743a2
6. Zhang C, Olsen SF, Hinkle SN, et al. Diabetes & Women's Health (DWH) Study: an observational study of long-term health consequences of gestational diabetes, their determinants and underlying mechanisms in the USA and Denmark. *BMJ Open*. 2019;9(4):e025517. doi:10.1136/bmjopen-2018-025517
7. Plows J, Stanley J, Baker P, Reynolds C, Vickers M. The pathophysiology of gestational diabetes mellitus. *Int J Mol Sci*. 2018;19(11):3342. doi:10.3390/ijms19113342
8. Moore K, Stotz S, Fischl A, et al. Pregnancy and gestational diabetes mellitus (GDM) in North American Indian adolescents and young adults (AYA): implications for girls and stopping GDM. *Curr Diab Rep*. 2019;19(11):113. doi:10.1007/s11892-019-1241-3
9. Daneshmand SS, Stortz S, Morrisey R, Faksh A. Bridging gaps and understanding disparities in gestational diabetes mellitus to improve perinatal outcomes. *Diabetes Spectrum*. 2019;32(4):317-323. doi:10.2337/ds19-0013
10. Aroda VR, Christophi CA, Edelstein SL, et al. The effect of lifestyle intervention and metformin on preventing or delaying diabetes among women with and without gestational diabetes: the Diabetes Prevention Program outcomes study 10-year follow-up. *J Clin Endocrinol Metab*. 2015;100(4):1646-1653. doi:10.1210/jc.2014-3761
11. US Census Bureau. Hawaii population characteristics 2019. Published online June 25, 2020. https://census.hawaii.gov/wp-content/uploads/2020/06/Hawaii-Population-Characteristics-2019.pdf
12. Hawaii State Department of Health, Hawaii Health Data Warehouse, Behavioral Risk Factor Surveillance System. Diabetes Prevalence, adult by race/ethnicity (DOH) 2017-2019. Published online August 6, 2021. http://ibis.hhdw.org/ibisph-view/indicator/view/DXDiabetesAA.RacEthDOH.html
13. Monteiro LJ, Norman JE, Rice GE, Illanes SE. Fetal programming and gestational diabetes mellitus. *Placenta*. 2016;48 Suppl 1:S54-S60. doi:10.1016/j.placenta.2015.11.015
14. Yan J, Yang H. Gestational diabetes mellitus, programing and epigenetics. *J Matern-Fetal Neonatal Med*. 2014;27(12):1266-1269. doi:10.3109/14767058.2013.853733
15. El Hajj N, Schneider E, Lehnen H, Haaf T. Epigenetics and life-long consequences of an adverse nutritional and diabetic intrauterine environment. *Reprod Camb Engl*. 2014;148(6):R111-120. doi:10.1530/REP-14-0334
16. Zhang C, Rawal S, Chong YS. Risk factors for gestational diabetes: is prevention possible? *Diabetologia*. 2016;59(7):1385-1390. doi:10.1007/s00125-016-3979-3
17. Chen L, Shi L, Zhang D, Chao SM. Influence of acculturation on risk for gestational diabetes among Asian women. *Prev Chronic Dis*. 2019;16:E158. doi:10.5888/pcd16.190212
18. Liu B, Lamerato LE, Misra DP. A retrospective analysis of the relationship between race/ethnicity, age at delivery and the risk of gestational diabetes mellitus. *J Matern-Fetal Neonatal Med*. 2020;33(17):2961-2969. doi:10.1080/14767058.2019.1566310
19. Shah A, Stotland NE, Cheng YW, Ramos GA, Caughey AB. The association between body mass index and gestational diabetes mellitus varies by race/ethnicity. *Am J Perinatol*. 2011;28(7):515-520. doi:10.1055/s-0031-1272968
20. Pu J, Zhao B, Wang EJ, et al. Racial/ethnic differences in gestational diabetes prevalence and contribution of common risk factors. *Paediatr Perinat Epidemiol*. 2015;29(5):436-443. doi:10.1111/ppe.12209

21. Hunsberger M, Rosenberg KD, Donatelle RJ. Racial/ethnic disparities in gestational diabetes mellitus: findings from a population-based survey. *Womens Health Issues*. 2010;20(5):323-328. doi:10.1016/j.whi.2010.06.003
22. Tsai P-JS, Roberson E, Dye T. Gestational diabetes and macrosomia by race/ethnicity in Hawaii. *BMC Res Notes*. 2013;6:395. doi:10.1186/1756-0500-6-395
23. Kim SY, England L, Sappenfield W, et al. Racial/ethnic differences in the percentage of gestational diabetes mellitus cases attributable to overweight and obesity, Florida, 2004-2007. *Prev Chronic Dis*. 2012;9:E88. doi:10.5888/pcd9.110249
24. Kim SY, Saraiva C, Curtis M, Wilson HG, Troyan J, Sharma AJ. Fraction of gestational diabetes mellitus attributable to overweight and obesity by race/ethnicity, California, 2007-2009. *Am J Public Health*. 2013;103(10):e65-72. doi:10.2105/AJPH.2013.301469
25. Hedderson M, Ehrlich S, Sridhar S, Darbinian J, Moore S, Ferrara A. Racial/ethnic disparities in the prevalence of gestational diabetes mellitus by BMI. *Diabetes Care*. 2012;35(7):1492-1498. doi:10.2337/dc11-2267
26. Brite J, Shiroma EJ, Bowers K, et al. Height and the risk of gestational diabetes: variations by race/ethnicity. *Diabet Med*. 2014;31(3):332-340. doi:10.1111/dme.12355
27. Williams AD, Grantz KL, Zhang C, Nobles C, Sherman S, Mendola P. Ambient volatile organic compounds and racial/ethnic disparities in gestational diabetes mellitus: are Asian/Pacific Islander women at greater risk? *Am J Epidemiol*. 2019;188(2):389-397. doi:10.1093/aje/kwy256
28. Hedderson MM, Darbinian JA, Ferrara A. Disparities in the risk of gestational diabetes by race-ethnicity and country of birth. *Paediatr Perinat Epidemiol*. 2010;24(5):441-448. doi:10.1111/j.1365-3016.2010.01140.x
29. Ramadhani TA, Canfield MA, Farag NH, et al. Do foreign- and U.S.-born mothers across racial/ethnic groups have a similar risk profile for selected sociodemographic and periconceptional factors? *Birt Defects Res A Clin Mol Teratol*. 2011;91(9):823-830. doi:10.1002/bdra.20839
30. Janevic T, Borrell LN, Savitz DA, Echeverria SE, Rundle A. Ethnic enclaves and gestational diabetes among immigrant women in New York City. *Soc Sci Med 1982*. 2014;120:180-189. doi:10.1016/j.socscimed.2014.09.026
31. Gunderson EP, Hurston SR, Ning X, et al. Lactation and progression to type 2 diabetes mellitus after gestational diabetes mellitus: a prospective cohort study. *Ann Intern Med*. 2015;163(12):889-898. doi:10.7326/M15-0807
32. Gunderson EP, Kim C, Quesenberry CPJ, et al. Lactation intensity and fasting plasma lipids, lipoproteins, non-esterified free fatty acids, leptin and adiponectin in postpartum women with recent gestational diabetes mellitus: the SWIFT cohort. *Metabolism*. 2014;63(7):941-950. doi:10.1016/j.metabol.2014.04.006
33. Bao W, Li S, Chavarro JE, et al. Low carbohydrate-diet scores and long-term risk of type 2 diabetes among women with a history of gestational diabetes mellitus: a prospective cohort study. *Diabetes Care*. 2016;39(1):43-49. doi:10.2337/dc15-1642
34. Bao W, Tobias DK, Bowers K, et al. Physical activity and sedentary behaviors associated with risk of progression from gestational diabetes mellitus to type 2 diabetes mellitus: a prospective cohort study. *JAMA Intern Med*. 2014;174(7):1047-1055. doi:10.1001/jamainternmed.2014.1795
35. Bao W, Yeung E, Tobias DK, et al. Long-term risk of type 2 diabetes mellitus in relation to BMI and weight change among women with a history of gestational diabetes mellitus: a prospective cohort study. *Diabetologia*. 2015;58(6):1212-1219. doi:10.1007/s00125-015-3537-4
36. Brown SD, Ehrlich SF, Kubo A, et al. Lifestyle behaviors and ethnic identity among diverse women at high risk for type 2 diabetes. *Soc Sci Med 1982*. 2016;160:87-93. doi:10.1016/j.socscimed.2016.05.024
37. Bao W, Chavarro JE, Tobias DK, et al. Long-term risk of type 2 diabetes in relation to habitual iron intake in women with a history of gestational diabetes: a prospective cohort study. *Am J Clin Nutr*. 2016;103(2):375-381. doi:10.3945/ajcn.115.108712
38. Allalou A, Nalla A, Prentice KJ, et al. A predictive metabolic signature for the transition from gestational diabetes mellitus to type 2 diabetes. *Diabetes*. 2016;65(9):2529-2539. doi:10.2337/db15-1720
39. Lai M, Liu Y, Ronnett GV, et al. Amino acid and lipid metabolism in post-gestational diabetes and progression to type 2 diabetes: A metabolic profiling study. *PLoS Med*. 2020;17(5):e1003112. doi:10.1371/journal.pmed.1003112
40. Batchuluun B, Al Rijjal D, Prentice KJ, et al. Elevated medium-chain acylcarnitines are associated with gestational diabetes mellitus and early progression to type 2 diabetes and induce pancreatic β-Cell dysfunction. *Diabetes*. 2018;67(5):885-897. doi:10.2337/db17-1150
41. Khan SR, Mohan H, Liu Y, et al. The discovery of novel predictive biomarkers and early-stage pathophysiology for the transition from gestational diabetes to type 2 diabetes. *Diabetologia*. 2019;62(4):687-703. doi:10.1007/s00125-018-4800-2
42. Bernstein J, Lee-Parritz A, Quinn E, et al. After gestational diabetes: impact of pregnancy interval on recurrence and type 2 diabetes. *BioResearch Open Access*. 2019;8(1):59-64. doi:10.1089/biores.2018.0043
43. Yuen L, Wong VW, Simmons D. Ethnic disparities in gestational diabetes. *Curr Diab Rep*. 2018;18(9):68. doi:10.1007/s11892-018-1040-2
44. Solomon CG, Willett WC, Carey VJ, et al. A prospective study of pregravid determinants of gestational diabetes mellitus. *JAMA*. 1997;278(13):1078-1083.
45. Silva JK, Kaholokula JK, Ratner R, Mau M. Ethnic differences in perinatal outcome of gestational diabetes mellitus. *Diabetes Care*. 2006;29(9):2058-2063. doi:10.2337/dc06-0458
46. Price LA, Lock LJ, Archer LE, Ahmed Z. Awareness of gestational diabetes and its risk factors among pregnant women in Samoa. *Hawaii J Med Public Health*. 2017;76(2):48-54.
47. Stotz S, Charron-Prochownik D, Terry MA, Gonzales K, Moore K. Reducing risk for gestational diabetes mellitus (GDM) through a preconception counseling program for American Indian/Alaska Native girls: perceptions from women with type 2 diabetes or a history of GDM. *Diabetes Educ*. 2019;45(2):137-145. doi:10.1177/0145721718821663
48. Anand SS, Gupta M, Teo KK, et al. Causes and consequences of gestational diabetes in South Asians living in Canada: results from a prospective cohort study. *CMAJ Open*. 2017;5(3):E604-E611. doi:10.9778/cmajo.20170027
49. Yuen L, Wong VW. Gestational diabetes mellitus: Challenges for different ethnic groups. *World J Diabetes*. 2015;6(8):1024-1032. doi:10.4239/wjd.v6.i8.1024
50. Koivusalo SB, Rönö K, Klemetti MM, et al. Gestational diabetes mellitus can be prevented by lifestyle intervention: the Finnish gestational diabetes prevention study (RADIEL): a randomized controlled trial. *Diabetes Care*. 2016;39(1):24-30. doi:10.2337/dc15-0511
51. Russo LM, Nobles C, Ertel KA, Chasan-Taber L, Whitcomb BW. Physical activity interventions in pregnancy and risk of gestational diabetes mellitus: a systematic review and meta-analysis. *Obstet Gynecol*. 2015;125(3):576-582. doi:10.1097/AOG.0000000000000691
52. Sanabria-Martínez G, García-Hermoso A, Poyatos-León R, Álvarez-Bueno C, Sánchez-López M, Martínez-Vizcaíno V. Effectiveness of physical activity interventions on preventing gestational diabetes mellitus and excessive maternal weight gain: a meta-analysis. *BJOG Int J Obstet Gynaecol*. 2015;122(9):1167-1174. doi:10.1111/1471-0528.13429
53. Vounzoulaki E, Khunti K, Abner SC, Tan BK, Davies MJ, Gillies CL. Progression to type 2 diabetes in women with a known history of gestational diabetes: systematic review and meta-analysis. *BMJ*. 2020;369:m1361. doi:10.1136/bmj.m1361
54. Zhu Y, Zhang C. Prevalence of gestational diabetes and risk of progression to type 2 diabetes: a global perspective. *Curr Diab Rep*. 2016;16(1):7. doi:10.1007/s11892-015-0699-x
55. Li Z, Cheng Y, Wang D, et al. Incidence rate of type 2 diabetes mellitus after gestational diabetes mellitus: a systematic review and meta-analysis of 170,139 women. *J Diabetes Res*. 2020;2020:3076463. doi:10.1155/2020/3076463
56. Moon JH, Kwak SH, Jang HC. Prevention of type 2 diabetes mellitus in women with previous gestational diabetes mellitus. *Korean J Intern Med*. 2017;32(1):26-41. doi:10.3904/kjim.2016.203
57. Dennison RA, Fox RA, Ward RJ, Griffin SJ, Usher-Smith JA. Women's views on screening for type 2 diabetes after gestational diabetes: a systematic review, qualitative synthesis and recommendations for increasing uptake. *Diabet Med J*. 2020;37(1):29-43. doi:10.1111/dme.1408

Factors Contributing to Snorkel Drowning in Hawai‘i

Philip R. Foti MD; Carol M. Wilcox; Ralph S. Goto

Abstract

Causes of the extraordinarily high and increasing incidence of snorkeler drownings in Hawai‘i have remained unexplained for years. Defining the mechanisms and factors predisposing to drowning while snorkeling is needed to provide recommendations to substantially mitigate the incidence of this form of preventable death. The mechanisms of drowning are described and insight into the predisposing factors are explored in this study. Methods included measuring snorkel airway resistance characteristics, case reports from the State of Hawai‘i Medical Examiner's office, and collating information by survey, principally from rescued survivors. This study identified 2 modes of drowning while snorkeling that need further investigation: accidental or inadvertent aspiration, and hypoxia resulting from acute negative pressure pulmonary edema. The incidence of drowning from mechanisms of hypoxia due to rapid onset pulmonary edema is an important focus of the study and a number of potentially significant predisposing factors are presented that need further investigation but provide bases that may become part of updated policies and practices for snorkelers to substantially lower the risk of death. This report is meant for both medical and public health information purposes.

Abbreviations

ACM = alveocapillary membrane
ANPPE = acute negative pressure pulmonary edema
HAPE = high altitude pulmonary edema
NTP = negative transthoracic pressure
ROPE = rapid onset pulmonary edema
SIPE = swimming induced pulmonary edema
SIROPE = snorkeling induced rapid onset pulmonary edema

Keywords

Aspiration, Hypoxia, Pulmonary Edema, Snorkels

Introduction

Hawai‘i is the focal point of numerous drownings, the great majority of which are ocean related, and involve snorkeling tourists over the age of 50. The Medical Examiner's Office has been assiduous in conducting postmortem examinations, but the nature of demise makes it difficult to reconstruct the reasons for drowning in most cases. Details of demographics of drowning elsewhere in the world have not been reported accurately, and the total number of deaths may be staggering. There are four mechanisms of drowning that may befall snorkelers: (1) trauma; (2) intervening acute medical adverse event; (3) inadvertent or accidental aspiration of water; and (4) hypoxia due to rapid onset pulmonary edema (ROPE). The first 2 are relatively uncommon and distinguishable from each other. Distinguishing between the last 2 of this list is difficult or impossible after death. Achieving the goals of this study requires that we determine as accurately as possible, methods of distinguishing between inadvertent aspiration and hypoxia due to ROPE in cases of drowning and near-drowning. Investigation of the possible reasons for death from available information in many cases indicates that the usually proposed explanations of these events (anxiety, panic, fatigue, inexperience, and lack of familiarity with ocean conditions, equipment and proper technique) are not adequate explanation for death from aspiration. For years the role of carbon dioxide rebreathing has been repeatedly implicated, but no science to support it as a serious contender has appeared. Recognizing ROPE as a mechanism of drowning has required documentation of cases of survivors of snorkeling induced ROPE (SIROPE) related hypoxemia. It has been suspected that the increase in negative transthoracic pressure (NTP) required to maintain adequate volumes of ventilation during immersion promote ROPE and hypoxia under these circumstances. Pulmonary edema results in hypoxemia which rapidly leads to weakness, loss of normal neurologic reflex responses, confusion, and diminished consciousness. The alveocapillary membrane (ACM) is permeable to water in both directions. Both endocapillary and alveolar pressures need to be more or less balanced to maintain homeostasis.

During inhalation, negative intrathoracic pressure is achieved by muscular contraction of the diaphragms and "bucket handle" motion of the ribs. This "vacuum" effect of increasing intrathoracic volume draws air into alveoli. When intraalveolar negative pressure is sufficient to exceed oncotic pressure of capillary contents, water flows toward the alveolus. When intracapillary pressure is substantially increased and/or ACM permeability is compromised, flow is toward alveoli unless intraalveolar pressure exceeds endocapillary pressure. When integrity of the ACM mechanically fails completely, capillary contents spill directly into alveoli. This type of acute negative pressure pulmonary edema (ANPPE) has been well described in scuba divers, by anesthesiologists and, more recently, is recognized in swimmers.[1] To our knowledge it has not been reported as a cause of death in snorkelers.

ANPPE is known to exist in larger mammals capable of high levels of ventilation and cardiac output during maximal effort, in which case it has been referred to as mechanical failure of the ACM.[2,3] In the case of scuba, it is referred to as immersion pulmonary edema (IPE), and in competitive swimmers SIPE (swimming induced pulmonary edema).[4] The connection between hypoxia due to these types of ROPE and that resulting from snorkeling activities has not been well documented or studied in the past. A literature search did find one 2017 case

report of hemorrhagic pulmonary edema ascribed to snorkeling.[5] Investigation of cases of individuals surviving these hypoxic episodes has led the team to believe that this mechanism of death is, indeed, reality. Clinical detection of hypoxia and oxygen desaturation with no sign of aspiration at the time of rescue, documentation of clinical and radiographic pulmonary edema rapidly resolving with or without oxygen and or diuretic therapy, and the lack of abnormal findings on cardiopulmonary testing cannot be otherwise explained. The incidence and pathophysiology involved, in addition to identifying the predisposing factors that increase the risk of its development are the scope of this study. Several of the potential causes for excessive NTP and ANPPE, which can contribute to or induce ROPE, include immersion, increased inspiratory resistance induced by various snorkel designs, and other factors. Snorkels are responsible for some increase in NTP depending upon the degree of resistance upon inhalation. Other factors, which are listed in the discussion section of this report play a role in increasing the risk of ROPE and include subclinical conditions which commonly go unrecognized because they produce little or no symptoms at usual levels of activity. Mountain climbers may be similarly affected from a form of ROPE referred to as high altitude pulmonary edema (HAPE).[6] There is reason to believe that these factors may affect air travelers as well. This is a preliminary report of findings because augmented education, messaging, and policy changes are urgently needed to diminish the risk of preventable deaths.

Methods

Three strategies were used to gain further information on the mechanisms of drowning among snorkelers: (1) snorkel airway resistance analysis, (2) medical examiner case reports, and (3) survivor-derived information. Because ANPPE is the common denominator for hypoxia under immersion circumstances, snorkel airway resistance analysis was achieved by designing and fabricating a device to measure negative pressures at various flow rates to test various snorkels to determine their potential contribution to negative transthoracic pressure. The device consists of a vacuum blower with adjustable flow, a flow meter, and a negative pressure transducer interposed between it and the mouthpiece of the snorkel. Because the number of varied designs of available snorkel devices is too numerous to count, the first 50 that were randomly received in the laboratory from various sources were tested at flow rates of 1, 2 and 3 liters per second. The results were recorded graphically in negative cmH_2O pressure, having been converted from kilopascals measured from the transducer. These were plotted on bar graphs at 3 liters per second for simplicity of review. These data were subjected to Mann Whitney statistical analysis. For each apparatus, the two technicians testing the snorkels who were familiar with various snorkel designs attempted to guess, after careful inspection, whether the device would test at high or low resistance. The technician estimates were recorded prior to testing. Pressure greater than $^{-}5$ cmH_20 pressure was designated as high. Estimates were compared with measurements on the analyzer to gain insight into how likely a would-be snorkeler might be expected to select a low resistance device by inspection alone.

The 50 devices were grouped into those with some form of dry device (designs in attempts to prevent water entering the snorkel tube), those with no dry device, and full-face masks. There were 29 dry devices, 16 without dry devices, and 4 different manufacture full face masks. One device was omitted from the analysis because it was lost and could not be confirmed to be dry or not.

State of Hawai‘i Medical Examiner reports from the summer of 2017 to summer of 2019 were reviewed in detail by the principal investigator. The state's Medical Examiner is responsible for submitting reports from all the islands and, when it is possible, necropsies are part of the report in virtually all cases. Medical Examiner reports consist of findings compiled by an investigator and a final report, which includes autopsy findings, prepared by the medical examiner. Data available from these documents were collected in order to cross reference investigator reports with necropsy findings, and to analyze each case of snorkel drowning for clues as to which of the two mechanism categories (aspiration vs hypoxia) a given death could most likely be ascribed. Criteria for distinguishing between the 2 mechanisms included presence of observed struggle vs quiet cessation of activity and motion, water in the mask, details of descriptive accounts of ocean conditions, and predeath behavior. Cross referencing other information accumulated during review of cases showed no correlation between snorkelers and nonsnorkelers in reference to presence or absence of "foam cones," sinus fluid volumes and description, gastric volumes or contents, ambient sea conditions, or position in which victims were found. Foam cones refer to the shape of salivary and oral fluid foam which commonly collects with the base of the cone covering the oral aperture. They have been commonly described in the case of drowning when examination may be conducted within hours after the incident and have been accepted as a sign highly suggestive of drowning. Correlation between information contained in investigator's reports concerning details of travel data, prior illness, preincident behaviors and activities engaged in by victims, whether or not they were found by first responders with water in the mask, and in most cases the type of snorkel equipment used, was unsuccessful. The reasons for this lack of success was because of insufficient detail in the reports, but also because the descriptions of macro and microscopic finding of necropsies were unable to distinguish between the two mechanisms responsible for a given death. For example, 100% of all victims had pulmonary edema with varying degrees of hemorrhage, so no correlation could be made between degree of hemorrhage and the mechanism of drowning.

Survivor-derived information: 10 cases of nonfatal drownings were selected from respondents to a survey posted on our website and investigated in as much detail as possible.

The survey had been developed over a period of years by the study team in concert with the Hawai'i Department of Health subcommittee on Aquatic Safety, even before this study was formally underway. Individuals interested in reporting events were directed to the website by various lifeguard and other first responders, by information posted in specific areas (for example, Hanauma Bay), and by word of mouth and media exposure. Each case was thoroughly investigated in person and by telephone by the principal investigator and included interviews with survivors, rescuers, and other knowledgeable persons (eg, lifeguards, bystanders, and emergency medical services personnel). Institutional Review Board approval for this investigation was obtained through the Department of Health. Consent for contacting survey responders was requested on the survey itself. No one was contacted if consent was not clearly agreed to in the survey. Documents including hospital records, radiographs, and laboratory information were reviewed. It was determined that these cases represented examples related to ROPE (rather than aspiration) which would have proceeded to agonal breathing (with potential aspiration in the process of termination of brain life) if the snorkeler were not rescued. The survey report questionnaire had been developed and implemented to allow for ongoing sources of information to refine cumulative data concerning the details of importance in determining which mechanisms may be responsible and critical information concerning factors predisposing to ROPE. This survey is ongoing and on the study website. It is updated and upgraded as needed.

Results

Snorkel Airway Resistance Analysis: Figure 1 expresses all 50 random measurements depicted as the negative pressure required at 3 liters per second. Of the 15 snorkels tested with greater than -5 cmH_2O, 4 were guessed correctly (26%) and 29 of 35 testing less than -5 cmH20 pressures were guessed correctly (80%). The preliminary information resulting from these graphs suggests that, in general, airway resistance in a given snorkel device is very variable, depending on features of design, and variability is similar in dry, non-dry, and full-face mask devices. Estimates of resistance, although strictly anecdotal, do indicate that the accuracy of quantitating resistance subjectively suggests that the likelihood of a would-be snorkeler to guess if a given device will have high resistance is poor. Submission of bar graph derived data to Mann Whitney testing indicated no statistical differences.

Medical Examiner Case Reports: Of the 98 drowning reports reviewed, 32 were snorkel-related including 8 deaths which involved swimmers known to have advanced experience in snorkeling (Table 1). They were all known to be free divers and spear fishing fishermen. None was engaged in free diving at the time, to explain their events. Because of insufficient information in reports, it is uncertain as to how many were actually spear fishing at the time of the event that resulted in death. The position in which victims were encountered in snorkels was floating face down at the time of first encounter, except 2 who had full face masks. Utilizing the information available in each case, the team grouped cases into 3 categories: very likely, less likely, and definitely not related to hypoxia as the source of drowning. Of the 32 deaths, 15 were judged to be very likely the result of hypoxia due to ROPE, and 14 cases were considered as likely to be due to either ROPE or aspiration. Three were "not able to be definitely assigned" to either mechanism.

Survivor derived information: Documentation from10 cases reviewed as outlined above indicated that all but 1 of the subjects were over 50 years of age. Because of echocardiographic signs of diastolic dysfunction, 1 was referred for further investigation and eventually a biopsy proven diagnosis of myocardial amyloidosis confirmed. Otherwise, there were no certain indications of cardiovascular disease in any of the10 cases. Features commonly encountered in the 10 near drowning survivors documented to have had findings consistent with ANPPE induced by ROPE-related hypoxia are as follows:

- No history or sign of aspiration
- Initial symptoms of shortness of breath, progressive fatigue, and weakness
- Rapid development of diminishing mental alertness/near syncope
- Often associated with extraordinary effort
- Required assistance
- Oxygen desaturation at time of first responder or EMS arrival
- Hypoxemia and pulmonary edema documented after arrival at emergency facility
- Usually treated with diuretics and oxygen
- Resolution of pulmonary edema within hours
- No unusual findings on cardiovascular testing to explain the pulmonary edema were found in the 6 subjects who were evaluated in emergency facilities.

Extraordinary effort described included intentional swim training workouts in 2 cases, effort required to swim against strong current (3 cases), and long-distance swimming in 2 cases. The syndrome of dyspnea, fatigue, weakness and rapid deterioration of mental alertness was described in all cases, just before being rescued.

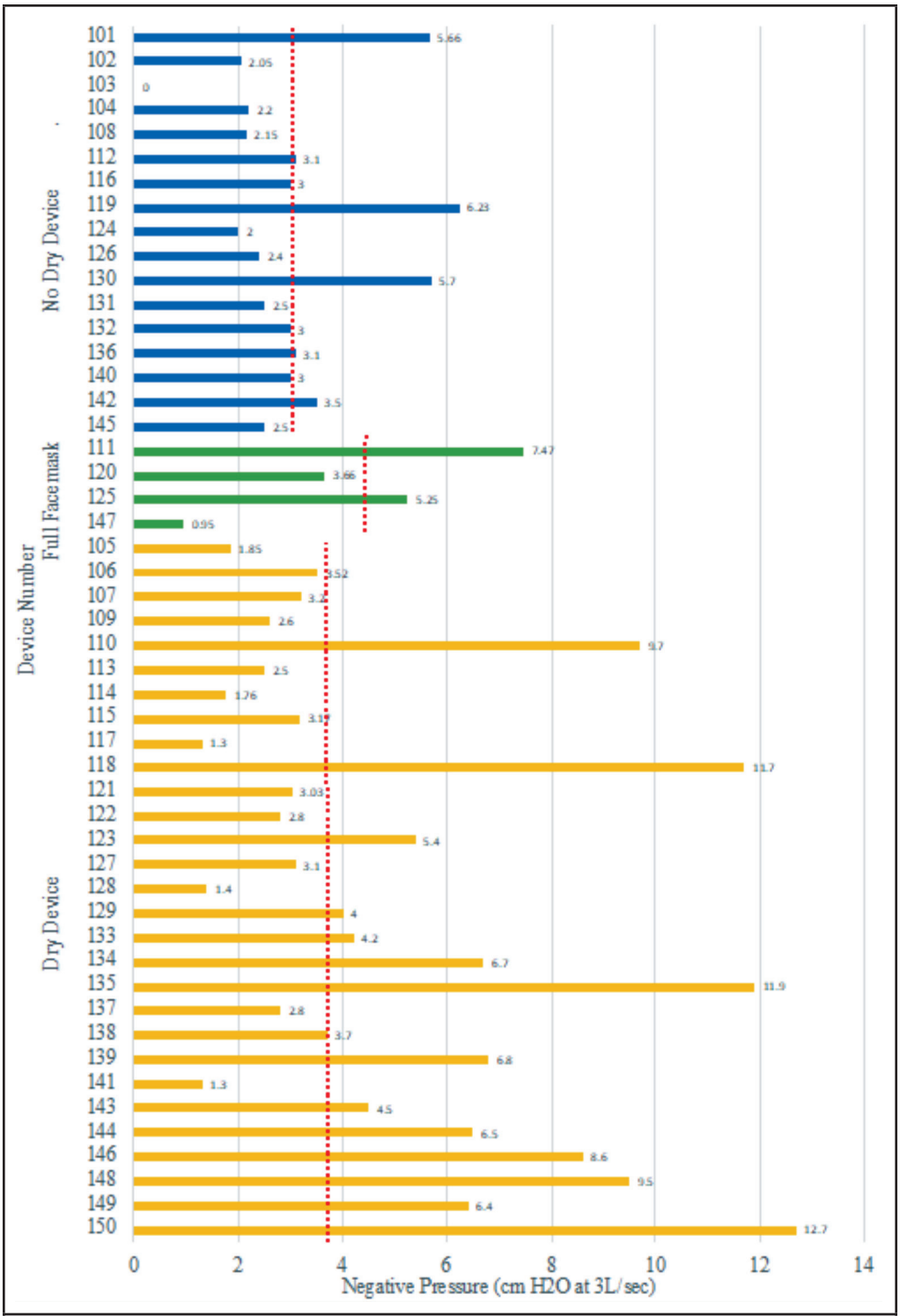


Figure 1. Separation of Negative Pressure Results Based on Snorkel Category Type

Blue = no dry device, Green = full-face mask, Yellow = dry device. Dotted Red line indicates the median negative pressure value per category: no dry device = 3.00, full facemask = 4.46, dry device = 3.7. There is no statistical significance in the difference of median based on Mann Whitney tests between full facemask and dry device (W = 55, *P* = .89), full facemask no dry device (W = 42, *P* = .37), and dry and no dry device (W = 310,p= *P* = .07).

Table 1. Demographic summary of snorkel-related deaths in Hawai'i

Grouping	Absolute number	Percentage
Gender		
Male	22	69
Female	10	31
Age		
<40	5	16
40-49	6	19
50-59	9	28
60-69	9	28
>70	3	9
Residency Status in Hawai'i		
Local resident	10	31
Visitor	22	69
Specific Activities		
Freediving/Spearfishing	8	25
Unspecified	24	75
Previous Travel		
No Information	25	78
>5 days	1	3
2 days	4	13
1 day	2	6
Cardiac Disease		
Cardiac disease likely to have increased left ventricular end diastolic pressure (LVEDP)	14	44
No clinical or autopsy evidence for cardiac disease	6	19
Insufficient cardiac information	12	38
Rating of Snorkel drowning for ROPE		
Very Likely	15	47
Likely (>50%)	14	44
Not Likely	3	9
Comorbidities of the six deaths not associated with pre-existing cardiac disease		
Bilateral Active Infectious Pneumonia	1	3
Amphetamine	2	6
THC	1	3
Alcohol	2	6

Data Source: Review of State of Hawai'i Medical Examiner's reports from summer of 2017 to 2019

Discussion

Snorkels, for the most part, offer relatively minor additional resistance to the NTP required to achieve usual inspiratory volumes during immersion. However, the major variation in snorkel resistance characteristics observed, and inability to estimate it by inspection, indicate that a substantial increase in required negative pressures may inadvertently become the case without the snorkeler's knowledge or ability to appreciate, especially at higher levels of work and minute ventilation. Immersion alone results in an increase in ambient pressure. For example, at 12 inches midthoracic depth, approximately 30 cm of H_2O pressure is added to the unsubmerged pressure of 1035 cm at sea level (eg, ±760 mmHg). In addition, the prone position results in redistribution of intravascular blood such that 500-700 ml accumulates in the pulmonary vasculature anteriorly, changing the pressure volume characteristics of the ACM.[7] At the same time, even with least resistance type snorkels, there is added some 3-5 cm of negative water pressure per breath, such that the NTP may be in the vicinity of minus 35 cm for each inhalation. At 10 breaths per minute, assuming 3 liters per second flow rate depending upon tidal volume and other variables, the cumulative negative pressure for that minute could total, conservatively, 350 cm of negative water pressure, or more. A snorkel causing high resistance adds to NTP accordingly. Sufficient negative pressure may be transferred to alveoli for a given period of time to result in focal hypoxia sufficient to trigger pulmonary arteriolar constriction.[8] Hypoxia-related pulmonary arterial hypertension and increased vascular resistance is generalized, heterogeneous and disorganized as compared to normal responses.[9] These mechanisms are suspected in HAPE as well. Results of medical examiners' reports and autopsies yield relatively little information of value in terms of distinguishing between accidental drowning and hypoxia-induced death. Nonetheless, the fact that 25% of the snorkeler deaths occurred to experienced divers tends to support the impression that inexperience, panic, anxiety, and lack of familiarity with equipment and techniques are not reasonable explanations in a significant number of cases.

Support for the hypothesis that a substantial number of such deaths are hypoxia related is also suggested by clinical and historical descriptions of information retrieved from investigators' reports. Necropsy does not provide information allowing for differentiation of accidental vs hypoxic causes. Histologic and other features of pulmonary edema, which was present in all cases, were not of assistance in distinguishing between the 2. Hypoxic causes may be more likely to occur in patients who have various cardiac conditions including diastolic dysfunction which may be a common predisposing factor. All but 3 cases were found floating face down at the time of first observation, except 2 which involved full-face masks. In the case of 1 victim found face up, there was no reported history of snorkel use. Whether full-face masks may pose additional risks needs further study but was not a focus of this investigation.

Survivor derived information provides the clues to the mechanisms of hypoxia as the cause for near-death. To date, we have insufficient information to draw conclusions of statistical significance concerning the frequency of hypoxia vs accidental aspiration-induced deaths. Ongoing analysis of surveys from nonfatal drownings, which include information targeting predisposing factors, will be more valuable as they increase in number.

The possible comorbid and nonpathologic states suspected to be predisposing contributing factors to precipitation of ROPE include elevated left ventricular end diastolic pressure, patent foramen ovale, septal defect, pulmonary hypertension, valve disorders and inherited or acquired variations in physiologic vascular, humoral and neurologic responses which control pulmonary vasoconstriction (eg, NO synthase activity, prostacycline, endothelin, mitochondrial function, and 2, 3 DPG levels). Of particular interest to Hawai‘i is evidence that long distance air travel may result in many hours of exposure to sufficient hypoxemia to compromise the integrity and permeability of the ACM in subtle, subclinical fashion, making newly arrived snorkelers at greater risk in the several days after landing. Despite exhaustive search of literature, communications with the Federal Aeronautics Administration, National Aeronautics and Space Administration, National and International Airline Pilots associations, and aeronautics companies in the United States, no references of consequence were found to address this hypothesis. Hypobaric chamber studies have shown that especially in older patients, mean pulmonary artery pressure and vascular resistance increase in response to low grade hypoxemia associated with high altitude commercial travel.[10] The degree of such response must vary with many co-factors, including individual variations in physiologic responsiveness to hypoxia. The passenger's habitat elevation could be another such variable.

Conclusion

This preliminary report suggests that measurements of snorkel airway resistance show that airway resistance in a given snorkel can be markedly variable and cannot always be safely determined by inspection. Furthermore, snorkels with high resistance can increase transthoracic negative pressure sufficiently to induce or add to hypoxia due to ANPPE under certain circumstances which is a cause for near drowning and death while snorkeling. Consequently, the incidence of drownings and near drownings due to this mechanism is unknown at this time. Postmortem examination reports investigation indicate: (1) for the most part, necropsy findings are unable to determine whether a given snorkel death is due to accidental aspiration or ANPPE-induced hypoxia; and (2) improvement in recording clinical historical features as part of postmortem evaluations would be valuable. Ten case studies of survivors indicate: (1) ANPPE and hypoxia have been documented in survivors of near drowning experiences; and (2) predisposing factors exist, which are thought to be capable of adding to the likelihood of ANPPE in snorkelers. They include many factors which need further study: left heart and other occult medical condition, victim habitat altitudes, and possibly long-haul air travel are included in this list.

Conflict of Interest

None of the authors identify a conflict of interest.

Authors' Affiliation:
- Snorkel Safety subdivision of the Advisory Committee on Drowning & Aquatic Safety, State of Hawai'i Department of Health, Honolulu, HI

Corresponding Author:
Philip R. Foti MD; Email: pfoti@snorkelsafetystudy

References

1. Marabotti C, Scalzini A, Cialoni D, Passera M, L'Abbate A, Bedini R. Cardiac changes induced by immersion and breath-holding diving in humans. *J Appl Physiol*. 2009;106:293-297.
2. West JB. Thoughts on pulmonary blood-gas barrier. *Am J Physiol Lung Cell Mol Physiol*. 2003;285(3):L50-13.
3. Birks EK, Mathieu-Costello, Fu Z, Tyler WS, West JB. Very high pressures are required to cause stress failure of pulmonary capillaries in thoroughbred racehorses. *J Appl Physiol*. 1997;82(5): 1584-1592.
4. Miller CC 3rd, Calder-Becker K, Modave F. Swimming-induced pulmonary edema in triathletes. *Am J Emerg Med*. 2010; 941-946.
5. Choo DM, Kim SS, Chung CU, Park DI, Kim JJ. Snorkeling-induced pulmonary hemorrhage: a case report. *J Korean Soc. Radiol.* 2017;77(5):344-347.
6. Bartch P, Maitbaurl H, Maggiorini M., Swenson ER. Physiologic aspects of high altitude pulmonary edema. *J Appl Physiol.* 1985;98(3):101-110.
7. Webster TE, Cherry AD, Pollock NW, et al. Effects of head and body cooling on hemodynamics during immersed prone exercise at 1 ATA. *J Appl Physiol.* 2009;106: 691-700. doi: 10.1152/japplphysiol.91237.2008.
8. Sylvester JT, Shimoda LA, Aaronson PI, Ward JP. Hypoxic pulmonary vasoconstriction. *Physiological Reviews.* 2012;92(1):367-520.
9. West JB, Mathieu-Costello O. Stress failure of pulmonary capillaries in the intensive care setting. *Schweiz Medication Wochonschr.* 1992;122(20):751-757.
10. Turner BE, Hodkinson PD, Timpeley AC, Smith TG. Pulmonary artery pressure response to simulated air travel in a hypobaric chamber. *Aerosp Med Hum Perform.* 2015;86(6):529-534. doi: 10.3357/AMHP.4177.2015.

Hali‘a Aloha no Kauka Elizabeth Tam: In Fond Memory of Dr. Elizabeth Tam from ‘Ahahui o Nā Kauka (Association of Native Hawaiian Physicians)

Kara Wong Ramsey MD; Helen Kaleleonalani Blaisdell-Brennan MD; Kapono Chong-Hanssen MD; Marcus Iwane MD; Nicole Mahealani Lum DO; Martina Kamaka MD

In 1993, the Medical School Hotline was founded by Satoru Izutsu PhD (former vice-dean UH JABSOM), it is a monthly column from the University of Hawai‘i John A. Burns School of Medicine and is edited by Kathleen Kihmm Connolly PhD; HJH&SW Contributing Editor.

Introduction

We, the board members of ‘Ahahui o Nā Kauka (AONK), the Association of Native Hawaiian Physicians, mourn the recent passing of one of our *kūpuna* (distinguished elder) Native Hawaiian physician members, Dr. Elizabeth Tam, former chair of the Department of Internal Medicine at the University of Hawai‘i John A. Burns School of Medicine and treasurer of our board. We would like to recognize Dr. Tam’s contributions to AONK by presenting a *ha‘i aloha*, a traditional Native Hawaiian chant, composed by one of our members. The chant references names of winds from significant geographical locations in Tam’s life — from her home in Wai‘alae to her workplace in Kaka‘ako. These winds are used to describe the far reach of Tam’s influence. Dr. Tam is described as facilitating students’ growth the way that the sun fosters a new plant’s growth. Her research discoveries elucidated pathways to optimal health like a wind clearing a path through clouds. Our mourning is compared with the earth’s trembling during a volcanic eruption; rain represents tears. Readers may view a video of this chant performed by author Dr. Mahealani Lum and an introduction by board president Dr. Emmett Noa Aluli on the ‘Ahahui o Nā Kauka YouTube page at https://youtu.be/VuwSueehjkk, presented at the virtual celebration of life for Dr. Tam hosted by her family.

AONK is a non-profit organization created in March 1998 by 22 Native Hawaiian doctors at the Native Hawaiian Health and Wellness Summit in Honolulu, Hawai‘i. The organization’s mission is to advocate for the health of Native Hawaiians by providing health education to the community, continuing medical education opportunities for medical professionals, testimonial support for public health-related policies that support Native Hawaiian well-being, and mentorship for Native Americans Hawaiian pre-medical and medical students.

Dr. Elizabeth Tam

In Memoriam

‘Ahahui o Nā Kauka deeply mourns the loss of Dr. Elizabeth Tam, our *A‘ā* (brightest star). Dr. Tam touched numerous lives as a *kauka* (physician), researcher, educator, leader, mother, mentor, and friend. While pages could be written of her numerous accomplishments, here we share our *hali‘a aloha* (fondest memories) of how Dr. Tam made a lasting impact on the Native Hawaiian community and shaped ‘Ahahui o Nā Kauka from her first *huaka‘i* (excursion) to her induction as a distinguished *kauka kūpuna* (respected elder physician), a permanent member of our governing board.

Dr. Tam possessed a strong sense of *kuleana* (responsibility) during her academic career. Her personal drive, powerful intellect and business acumen allowed ‘Ahahui o Nā Kauka to metamorphosize from a casual checkbook club to the solid financial organization it is today when ‘Ahahui o Nā Kauka was fortunate that Dr. Tam brought with her experience as former

treasurer for the Hawai‘i State Rural Health Association. To that end, Dr. Tam guided us through the paperwork needed for taxes and certifications, re-organized our financial bookkeeping, and provided leadership at meetings. She was one of just a few members who underwent traditional Hawaiian protocol training with Dr. Kekuhi Kanahele in preparation for organizing the international Pacific Region Indigenous Doctors Congress in Hilo, Hawai‘i, in 2018 and was instrumental in establishing an endowed scholarship for Native Hawaiian medical and pre-medical students with Ke Ali‘i Pauahi Foundation. In addition, Dr. Tam provided mentorship and spent hours training her ‘Ahahui o Nā Kauka treasurer successor. Her hours of hard work balancing the books ensured a seamless transition for what traditionally has been a challenging role.

As a faculty member at the John A. Burns School of Medicine, Dr. Tam also played a key role in mentoring *kauka haumāna (*medical students). Former students and medical residents recall witnessing firsthand the power of her personal touch and calming voice at the bedside. Some say that Dr. Tam treated her students as her own *keiki* (children); she would call to check in, talk about life and *‘ohana* (family), and sometimes to scold. In addition, she emceed the annual Kihei graduation ceremony for graduating *Kānaka Maoli kauka haumāna* (Native Hawaiian medical students) for the past decade. As a pulmonologist and researcher, Dr. Tam advocated for public policy safeguarding lung health, including tobacco control and the role of volcanic air pollution and respiratory disease in *keiki* (children), ultimately finding little connection between vog and asthma.

In the 1990s, when female doctors were not as ubiquitous, Dr. Tam was a role model for other young *wāhine* (women), especially those aspiring to be *kauka* (physicians). She was frequently featured as a speaker at events that encouraged these dreams. She would later say, “My philosophy in all this is, as a mom, a teacher, and a physician, you get so that people don’t need you anymore. You push for this independence and empower them. That’s my goal.”

Dr. Tam’s vibrancy, beauty, legacy, and commitment to the next generation of healers will never be forgotten. We will remember her as our *Hokuho‘okelewa‘a,* our canoe-guiding star. In our times of *kaumaha* (sadness), we need only look up at night to see her: *A‘ā:* the brightest star in the sky. *Ola mau kou aloha iā mākou*, your everlasting love for us will never be forgotten.

Ka Mauli Ola: He Ha‘i Aloha no Kauka Elizabeth Tam
Na Kauka Nicole Mahealani Lum

The Breath of Life: A chant in loving memory for Dr. Elizabeth Tam

By Dr. Nicole Mahealani Lum, ‘Ahahui o Nā Kauka Association of Native Hawaiian Physicians board member

Uē kākou me ke ano
We weep in reverence

Hanohano ka wahine i ke ao
To honor the woman whose brilliance lit this world

Mai Māunuunu a ‘Ao‘aoa
From the Māunuunu wind of Wai‘alae, to the ‘Ao‘aoa wind of Kaka‘ako, and beyond,

Aloalo nō kona ‘ike loa
Her mastery & grace is well-known and cherished.

Anuanu ko‘u ho‘omaka ‘ana
In the beginning I was afraid, a new plant shoot emerging,

Lamalama i kona ‘a‘ā
But then I was enlightened and nourished by her warm glow.

Ua ‘ā akaaka
Shining brightly, as the moon and stars,

Ua a‘o a ‘aka‘aka
She shared her wisdom with such joy and kind laughter.

Nui ke aloha no ke kānaka
She had great love for the people she served.

He koa ho‘ōla
She was a warrior, a healer for our people,

He mauli ola
Giver of life, who breathed life into our people,

He aheahe ihola
Like a gentle trade wind, a breath of fresh air, coming down from the mountain,

Pale aku i ka uahi a pau
Pushing the stifling haze out to sea, until clear again.

Auē! Ua ahe, hanu pau
Alas! Just as humbly as she breathed on this earth, she quietly took her last breath.

Hanuʻu, hāneʻe
Ka una honua
The earth shifted, ever fluctuating,

Ua naue, ʻā pele
Trembling, erupting.

Ka makani ikaika
The winds roar,

Uē ka lani, uē kākou
The heavens weep, as we grieve

No ka meʻe wahine
I alakaʻi ai
For this admired woman who led the way.

E hoʻomālie ē
E kuʻu hulu, e lele ʻoe,
Hele mālie ē.
Rest now.
Our beloved friend, fly now,
Go peacefully.

Author Affiliations:
- Department of Pediatrics, University of Hawaiʻi John A. Burns School of Medicine, Honolulu, HI (KWR)
- Department of Native Hawaiian Health, University of Hawaiʻi John A Burns School of Medicine, Honolulu, HI (MK)
- Department of Family Practice, Hoʻola Lahui Hawaiʻi Kauaʻi Community Health Center, Lihue, HI (KCH)
- Department of Internal Medicine, Kaiser Permanente West Oahu Medical Office, Kapolei, HI (MI)
- H.K. Blaisdell-Brennan MD, Honolulu, HI (NBB)
- Ke Ola Mamo Clinic, Honolulu, HI (NL)

Hawai'i Journal of Health & Social Welfare (HJH&SW)

Guidelines for Publication of HJH&SW Supplements

The Hawai'i Journal of Health & Social Welfare (HJH&SW) partners with organizations, university divisions, and other research units to produce topic-specific issues of the journal known as supplements. Supplements must have educational value, be useful to HJH&SW readers, and contain data not previously published elsewhere. Each supplement must have a sponsor(s) who will work with the HJH&SW staff to coordinate all steps of the process. Please contact the editors at hjhsw@hawaii.edu for more information if you would like to pursue creating a supplement.

The following are general guidelines for publication of supplements:

1. Organizations, university divisions, and other research units considering publication of a sponsored supplement should consult with the HJH&SW editorial staff to make certain the educational objectives and value of the supplement are optimized during the planning process.

2. Supplements should treat broad topics in an impartial and unbiased manner. They must have educational value, be useful to HJH&SW readership, and contain data not previously published elsewhere.

3. Supplements must have a sponsor who will act as the guest editor of the supplement. The sponsor will be responsible for every step of the publication process including development of the theme/concept, peer review, editing, preliminary copy editing (ie, proof reading and first round of copy editing), and marketing of the publication. HJH&SW staff will only be involved in layout, final copy editing and reviewing final proofs. It is important that the sponsor is aware of all steps to publication. The sponsor will:

a. Be the point of contact with HJH&SW for all issues pertaining to the supplement.
b. Solicit and curate articles for the supplement.
c. Establish and oversee a peer review process that ensures the accuracy and validity of the articles.
d. Ensure that all articles adhere to the guidelines set forth in journal's Instructions to Authors page, especially the instructions for manuscript preparation and the statistical guidelines.
e. Obtain a signed Copyright Transfer Agreement for each article from all authors.
f. Comply with all federal, state, and local laws, rules, and regulations that may be applicable in connection with the publication, including ensuring that no protected health information appears in any article.
g. Work with the editorial staff to create and adhere to a timeline for the publication of the supplement.
h. Communicate any issues or desired changes to the HJH&SW staff in a timely manner.

4. Upon commissioning a supplement, the sponsor will be asked to establish a timeline for the issue which the sponsor and the HJH&SW editor(s) will sign. The following activities will be agreed upon with journal publication to take place no later than 24 months after signing. Extensions past the 24 months will be subject to additional fees based on journal publication rates at that time:

- Final date to submit a list of all articles, with working titles and authors
- Final date for submitting Word documents for copy editing
- Final date for submitting Word documents for layout
- Final date to request changes to page proofs (Please note that changes to page proofs will be made only to fix any errors that were introduced during layout. Other editing changes will incur an additional fee of $50 per page.)

5. The cost of publication of a HJH&SW supplement is $5,000 for an 8-article edition with an introduction from the sponsor or guest editor. Additional articles can be purchased for $500 each with a maximum of 12 articles per supplement. This cost covers one round of copy editing (up to 8 hours), layout, online publication with an accompanying press release, provision of electronic files, and indexing in PubMed Central, SCOPUS, and Embase. The layout editor will email an invoice for 50% of the supplement to the designated editor for payment upon signature of the contract. The remaining will be due at the time of publication. Checks may be made out to UCERA.

6. The sponsor may decide to include advertisements in the supplement in order to defray costs. Please consult with the HJH&SW advertising representative Michael Roth at 808-595-4124 or email rothcomm@gmail.com for assistance.

7. Supplement issues are posted on the HJH&SW website (http://www.hawaiijournalhealth.org) as a full-text PDF (both of the whole supplement as well as each article). An announcement of its availability will be made via a press release and through the HJH&SW email distribution list. Full-text versions of the articles will also be available on PubMed Central.

8. It is the responsibility of the sponsor to manage all editorial, marketing, sales, and distribution functions. If you need assistance, please contact the journal production editor. We may be able to help for an additional fee.

9. The editorial board reserves the right of final review and approval of all supplement contents. The HJH&SW will maintain the copyright of all journal contents.

— — — — — — — — — —

Sample Workflow and Timeline for a Supplement

1. The sponsor contacts the HJH&SW editors (hjhsw@hawaii.edu) to discuss the supplement topic, estimated timeline, length and cost. HJH&SW staff will review the journal requirements for articles and share our review process with the sponsor. **Time frame: 2 weeks**

2. The sponsor will complete the draft contract and pay a non-refundable deposit of $2500 or half the contract value. **Time frame: 3 days**

3. The sponsor will solicit articles for the supplement. **Time frame: 3-6 months**

Articles must comply with:

- Instructions for Manuscript Preparation and Submission of Research Articles
- Instructions for Manuscript Preparation and Submission of Columns
- HJH&SW Statistical Guidelines
- HJH&SW Style Guide for Native Hawaiian Words and Phrases
AMA Manual of Style A free summary can be found here.

4. The sponsor will oversee the article selection, peer review, and editing process. We recommend that time be allowed for at least two rounds of reviews for each article. **Time frame: 3-6 months**

- Ensure that each article includes Institutional Review Board (IRB) review and approval, and a statement disclosing any conflicts of interest.
- Obtain a Copyright Transfer Agreement signed by all authors for each article.

5. *Optional*: During this time, the sponsor can solicit advertisements for the supplement to help defray costs for publication and/or printing. To initiate this process, the sponsor will work the HJH&SW advertising representative Michael Roth at 808-595-4124 or rothcomm@gmail.com.

6. The sponsor or their designee will conduct a final review of each article to ensure adherence to HJH&SW guidelines and AMA style. **Time frame: 2 weeks**

7. For each article, the sponsor will submit the final Word document and Copyright Transfer Agreement to the HJH&SW journal production editor. The journal production editor will send the articles to the copy editor for final journal style review. Copyediting will be 8 hours per edition plus 1 hour per article for additional articles purchased. Any additional hours will be billed at $100 per hour. **Time frame: 2 weeks**

8. The sponsor will submit the final articles to the layout editor for formatting. **Time frame: 1 month**
Acting in the role of guest editor, the sponsor will include a column introducing the supplement.
IMPORTANT: All articles submitted for layout should be in their finalized form. Page proofs will be returned to the sponsor for their review and approval, but changes will only be made to fix any errors that were introduced during the layout process. Any editing or changes to the text or figures after the initial copy layout will incur a fee of $50 per page.

9. The sponsor will review the electronic copy from the layout editor and submit any final corrections. **Time frame: 5 working days**

10. The layout editor will make the final corrections and provide a finished electronic copy of the supplement to the sponsoring editors to allow time for printing.

11. The managing editor will work with the sponsor to draft a press release. Sponsors should contact the managing editor at least 30 days prior to the date of publication to plan and script the press release. Sponsors are encouraged to submit 1-2 photos to accompany the press release. Note that obtaining signed photo releases is the responsibility of the sponsor.

12. The supplement will be published online along with the press release. An electronic copy will be sent to our subscribers and circulation lists, and the edition will be forwarded to the National Library of Medicine for indexing and made available for no cost access to the public.

Revised 2/6/20

Hawai‘i Journal of Health & Social Welfare (HJH&SW)

Style Guide for the Use of Native Hawaiian Words and Diacritical Markings

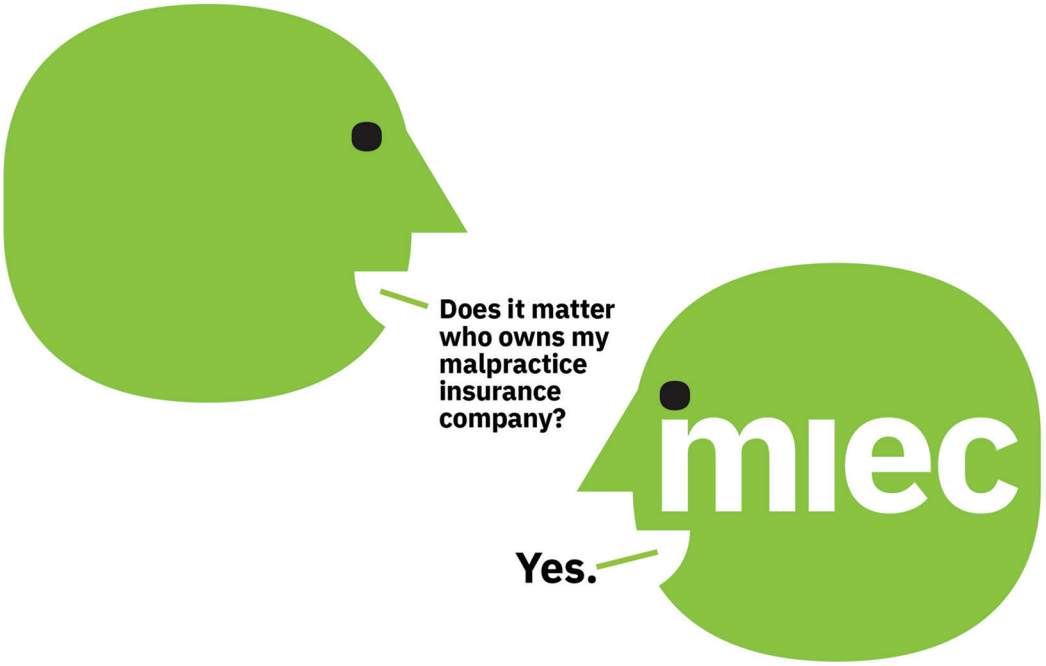
The HJH&SW encourages authors to use the appropriate diacritical markings (the ‘okina and the kahakō) for all Hawaiian words. We recommend verifying words with the Hawaiian Language Dictionary (http://www.wehewehe.org/) or with the University of Hawai‘i Hawaiian Language Online (http://www.hawaii.edu/site/info/diacritics.php).

Authors should also note that Hawaiian refers to people of Native Hawaiian descent. People who live in Hawai‘i are referred to as Hawai‘i residents.

Hawaiian words that are not proper nouns (such as *keiki* and *kūpuna*) should be written in italics throughout the manuscript, and a definition should be provided in parentheses the first time the word is used in the manuscript.

Examples of Hawaiian words that may appear in the HJH&SW:

‘āina	***Mānoa***
ali‘i	***Māori***
Hawai‘i	***Moloka‘i***
kūpuna	***O‘ahu***
Kaua‘i	***‘ohana***
Lāna‘i	***Wai‘anae***



As a reciprocal exchange, MIEC is entirely owned by the policyholders we protect. With no external shareholders to satisfy, this ownership model allows us to return profits to whom they rightfully belong—MIEC policyholders. We do not inflate our surplus or tie up profits in nonguaranteed deferred retirement plans, we give it back. Over the last 45 years we have put more than **$446 million** back in the pockets of our policyholders. To learn more about the benefits of being an MIEC policyholder, or to apply, visit **miec.com** or call **800.227.4527**.

Get a quote today.

Insurance by physicians, for physicians.™

miec

miec.com | 800.227.4527