Brenner N, Ishikawa K, Graham A, et al. Maternal Health Trends and Disparities in Hawai'i: Visualizing Pregnancy Risk Assessment Monitoring System Data Through an Interactive Shiny Web Application. *Hawaii J Health Soc Welf*. 2026;85(11):315-322. doi:10.62547/DBYW5314

Maternal Health Trends and Disparities in Hawai'i: Visualizing Pregnancy Risk Assessment Monitoring System Data Through an Interactive Shiny Web Application

Noa Brenner, BS[1], Kyle Ishikawa, MS[1], Ashley Graham, BS[2], April Binari, MBA[2], Elizabeth Mercer, MD[2], Men-Jean Lee, MD[2], Hyeong Jun Ahn, PhD[1]

[1] Department of Quantitative Health Sciences, University of Hawai'i John A. Burns School of Medicine, [2] Department of Obstetrics and Gynecology, University of Hawai'i John A. Burns School of Medicine

Keywords: Hawai'i, PRAMS, maternal health, health disparities, Shiny App

https://doi.org/10.62547/DBYW5314

Abstract

Significant racial and socioeconomic disparities persist in maternal health outcomes in Hawai'i, particularly among Native Hawaiian, Pacific Islander, and other historically marginalized populations. While the Pregnancy Risk Assessment Monitoring System (PRAMS) offers robust maternal health surveillance data, few tools exist to dynamically explore this information at the state level. The objective of this study was to develop and deploy an interactive data visualization tool using Hawai'i PRAMS data to examine maternal health patterns stratified by race, education level, and socioeconomic status. The authors developed an R Shiny web application using publicly available PRAMS data from 2000 to 2022 (Phases 4–8). The application includes a trend-display tab using survey-weighted estimates and a logistic regression tab examining adjusted associations between demographic factors and maternal outcomes. Both features account for the complex survey design. A total of 32 710 responses were analyzed. The application displayed differences across racial, educational, and socioeconomic groups, while cross-phase comparisons were treated as exploratory because questionnaire items and coding changed over time. Multivariable logistic regression identified associations between demographic characteristics and selected maternal health outcomes. This tool offers an accessible platform for exploring maternal health data in Hawai'i and supports hypothesis generation and data-informed discussion among researchers, public health professionals, and policymakers.

Abbreviations and Acronyms

ARF = PRAMS Automated Research File
NHPI = Native Hawaiian and Pacific Islander
OR = odds ratio
PRAMS = Pregnancy Risk Assessment Monitoring System
PSU = primary sampling unit
SES = socioeconomic status

Introduction

The Pregnancy Risk Assessment Monitoring System (PRAMS) is a nationwide, state-based surveillance system conducted by the Centers for Disease Control and Prevention (CDC) in collaboration with state health departments. PRAMS collects information on maternal behaviors, conditions, and experiences before, during, and after pregnancy.[1,2] In Hawai'i, approximately 200 mothers are selected each month from birth certificate files.[3] Selection uses a site-specific stratified random sampling plan, with geographic and other subpopulations sampled at different rates to support reliable jurisdictional estimates.[2,3] Hawai'i PRAMS uses separate state- and county-level analysis weights to support both types of reporting. The present analysis used the state-level weight released in the PRAMS Automated Research File (ARF); the county-level weight was not included in that file.

Hawai'i's unique multiethnic population makes it a particularly important case study for understanding maternal racial health disparities. National pregnancy-related research may not fully capture Hawai'i's diverse maternal health experiences. Local analyses using Hawai'i PRAMS data are essential for developing targeted interventions, given persistent racial disparities in maternal outcomes. Previous research studies have documented significant disparities in postpartum depression, gestational diabetes mellitus, and preeclampsia among Native Hawaiian and Pacific Islander (NHPI) populations.[4-6] Such disparities highlight the need for accessible, interactive tools that enable both clinicians and researchers to explore maternal and infant health trends in Hawai'i.

Critical gaps remain in the dissemination of PRAMS data, particularly in interactive and customizable formats. National PRAMS resources include static summaries such as Selected Maternal and Child Health Indicators by Site.[7] The Hawai'i Department of Health produces reports, and the Hawai'i Health Data Warehouse (HHDW) PRAMS dashboard provides weighted estimates and customizable filters.[8,9] These resources primarily present summary statistics and do not offer user-specified survey-weighted regression. To complement these resources, the study team developed a web application that provides stratified visualizations and regression outputs from the Hawai'i subset of the CDC public-use ARF. The publicly available Hawai'i PRAMS Data Explorer was deployed using shinyapps.io.[10]

Methods

Overview of the Shiny Application Framework

The interactive Shiny application was designed to provide an accessible, user-friendly interface for exploring Hawai'i PRAMS data. The app consists of multiple tabs supporting different analytical functions. Upon launching the application, users are first greeted by an "About" page, which provides a brief overview of the app's purpose and features. The 2 primary analytical components of the app include a trend analysis tab and a multivariable logistic regression tab, each allowing for survey-weighted exploration of the PRAMS dataset.

Help dialogs are available throughout the application, and users can export selected plots as HTML, PNG, or PDF files. HTML downloads retain plot interactivity.

PRAMS Data

The primary manuscript analyses used cross-sectional PRAMS data for Hawai'i from 2000 through 2022: Phase 4 (2000–2003), Phase 5 (2004–2008), Phase 6 (2009–2011), Phase 7 (2012–2015), and Phase 8 (2016–2022).[1] The 2017 Hawai'i survey year was excluded because the state did not deem it valid for reporting; data was not collected in 2018. PRAMS datasets were accessed through the CDC ARF portal.[1] The files were de-identified and contained no directly identifying information. *Note:* The application screenshots in **Figures 3** and **4** include an illustrative 2023 (Phase 9) output; that display is identified separately and is not included in the cross-phase results summarized in the text.

The ARF was restricted to respondents from Hawai'i. Demographic variables included maternal race/ethnicity, education, and socioeconomic status (SES). Income-based SES categories were defined separately within each phase and were not treated as absolute equivalents across phases. For example, Phase 8 categories were low (<$37 000), middle ($37 000–$84 000), and high (>$84 000); Phase 7 categories were low (<$43 000), middle ($43 000–$77 000), and high (>$77 000). Accordingly, SES displays represent approximate within-phase rankings.

Maternal conditions and behaviors were defined from released PRAMS questionnaire or analytic variables for diabetes, hypertension, depression, asthma, smoking, alcohol use, intimate partner violence, and insurance. **Supplementary Table S1** lists the application variables, their definitions, phase availability, and restrictions on cross-phase comparison. Availability in multiple phases was not considered sufficient evidence of comparability; variables with material changes in wording, recall period, or coding were limited to comparable periods or displayed cross-sectionally. The 2019 cycle had a substantially smaller sample than adjacent years, increasing uncertainty. Estimates with fewer than 30 unweighted observations were suppressed.

Statistical Methods

PRAMS uses jurisdiction-specific stratified sampling and survey weighting.[2] Hawai'i program data include separate analysis weights for state- and county-level reporting. The national ARF used for this study contains the state analysis weight, which accounts for sampling probabilities, nonresponse, and noncoverage; the released stratification variable was also incorporated. Because the county-level weight is not included in the national ARF, county-level analyses were not performed. Survey-weighted variances were estimated with Taylor series linearization.

Weighted proportions were estimated for maternal health indicators by demographic group and year. Survey-weighted logistic regression models used binary outcomes and selected demographic predictors; adjusted odds ratios (ORs), 95% confidence intervals (CIs), and *P* values were reported. These analyses were implemented with the same survey-design object used throughout the application.

Missing observations were handled by complete-case analysis separately for each display or model. Because users can select different outcomes, stratifiers, phases, and predictors, the number and percentage excluded are analysis-specific rather than a single fixed value. The application displays the unweighted analytic denominator for each trend estimate, and regression outputs use all records complete for the selected model. Multiple imputation was not performed because the application was designed for exploratory visualization and model demonstration rather than confirmatory inference.

Descriptive statistics were calculated to summarize participant demographics and key maternal health indicators across survey years. These statistics provide an overview of the sample demographic characteristics, including race, education, and SES. For these variables, sample size counts and frequencies (percentages) were calculated.

Shiny App Features

The second tab provides a user-selection panel for the trend tool (**Figure 1**) and an interactive trend graph (**Figure 2**). Users select a maternal indicator and a stratifier such as race/ethnicity, education, or SES. Each point represents a survey-weighted percentage for a year-by-subgroup cell. The graph displays 95% CIs, and the interactive tooltip reports the year, subgroup, estimate, and unweighted analytic denominator. Cells with fewer than 30 unweighted observations are suppressed. Cross-phase displays are exploratory and are restricted or discouraged when questionnaire wording, coding, or construct definitions changed across phases. The trend tool also permits simultaneous display of 2 or 3 selected variables. These visual comparisons are intended for exploratory use and do not constitute formal tests of temporal change.

The third tab provides survey-weighted multivariable logistic regression. Users select an outcome, predictors, and 1 of 3 phase ranges: Phase 8, Phases 6–8, or Phases 4–8. Results are presented as a regression table with a mini forest plot (**Figure 3**) and as a forest plot (**Figure 4**). Binary outcomes use "No" or 0 as the reference category. **Figure 3** and **Figure 4** show illustrative application outputs using 2016 and 2019–2023; 2017 and 2018 are absent. The 2023 observation belongs to Phase 9 and is shown only as part of the application demonstration, not the Phase 4–8 cross-phase

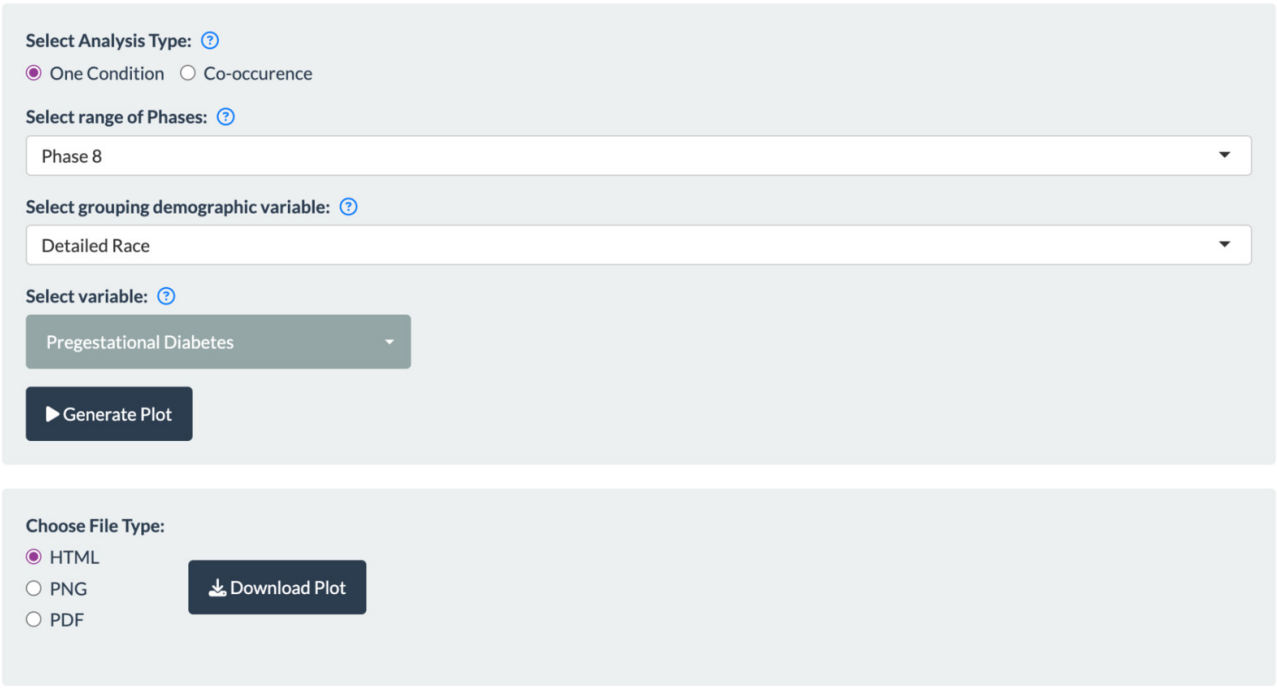

Figure 1. Example User-selection Panel Showing a Phase 8 Selection.

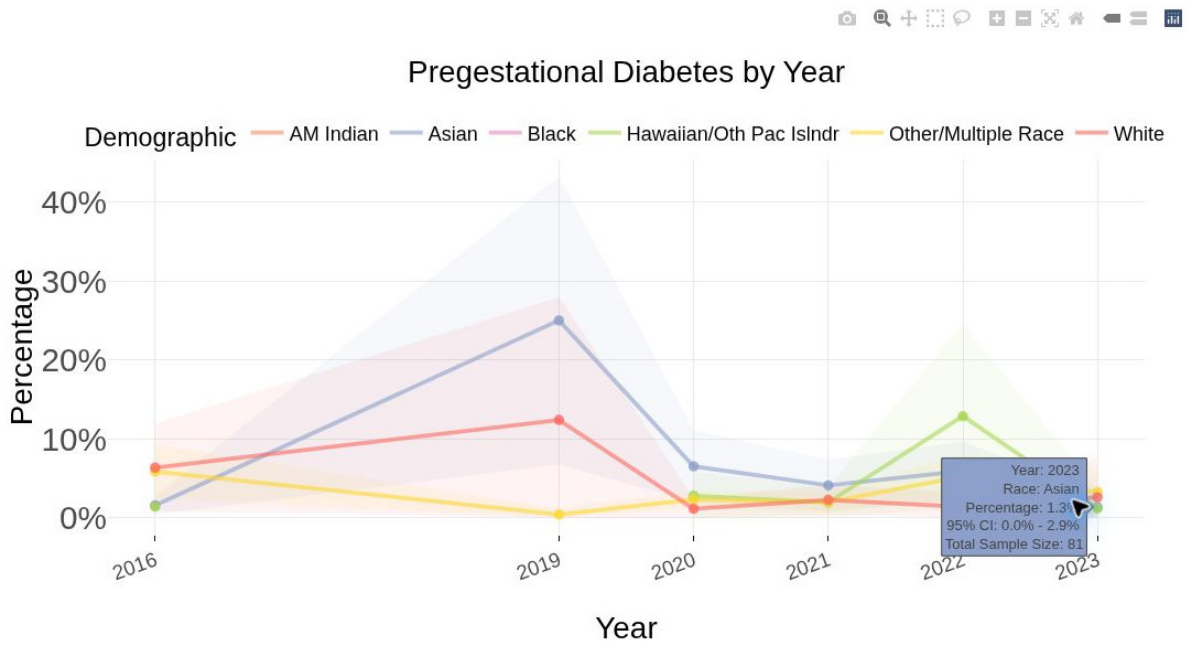

Figure 2. Screenshot of the Interactive Pregestational Diabetes Display by Race/Ethnicity, with the Tooltip Open for Asian Respondents in 2023.[a,b]

[a]Figure 2 is a separate Phase 9 tooltip demonstration and is not the output generated from Figure 1 selection
[b]The 2023 point is a Phase 9 demonstration and is not pooled with Phase 4–8 summaries; 2017 and 2018 are absent.

analyses summarized in the manuscript. **Figure 1** and **Figure 2** are separate illustrative screenshots: **Figure 1** shows a Phase 8 selection, whereas **Figure 2** shows a 2023 Phase 9 output solely to demonstrate the tooltip.

Software and Packages

All analyses and application components were implemented in R version 4.4.1 (R Foundation for Statistical Computing, Vienna, Austria).[11] The survey package specified the released PRAMS survey-design variables and fit survey-weighted models.[12] The *gtsummary* package created

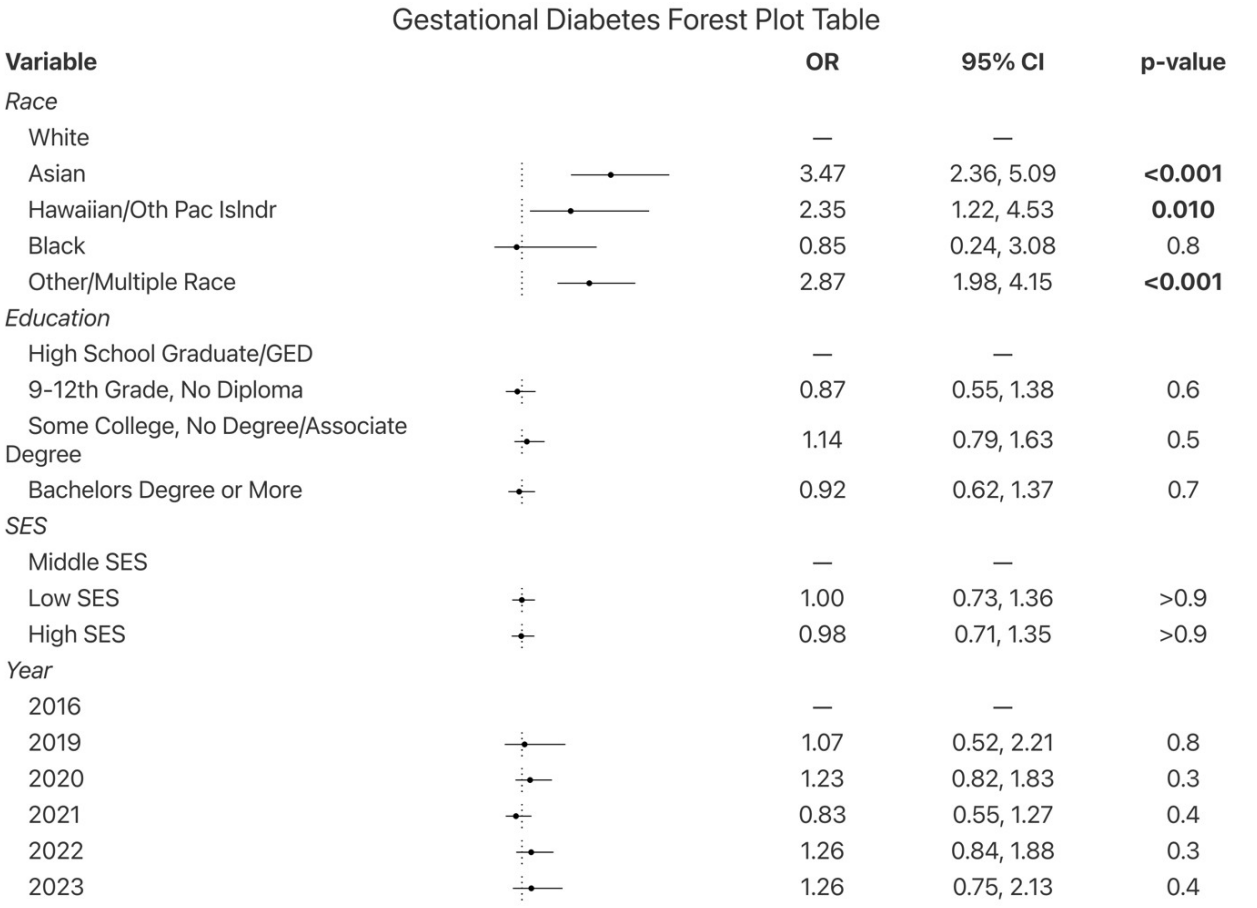

Figure 3. Illustrative Survey-Weighted Logistic Regression Output for Gestational Diabetes, Including Race/Ethnicity, Education, Phase-specific SES, and Year.[a]

[a] Years 2017 and 2018 are absent, and 2023 is Phase 9 and is shown only as an application demonstration. Columns display predictors, mini forest plots, ORs, 95% CIs, and *P* values.

descriptive and regression summaries,[13] *tidyverse* packages supported data management and plotting,[14] *gt* generated display tables,[15] and *Shiny* provided the web application framework.[16] These are R software packages executed by the application; CDC does not designate or approve specific software packages. Methodological compliance depends on correctly applying the released PRAMS design variables, weights, and reporting rules. Statistical significance was defined as $P<.05$.

Results

A total of 32 710 Hawai'i respondents from Phases 4–8 were included. Overall, 64.9% were represented in the national ARF category Asian/Pacific Islander, 22.1% as White, and 10.3% as Other/Multiple Race. College graduates comprised 29.6% and high school graduates 35.1% of respondents; 49.0% were classified as low SES under phase-specific cut points. Apparent changes in race/ethnicity composition across phases were not interpreted as population trends because the national ARF aggregation of Hawai'i race categories changed over time. Similarly, education was not compared across the 2014 birth-certificate change.

Exploratory Trend Analysis

Exploratory trend displays showed year-to-year variability in several indicators. Estimates for 2019 were notably imprecise because of the reduced sample. No formal test was performed to determine whether the 2019 values were sampling artifacts; they were therefore interpreted cautiously and not treated as evidence of abrupt population change. Pregestational diabetes was not trended across the 2009 questionnaire change, and variables with other material wording changes were restricted as detailed in **Supplementary Table S1**. The application therefore supports visual exploration while emphasizing CIs, analytic denominators, and phase-specific interpretation.

Multivariable Logistic Regression

Survey-weighted logistic regression across available comparable data examined pregestational diabetes, gestational diabetes, chronic hypertension, and intimate partner violence. In these exploratory models, the Asian/Pacific Islander and Other/Multiple Race categories had higher odds of selected diabetes outcomes than the White category. The Asian/Pacific Islander category had higher odds of preges-

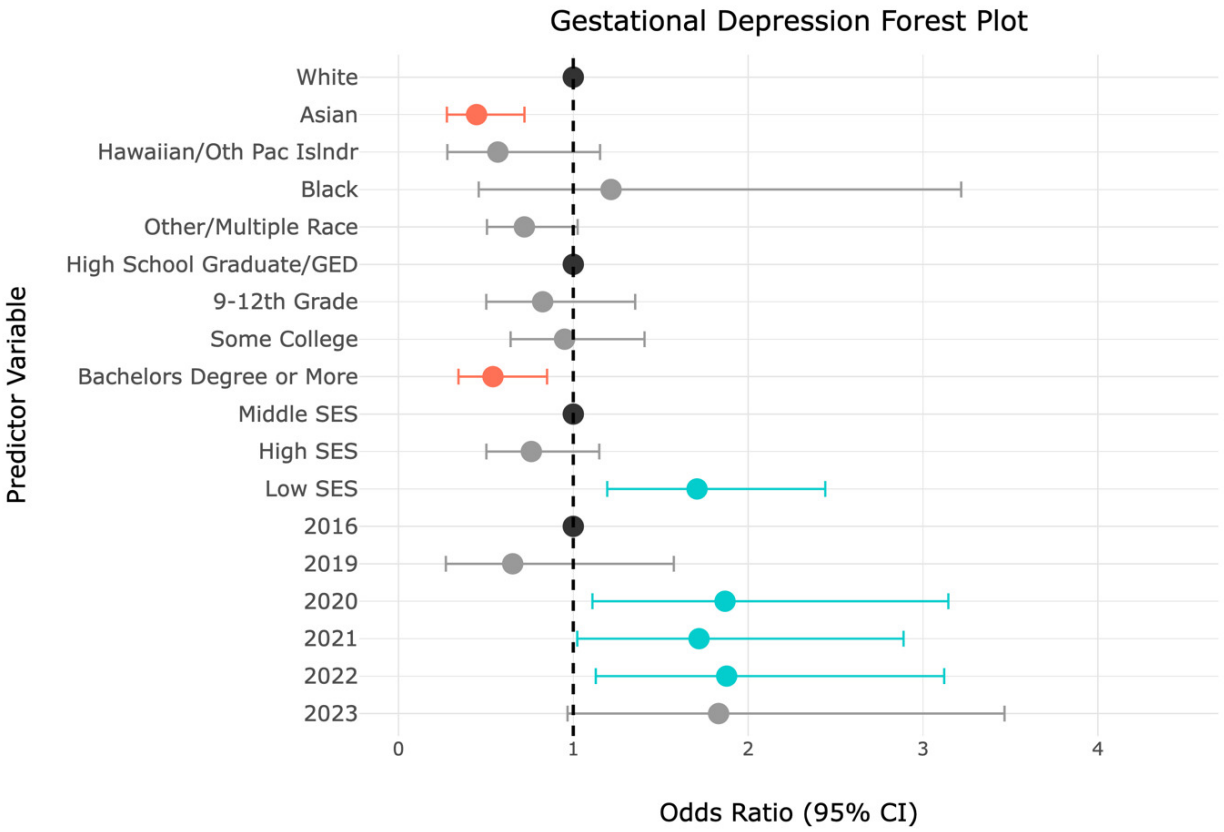

Figure 4. Illustrative Survey-Weighted Logistic Regression Output for the Application-Defined Depression Outcome[a] Including Race/Ethnicity, Education, Phase-specific SES, and Year[b]

[a]PRAMS depression items refer to phase-specific periods before or after pregnancy, so the label "Gestational Depression" should not be interpreted as a harmonized cross-phase construct.

[b] Years 2017 and 2018 are absent, and 2023 is Phase 9 and is shown only as an application demonstration. Points show adjusted ORs and horizontal lines show 95% CIs; color indicates statistically significant decreased (orange) or increased (blue) odds, and black points denote reference categories.

tational diabetes (OR=2.67; 95% CI, 1.86–3.83), and the Other/Multiple Race category had higher odds of intimate partner violence (OR=2.47; 95% CI, 1.47–4.14). A bachelor's degree or higher was associated with lower odds of pregnancy-induced hypertension (OR=0.75; 95% CI, 0.64–0.87) and intimate partner violence (OR=0.45; 95% CI, 0.33–0.63) than a high school education. These estimates should be interpreted within the relevant phase and variable definitions.

In the recent-year application output, Asian, NHPI, and Other/Multiple Race respondents had higher odds of gestational diabetes than White respondents (**Figure 3**). Adjusted ORs were 3.47 (95% CI, 2.36–5.09) for Asian respondents, 2.35 (95% CI, 1.22–4.53) for NHPI respondents, and 2.87 (95% CI, 1.98–4.15) for Other/Multiple Race respondents. Lower SES was associated with higher odds of the app-defined depression outcome (OR=1.71; 95% CI, 1.19–2.44) than middle SES (**Figure 4**). Because "gestational depression" is not a standard PRAMS construct and depression questions refer to phase-specific periods before or after pregnancy, this application label is interpreted only as the exact underlying item for the selected phase. No substantive conclusion was drawn from the isolated 2019 year coefficient because of the reduced sample.

Regarding insurance type, Asian and Other/Multiple Race respondents had higher odds of job-based insurance or Medicaid than White respondents. Black respondents had higher odds of military insurance (OR=4.66; 95% CI, 2.25–9.65), and NHPI respondents had higher odds of Medicaid coverage (OR=2.25; 95% CI, 1.28–3.95), compared with White respondents (*data not shown*).

Discussion

This study demonstrates how an interactive R Shiny application can make the Hawai'i subset of the national PRAMS ARF easier to explore. The tool combines survey-weighted descriptive displays with user-selected regression outputs. Its principal contribution is access and hypothesis generation; it does not replace Hawai'i-specific analyses using the state's more granular race/ethnicity data and county-level weights.

Limitations

This study has several limitations. PRAMS questionnaires and coding changed across phases, so data availability alone does not establish trend comparability. Pregestational diabetes was not compared across the 2009 item

change, postpartum depression questions changed across phases, intimate partner violence items changed, and maternal education was affected by the 2014 birth-certificate revision. Income was unavailable in Phase 4, and phase-specific income cut points provide only approximate relative SES rankings. The analysis used the Hawai‘i subset of the national CDC ARF rather than Hawai‘i-specific files; consequently, the more granular local race/ethnicity categories and county-level weights were unavailable. The 2017 survey year was excluded, data was not collected in 2018, and the reduced 2019 sample produced unstable estimates. Cells with fewer than 30 unweighted observations were suppressed. Missing-data exclusions varied by user-selected analysis, and multiple imputation was not performed. Formal external validation against matching CDC or HHDW estimates was not completed. PRAMS questionnaires are only available in English and Spanish,[1] and survey participation may therefore underrepresent respondents who prefer other languages. Finally, the illustrative application screenshots include a 2023 Phase 9 output, which was not pooled into the manuscript's Phase 4–8 cross-phase summaries.

Public Health Implications

The application can help researchers, public health professionals, and community organizations generate stratified state-level displays and exploratory models. Findings should be interpreted alongside Hawai‘i-specific reports and, when county or granular race/ethnicity inference is required, confirmed with Hawai‘i program data and the appropriate local weights.

The *Shiny* framework provides a reproducible approach for presenting survey-weighted PRAMS outputs. Potential uses include preliminary exploration, hypothesis generation, educational activities, and identification of questions requiring confirmatory analysis with Hawai‘i-specific data. Extension to another jurisdiction would require site-specific variable mapping, sampling-design specifications, and review of phase comparability.

Conclusion

The Hawai‘i PRAMS Data Explorer provides an accessible way to explore state-level maternal health data from the CDC public-use ARF. By pairing interactive visualizations with survey-weighted models and explicit cautions about phase comparability, suppression, and precision, the tool can support responsible hypothesis generation and data-informed public health discussion.

Acknowledgments

NYB, KMI, and HJA were partially supported by National Institutes of Health grants U54MD007601 and U54GM138062. AAB, AG, EM, and MJL were partially supported by Federal Award NT23TBC0290054 through the Department of Hawaiian Home Lands. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH or DHHL. The authors thank the PRAMS Working Group, including the PRAMS Team, Division of Reproductive Health, CDC, and PRAMS Hawai‘i, for conducting PRAMS surveillance and permitting use of the data.

Conflict of Interest and Disclosures

None of the authors identify any conflict of interest.

Submitted: May 12, 2025 PDT. Accepted: September 06, 2026 PDT. Published: November 02, 2026 PDT.

References

1. Centers for Disease Control and Prevention. Pregnancy Risk Assessment Monitoring System (PRAMS). Accessed April 7, 2025. https://www.cdc.gov/prams

2. Shulman HB, D'Angelo DV, Harrison L, et al. The Pregnancy Risk Assessment Monitoring System (PRAMS): overview of design and methodology. *Am J Public Health*. 2018;108(10):1305-1313. doi:10.2105/AJPH.2018.304563

3. State of Hawai'i Department of Health, Family Health Services Division. Hawai'i Pregnancy Risk Assessment Monitoring System (PRAMS). Accessed April 7, 2025. https://health.hawaii.gov/fhsd/home/hawaii-pregnancy-risk-assessment-monitoring-system-prams/

4. Roberson EK, Hurwitz EL, Li D, et al. Depression, anxiety, and pharmacotherapy around the time of pregnancy in Hawaii. *Int J Behav Med*. 2016;23:515-526. doi:10.1007/s12529-015-9493-z

5. Go M, Sokol N, Ward LG, et al. Characterizing sociodemographic disparities and predictors of gestational diabetes mellitus among Asian and Native Hawaiian or other Pacific Islander pregnant people: an analysis of PRAMS data, 2016–2022. *BMC Pregnancy Childbirth*. 2024;24:833. doi:10.1186/s12884-024-07034-5

6. Nakagawa K, Lim E, Harvey S, et al. Racial/ethnic disparities in the association between preeclampsia risk factors and preeclampsia among women residing in Hawaii. *Matern Child Health J*. 2016;20(9):1814-1824. doi:10.1007/s10995-016-1984-2

7. Centers for Disease Control and Prevention. Selected 2016–2022 maternal and child health indicators by site. Accessed October 7, 2025. https://www.cdc.gov/prams/php/data-research/mch-indicators-by-site.html

8. Hawai'i Department of Health, Family Health Services Division. Women/Maternal Health Population Domain Overview. July 2024. Accessed October 7, 2025. https://health.hawaii.gov/fhsd/files/2024/08/Women_Maternal-Health-Population-Overview_Intermediate-Product_Revised-after-May-2024-Feedback.pdf

9. Hawai'i Health Data Warehouse. PRAMS Selection Dashboard. Accessed October 7, 2025. https://hhdw.org/report/query/selection/prams/_PRAMSSelection.html

10. Brenner N. Hawai'i PRAMS Data Explorer. 2025. Accessed October 7, 2025. https://jabsom-dqhs.shinyapps.io/hawaii-prams-data-explorer/

11. R Core Team. R: a language and environment for statistical computing. Published online 2024. https://www.R-project.org/

12. Lumley T. *Survey: Analysis of Complex Survey Samples*. R package version 4.4; 2024. https://CRAN.R-project.org/package=survey

13. Sjoberg DD, Whiting K, Curry M, et al. Reproducible summary tables with the gtsummary package. *R J*. 2021;13:570-580. doi:10.32614/RJ-2021-053

14. Wickham H, Averick M, Bryan J, et al. Welcome to the tidyverse. *J Open Source Softw*. 2019;4(43):1686. doi:10.21105/joss.01686

15. Iannone R, Cheng J, Schloerke B, et al. *Gt: Easily Create Presentation-Ready Display Tables*. R package; 2025. https://github.com/rstudio/gt

16. Chang W, Cheng J, Allaire JJ, Sievert C, et al. shiny: web application framework for R. R package. 2023. https://shiny.posit.co/

Supplementary Materials

Supplementary Table S1. Variables Included in the Hawaiʻi PRAMS Interactive Shiny Application: Phase Availability and Comparison Restrictions

Download: https://hjhsw.scholasticahq.com/article/169861-maternal-health-trends-and-disparities-in-hawai-i-visualizing-pregnancy-risk-assessment-monitoring-system-data-through-an-interactive-shiny-web-appli/attachment/364297.xlsx?auth_token=3N-mceGhwf48yZSP0w3a