# Characterizing Workplace Exposures in Vietnamese Women Working in California Nail Salons

Thu Quach, PhD, Robert Gunier, MPH, Alisha Tran, Julie Von Behren, MPH, Phuong-An Doan-Billings, Kim-Dung Nguyen, Linda Okahara, Benjamin Yee-Bun Lui, MD, Mychi Nguyen, MD, Jessica Huynh, and Peggy Reynolds, PhD

*Objectives.* We engaged Vietnamese nail salon workers in a community-based participatory research (CBPR) study to measure personal and area concentrations of solvents in their workplace.

*Methods.* We measured average work-shift concentrations of toluene, ethyl acetate, and isopropyl acetate among 80 workers from 20 salons using personal air monitors. We also collected area samples from 3 salons using summa canisters.

*Results.* For personal measurements, the arithmetic mean was 0.53 parts per million (range=0.02–5.50) for ethyl acetate, 0.04 parts per million (range=0.02–0.15) for isopropyl acetate, and 0.15 parts per million (range=0.02–1.0) for toluene. Area measurements were lower in comparison, but we detected notable levels of methyl methacrylate, a compound long banned from nail products. Predictors of solvent levels included different forms of ventilation and whether the salon was located in an enclosed building.

*Conclusions.* Using a CBPR approach that engaged community members in the research process contributed to the successful recruitment of salon workers. Measured levels of toluene, methyl methacrylate, and total volatile organic compounds were higher than recommended guidelines to prevent health symptoms such as headaches, irritations, and breathing problems, which were frequently reported in this workforce. (*Am J Public Health.* 2011;101:S271–S276. doi:10.2105/AJPH.2010.300099)

Nail care services has been a booming industry over the past 2 decades. According to industry estimates, the United States currently has more than 58 000 beauty salons and nearly 350 000 licensed nail technicians.[1] California, in particular, experienced the largest expansion in this sector; the number of licensed nail technicians grew nearly 3-fold from 35 500 in 1987 to 114 000 in 2007.[2] The growth of this service sector was also accompanied by significant demographic shifts in this workforce, with the proportion of Vietnamese nail technicians increasing from 10% in 1987 to 59% in 2002.[3]

The health and safety of workers in this industry drew public attention because of concerns about hazardous chemical ingredients in personal care products. Nail technicians handle solvents, glues, polishes, and other agents on a daily basis, exposing them to numerous chemicals, many of which are known or suspected to cause cancer, allergies, and respiratory, neurologic, and reproductive harm. Despite their heavy use, industrial chemicals in cosmetic products are largely unregulated in the United States. Of the 10 000 chemicals used in personal care products, nearly 90% have not been assessed for safety.[4]

The striking emergence of the nail salon industry, with a workforce composed largely of Vietnamese immigrant workers, combined with the lack of governmental regulation of compounds in cosmetics, underscores the complexity of worker health and safety issues in this vulnerable population. A primary concern lies with the heavy use of volatile compounds in poorly ventilated salons. Solvents such as toluene are used indiscriminately in this profession and pose a threat to workers because they are linked to adverse neurologic and reproductive effects as well as endocrine disruption.[5,6] Occupational exposure studies in nail salons are limited, and most are either decades old or were not conducted in the United States.[7–9] Thus, data to date have inadequately captured the complexities of this burgeoning industry, the changes in nail care services that are likely to result in changes in chemical use, and the changes in salon characteristics as the business expands.

In response to the growing concerns for the nail salon workforce, a community-research partnership between a cancer prevention research organization and a community health center serving indigent Asian populations was established to examine workplace exposure and prevalent health problems to inform worker health and safety promotion efforts. As an initial step to examining the relationship between workplace exposures and adverse health outcomes, we collected personal and area measurements of selected solvents in nail salons with Vietnamese workers. We intended this pilot project to provide descriptive information on solvent levels in nail salons and inhalation exposure among salon workers. Furthermore, we assessed the feasibility of engaging Vietnamese salon owners and workers, a group that has been historically understudied, for future research endeavors. This study is the first to focus on Vietnamese nail salon workers to collect personal and area air monitoring data along with relevant salon and worker characteristics.

## METHODS

We built this study on a developmental community-based participatory research project between a research organization and a community health center to characterize nail salon worker chemical exposures and health problems.[10] In addition, members of the California Healthy Nail Salon Collaborative, a large network of community advocates, public health experts, health practitioners, and environmental activists, provided input into the development of the study instruments, protocols, recruitment process, and interpretation of results.[11] We also

convened a community advisory committee composed of Vietnamese salon owners and workers to provide guidance on recruitment strategies and survey development.

We asked workers who participated in the study to wear a small personal air-monitoring device during their work shift. Each worker participant contributed 2 to 3 measurements on nonconsecutive work days. Participants also responded to a questionnaire that was administered by a bicultural and bilingual interviewer after each sampling event. In addition, we collected area samples in a few salons using stationary monitors. The study protocol was reviewed and approved by the institutional review board of the Cancer Prevention Institute of California. Air monitoring and survey administration were conducted between November 2008 and June 2009.

### Recruitment of Salons and Workers

We selected salons from different areas of Alameda County, California, through convenience sampling. To our knowledge, no rosters of nail salons with Vietnamese workers exist; our selection of salons was informed by our knowledge of and existing relationships with salon workers and owners. During recruitment, our staff first approached salon owners to explain the purpose of the study and what type of information would be collected from the salon and workers for the air-monitoring measurements. With permission from the owners, our staff then approached Vietnamese female workers in that salon to recruit them into the study. We based selection of worker participants in the salon on the workers present at the time and, in some cases, recommendations from salon owners.

The overall response rate for salons was 50%. Of the 20 salons in which owners and workers agreed to participate in the air-monitoring study, 13 (65%) shops agreed on a first visit by our staff. Midway through the recruitment phase, the study was publicized in local popular Vietnamese ethnic media, with a resulting increase in response rate from 30% to 75%.

### Description of the Salons and Work Performed

Our interview staff documented observational data about select salon characteristics during visits to collect the air-monitoring devices and administer the questionnaire. Staff measured the volume (cubic feet) of the salon using an ultrasonic tape measure to obtain the salon's length, width, and height. Other observational salon characteristics included whether the shop was in an enclosed building such as an indoor mall and the number of manicure and pedicure stations in the salon.

The staff administered the questionnaire at the end of each work shift when the air-monitoring device was worn. The questionnaire included information on the length of time that the worker wore the device, including any times when the worker may have taken it off to go outside the salon, the type and number of nail care services, the number of customers in the salon, and the different types and length of time that specific types of ventilation were used (e.g., table fan, ventilation table, roof fan, doors or windows open, and central ventilation system). In addition, we collected information about the workers, including demographics, work history, self-reported health problems, and use of protective work equipment (e.g., gloves and masks).

### Personal and Area Air Monitoring

To obtain personal air measurements, we measured time-weighted average concentrations during the work shift for toluene, ethyl acetate, and isopropyl acetate among worker participants using a passive organic vapor monitor (Organic Vapor Monitor 3500; 3M, St. Paul, Minnesota). The worker participant clipped the passive monitor on the collar of her shirt or coat to obtain samples near the breathing zone. We measured the temperature and relative humidity in the salon at the beginning of each monitoring period. Each participant wore the device for an entire work shift, with a minimum sampling time of 4 hours. We collected and sealed the air-monitoring devices at the end of each sampling event. The air-monitoring devices were stored at 4°C for up to 1 month until laboratory analysis.

Laboratory analysis was conducted by an American Industrial Hygiene Association–accredited laboratory (Columbia Analytical Services, Monrovia, California), using solvent desorption followed by gas chromatography and mass spectroscopy (GC–MS) to determine the mass collected on the charcoal absorbent.[12] Quality assurance procedures included field and solvent blanks to check for contamination, regular calibration with certified standards, and duplicate samples to determine measurement variability. We calculated personal air concentrations using the mass absorbed, sampling time, and diffusion coefficient for each compound. The method reporting limits for a sample collected over a typical sampling time of 360 minutes were 0.03 parts per million for toluene, ethyl acetate, and isopropyl acetate.

In addition to personal air monitoring, we also conducted area air monitoring in a few nail salons to quantify air concentrations for a more comprehensive set of volatile organic compounds. We collected area samples using 6-liter summa canisters in 3 randomly selected nail salons at which we had previously conducted personal air measurements. The summa canisters were placed near manicure or pedicure stations, and we sampled using a flow rate of 1 liter per hour for 6 hours at each salon. The canisters were analyzed by GC–MS at the same laboratory.[13] The method reporting limits for toluene and ethyl acetate were 0.002 parts per million.

### Data Analysis

We calculated standard descriptive statistics for the questionnaire and air-monitoring data, including mean, median, proportions, standard deviation, and range. Because personal air measurements were not normally distributed, we used nonparametric methods for statistical comparisons. We calculated Spearman rank correlation coefficients to examine continuous variables and used the Wilcoxon rank-sum test for categorical comparisons. We did not conduct categorical comparisons for isopropyl acetate because the levels were always at or near the method reporting limit. We set the statistical significance level to .05 and performed all analyses using SAS Version 9.1 (SAS Institute Inc., Cary, North Carolina).[14]

## RESULTS

We collected data from 80 Vietnamese female nail salon workers from 20 different nail salons. Each nail salon worker had 2 to 3 measurements (air monitoring and questionnaire completion), for a total of 167 measurements. Characteristics of the salons and worker

participants are shown in Table 1. Each salon had on average 4 worker participants and 8 personal air measurements. Half of the salons that participated were in the city of Oakland. Salons ranged, an order of magnitude in size, from approximately 127 to more than 1300 square feet, with a mean of 512 square feet. Six salons (30%) were located in enclosed buildings, and only 1 salon also offered hair care services. The mean worker age was 41 years and ranged from 21 to 67 years. On average, participants had worked in the nail salon sector for 8 years. One participant started working as early as 13 years old. Workers typically worked 35 hours per week, which, however, often included long (>8 hours) days. When asked whether workers had experienced certain health symptoms such as irritations, headaches, nausea, and breathing problems, approximately one third (31.3%) responded that they had experienced at least 1 of these symptoms after entering this workforce (Table 2). Irritations of the nose, throat, lungs, skin, and eyes were the most common symptoms reported (26.5%).

Measured personal concentrations of the 3 compounds were moderately correlated, with Spearman correlation coefficients between 0.21 and 0.55. Temperature was weakly correlated with toluene and isopropyl acetate levels. Sample time in minutes or percentage of relative humidity had no relationship with measured personal concentrations for any of the compounds.

Distributions of personal and stationary air-monitoring concentrations are shown in Table 3. For personal air measurements, the arithmetic mean for ethyl acetate was 0.53 parts per million (range=0.02–5.50); for isopropyl acetate, 0.04 parts per million (range=0.02–0.15); and for toluene, 0.15 parts per million (range=0.02–1.0). In comparison, area measurements were lower, with an arithmetic mean of 0.09 parts per million (range=0.02–0.15) for ethyl acetate and 0.04 parts per million (range=0.01–0.06) for toluene. Area monitoring also detected other volatile compounds, including methyl methacrylate in all 3 salons, with the highest level at 1.3 parts per million.

Results from our categorical analyses showed that salons using table ventilators had significantly lower measured personal levels of toluene and ethyl acetate (Table 4). Salons that were in an enclosed building had higher measured levels of both compounds. Salons using other forms of ventilation also had lower measured personal levels, including opening doors for toluene and the use of table or roof fans for ethyl acetate. However, worker participants who reported use of a central ventilation system had higher personal levels of ethyl acetate than those who did not. Workers who performed pedicures were more likely to have higher measured levels of ethyl acetate. We also found that those who performed silk nails and acrylic nails had lower personal levels of toluene and ethyl acetate, suggesting that

**TABLE 1—Descriptive Characteristics of Nail Salon Shops and Female Vietnamese Nail Salon Workers: Alameda County, CA, 2008–2009**

| Characteristics | Mean (Median; Range) or No. (%) |
|---|---|
| **Salons** | |
| Nail salons (n = 20) | |
| Volume (cubic ft) | 5882 (4754; 1158–14 853) |
| Area (square ft) | 512 (453; 127–1338) |
| No. of workers measured in salons (n = 80) | 4 (4; 1–8) |
| No. of measurements taken in salons (n = 167) | 8.35 (8; 2–16) |
| Nail salon participants (n = 80) | |
| Age, y, at survey | 41.3 (41; 21–67) |
| Age, y, at hire | 33.3 (32; 13–59) |
| No. of years worked as nail technician | 8 (7; 0.5–22) |
| No. of work hours per week | 35.4 (40; 20–60) |
| **Salon workers** | |
| Birthplace | |
| United States | 0 (0) |
| Vietnam | 80 (100) |
| Language spoken at home | |
| English | 0 (0) |
| Vietnamese | 80 (100) |
| Decade began working as nail technician[a] | |
| 1970–1979 | 3 (3.8) |
| 1980–1989 | 20 (25.3) |
| 1990–1999 | 31 (39.2) |
| 2000–2008 | 25 (31.6) |
| Manicure tables | |
| <5 | 9 (45) |
| ≥5 | 11 (55) |
| Pedicure stations | |
| <5 | 14 (70) |
| ≥5 | 6 (30) |
| Hair stations | |
| None | 19 (95) |
| ≥1 | 1 (5) |
| Geographic location | |
| Alameda | 2 (10) |
| Oakland | 10 (50) |
| Hayward | 2 (10) |
| Other area | 6 (30) |

[a]Missing n = 1.

**TABLE 2—Health Symptoms Experienced by Female Vietnamese Nail Salon Workers (n = 80) Since Performing Nail Care Services: Alameda County, CA, 2008–2009**

| Health Symptoms | No. (%) |
|---|---|
| Nose, throat, lung, skin, or eye irritation | |
| Yes | 21 (26.3) |
| No | 59 (73.8) |
| Headaches | |
| Yes | 1 (1.3) |
| No | 79 (98.8) |
| Nausea | |
| Yes | 4 (5.0) |
| No | 76 (95.0) |
| Increased pulse rate | |
| Yes | 1 (1.3) |
| No | 79 (98.8) |
| Confusion | |
| Yes | 2 (2.5) |
| No | 78 (97.5) |
| Coughing[a] | |
| Yes | 4 (5.1) |
| No | 75 (94.9) |
| Shortness of breath | |
| Yes | 7 (8.8) |
| No | 73 (91.3) |
| Chest tightness | |
| Yes | 2 (2.5) |
| No | 78 (78.0) |
| Any listed health symptoms | |
| Yes | 25 (31.3) |
| No | 55 (68.8) |

[a]Missing n = 1.

products used for these services may not contain those compounds or contain lower levels.

## DISCUSSION

The complexities of this largely immigrant workforce, characterized by chronic exposure to several different compounds, and the lack of governmental oversight in chemical regulation in cosmetics and worker health surveillance, underscore the challenges but importance of evaluating exposures in this hard-to-reach population. By applying a community-based participatory research approach that engaged community advocates and members in our research process, we were successful in recruiting participants from this vulnerable population and in beginning to understand some of the hazards they face in their workplace.

Measured personal concentrations in this study were similar to personal measurements from a recent study in California for toluene,[15] higher than those measured in Europe for both toluene and ethyl acetate,[9,16] but lower than toluene levels measured in the United States 20 years ago.[8] Personal air-monitoring levels were higher than stationary air-monitoring levels. Stationary monitors are sensitive to placement in the salon, and personal air monitors placed on the shirt collar of the worker are closer to the source and better reflect worker exposure. Previous studies using stationary monitors may have underestimated worker exposures, even when stationary monitors were placed close to the worker's breathing zone.[9,16]

All measured values were much less than the occupational limits set by the California Division of Occupational Safety and Health.[17] However, the average measured level of toluene from personal air monitoring was higher than the California Environmental Protection Agency's recommended ambient air levels of 0.08 parts per million.[18] In 1974, the Food and Drug Administration identified methyl methacrylate as a hazardous substance and banned its use in adhesives for cosmetic nail products.[19] Yet, in our study the average measured level of methyl methacrylate was 0.54 parts per million, which is more than 3 times higher than the US Environmental Protection Agency's recommended ambient air levels of 0.17 parts per million.[20] Moreover, the levels of total volatile organic compounds measured using area samples were much higher than recommended guidelines ($<0.2$ mg/m$^3$) in indoor air for nonindustrial workers and may explain some of the health symptoms reported by workers in this study.[21–23] Although concentrations from area samples were less than those from personal samples, the concentration of total volatile organic compounds from our area samples were in the range (3–25 mg/m$^3$) at which discomfort is expected and complaints of health symptoms, including headaches and irritations of the eyes, nose, and throat, are common.[22]

When asked whether they experienced select acute health symptoms after they began working in the nail care industry, one third of our study participants responded positively. The highest prevalence was for irritations of the eyes, nose, throat, and skin, with more than one quarter reporting experiencing such symptoms. In our previous survey of 201 Vietnamese nail salon workers in Alameda County, California, we found that 47% of workers reported health symptoms potentially related to solvent exposure.[10] Yet, despite the high prevalence in both studies, we suspect that this figure is still an underestimate of the

**TABLE 3—Distribution of Personal and Area Monitoring Solvent Concentrations Among Female Vietnamese Nail Salon Workers: Alameda County, CA, 2008–2009**

| Solvents | No. of Salons | No. of Measurements | Mean ±SD (Range), ppm |
|---|---|---|---|
| Personal air monitoring | | | |
| Ethyl acetate | 20 | 167 | 0.53 ±0.71 (0.02-5.50) |
| Isopropyl acetate | 20 | 167 | 0.04 ±0.02 (0.02-0.15) |
| Toluene | 20 | 167 | 0.15 ±0.15 (0.02-1.0) |
| Stationary air monitoring | | | |
| Acetone | 3 | 3 | 3.10 ±3.20 (0.31-6.60) |
| Butyl acetate | 3 | 3 | 0.03 ±0.02 (0.01-0.06) |
| Ethyl acetate | 3 | 3 | 0.09 ±0.06 (0.02-0.15) |
| Isopropyl alcohol | 3 | 3 | 0.82 ±1.03 (0.06-2.0) |
| Methyl methacrylate | 3 | 3 | 0.54 ±0.66 (0.12-1.30) |
| Toluene | 3 | 3 | 0.04 ±0.03 (0.01-0.06) |

**TABLE 4—Univariate Analysis of Personal Monitoring Concentrations and Categorical Variables Among Female Vietnamese Nail Salon Workers: Alameda County, CA, 2008–2009**

| Variable and Categories | Proportions, % | Toluene | | Ethyl Acetate | |
|---|---|---|---|---|---|
| | | Mean (SD), ppm | *P* | Mean (SD), ppm | *P* |
| Doors open in salon | | | <.001 | | .98 |
| Yes | 73 | 0.13 (0.13) | | 0.59 (0.81) | |
| No | 27 | 0.20 (0.18) | | 0.39 (0.32) | |
| Windows open in salon | | | .35 | | .61 |
| Yes | 10 | 0.14 (0.07) | | 0.14 (0.07) | |
| No | 90 | 0.15 (0.16) | | 0.52 (0.72) | |
| Table vent used by worker | | | <.001 | | <.001 |
| Yes | 8 | 0.03 (0.01) | | 0.14 (0.08) | |
| No | 92 | 0.16 (0.15) | | 0.57 (0.73) | |
| Roof fan used in salon | | | .77 | | .03 |
| Yes | 4 | 0.10 (0.05) | | 0.18 (0.05) | |
| No | 96 | 0.15 (0.15) | | 0.54 (0.72) | |
| Table fan used by worker | | | .79 | | <.001 |
| Yes | 92 | 0.15 (0.16) | | 0.40 (0.38) | |
| No | 8 | 0.12 (0.06) | | 2.05 (1.57) | |
| Central ventilation system used in salon | | | .07 | | <.001 |
| Yes | 28 | 0.17 (0.17) | | 0.98 (1.15) | |
| No | 72 | 0.14 (0.14) | | 0.35 (0.29) | |
| Waxing performed by worker | | | .44 | | .46 |
| Yes | 21 | 0.19 (0.20) | | 0.43 (0.51) | |
| No | 79 | 0.14 (0.13) | | 0.56 (0.76) | |
| Silk nails performed by worker | | | .005 | | .01 |
| Yes | 10 | 0.08 (0.07) | | 0.28 (0.33) | |
| No | 90 | 0.16 (0.15) | | 0.56 (0.74) | |
| Acrylic nails performed by worker | | | .68 | | .02 |
| Yes | 78 | 0.16 (0.16) | | 0.41 (0.40) | |
| No | 22 | 0.12 (0.08) | | 0.98 (1.25) | |
| Pedicure performed by worker | | | .46 | | .03 |
| Yes | 77 | 0.15 (0.16) | | 0.60 (0.79) | |
| No | 23 | 0.15 (0.12) | | 0.30 (0.22) | |
| Manicure performed by worker | | | .09 | | .40 |
| Yes | 72 | 0.14 (0.15) | | 0.59 (0.82) | |
| No | 28 | 0.17 (0.15) | | 0.37 (0.29) | |
| Salon in enclosed building structure | | | .02 | | .003 |
| Yes | 26 | 0.18 (0.17) | | 0.97 (1.18) | |
| No | 74 | 0.14 (0.14) | | 0.37 (0.33) | |
| Gas station near salon | | | .23 | | .27 |
| Yes | 56 | 0.17 (0.18) | | 0.62 (0.90) | |
| No | 44 | 0.12 (0.08) | | 0.42 (0.33) | |

*Note.* Univariate analyses performed using the Wilcoxon rank-sum test.

overall prevalence of health problems in this workforce because many workers have likely already left the workforce because of problematic health symptoms.

Nail salon workers and owners have a prevailing distrust of regulatory agencies because most of their interactions have focused on penalizing workers and owners for violations of standards in the workplace. Workers often complain that they do not always understand why they are being cited.[24] Thus, we initially encountered some challenges in engaging their participation in our research study. However, the partnership with a well-known community health center that had a long history of serving this population helped to address some of the challenges and to alleviate some of the perceived threat to workers' job security in participating in a research project of this nature. Furthermore, our use of ethnic media helped to inform workers of the purpose of our study and served to enhance study participation.

We applied a right-to-know principle in which we communicated results to study participants to inform them of their exposures and to help promote future efforts to reduce their workplace exposure. After obtaining air-monitoring results, we communicated grouped results to worker participants and salon owners and made recommendations on how they could lower their exposures. We reported grouped results rather than individual results to safeguard individuals and salon owners from any liability.

As a preliminary exploration, our study had some limitations worth noting. The small number of participating salons and salon workers and convenience sampling may have resulted in a study population that was not representative of all nail salons and workers in California or the United States. We focused on airborne exposures to solvents and measured only a few compounds, although several other compounds may also be of high concern in this workforce. We did not address skin absorption, which may be an important route of exposure to solvents and could also contribute to the health problems reported in our study. Our questions about health symptoms were brief and did not include questions about chronic health problems. Thus, we could not assess the type and extent of health problems that may be associated with chronic exposures to these compounds and the synergistic effects from the numerous compounds handled by workers. Overall, we intended this study to provide a descriptive overview of inhalation exposures, which are of high concern, and provide some insight into the feasibility of recruiting Vietnamese immigrant workers into

research studies that can help inform future targeted outreach efforts.

Future analyses will include the use of mixed-effects models to account for correlation between measurements taken within the same worker over time and between workers in the same nail salon. Ultimately, this information can inform future research efforts, such as a cohort study on chronic health effects and a randomized intervention trial to evaluate the effectiveness of training both nail salon workers and owners in ways to reduce workplace chemical exposures.

Our study highlighted the importance of identifying appropriate recruitment and monitoring strategies to characterize workforce exposures in this immigrant population, and it could not have been accomplished without active collaboration between the research and community partners. Our study findings highlight, the need to go beyond the traditional approach of comparing measured values with existing occupational exposure limits, which were set decades ago and do not take into account changes in the industry. These standards are also based on serious health outcomes (e.g., death or cancer) and do not address other health symptoms that may be early warning signs of more serious health problems to come. Our findings underscore the need for more attention to preventive public health strategies for this workforce. Recommendations to promote worker health and safety include policy changes to update occupational exposure limits that take into account various chronic health conditions, better regulatory oversight of chemicals in cosmetic products, and more research focused on the health of understudied and vulnerable worker populations. ■

## About the Authors

*Thu Quach, Robert Gunier, Julie Von Behren, and Peggy Reynolds, are with the Cancer Prevention Institute of California, Berkeley. Alisha Tran, Phuong-An Doan-Billings, Kim-Dung Nguyen, Linda Okahara, Benjamin Yee-Bun Lui, and Mychi Nguyen are with Asian Health Services, Oakland, CA. At the time of the study Jessica Huynh was with the University of California, Berkeley.*

*Correspondence should be sent to Thu Quach, PhD, MPH, Cancer Prevention Institute of California, 2001 Center Street, Suite 700, Berkeley, CA 94704 (e-mail: thu.quach@cpic.org). Reprints can be ordered at http://www.ajph.org by clicking the "Reprints/Eprints" link.*

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## Contributors

T. Quach conceptualized and supervised the study, conducted some of the data analysis, and led the writing of the article. R. Gunier and J. Von Behren conducted the data management and data analysis. A. Tran collected all the data and helped in the results interpretation and communication. P. A. Doan-Billings, K. D. Nguyen, and L. Okahara provided significant input in the interpretation of the results and the writing of the article. Given their knowledge of the workforce members. B. Y.-B. Lui and M. Nguyen provided critical input in the results interpretation. J. Huynh entered the data and assisted in analysis and results interpretation. P. Reynolds, who was the principal investigator of the study, provided overall scientific direction for the project, including survey development, data collection, data analysis, and results interpretation. All authors contributed to the writing of the article.

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## Human Participant Protection

This study was reviewed and approved by institutional review board of the Cancer Prevention Institute of California.

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