

Appendix 1. Pregnancy Risk Assessment Monitoring System (PRAMS) Working Group Members

PRAMS Working Group members who assisted in the coordinating collection of the data used in this analysis included: Alaska: Kathy Perham-Hester, MS, MPH; Alabama: Kristen Johnson, MPH; Arkansas: Ruby D. Brown; Colorado: Ashley Juhl, MSPH; Connecticut: Jennifer Morin, MPH; Delaware: George Yocher, MS; Georgia: Florence A. Kanu, PhD; Hawaii: Jane Awakuni; Iowa: Jennifer Pham; Illinois: Joyce Prince; Kansas: Lisa Williams; Kentucky: Tracey D. Jewell, MPH; Louisiana: Rosaria Trichilo, MPH; Maine: Virginia Daniels, LMSW; Maryland: Laurie Kettinger, MS; Massachusetts: Emily Lu, MPH; Michigan: Peterson Haak; Missouri: Venkata Garikapaty, PhD; Montana: Miriam Naiman-Sessions, PhD; Nebraska: Jessica Seberger; New Hampshire: Sara Riordan, M.Ed.; New Jersey: Sharon Smith Cooley, MPH; New Mexico: Sarah Schrock; New York City: Hannah Searing; New York State: Anne Radigan-Garcia; North Carolina: Fatma Simsek; North Dakota: Grace Njau; Oklahoma: Ayesha Lampkins, MPH; Pennsylvania: Sara Thuma, MPH; Rhode Island: Karine Monteiro; South Dakota: Linda Ahrendt; Texas: Tanya Guthrie, PhD; Utah: Barbara Algarin; Virginia: Kenesha Smith; Washington: Linda Lohdefinck; West Virginia: Monica Pegram, MA; Wisconsin: Fiona Weeks, MSPH; Wyoming: Lorie Wayne Chesnut.

Regan AK, Bombard JM, O’Hegarty MM, Smith RA, Tong VT. Adverse birth outcomes associated with prepregnancy and prenatal electronic cigarette use. *Obstet Gynecol* 2021;138.

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Appendix 2. Survey Items Collecting Information on Electronic Cigarette Use Included in the PRAMS Phase 8 Questionnaire (2016-2018)

| Item | Question | Response options |
|-------------------|---|--|
| Past use | <i>“Have you used any of the following products [e-cigarettes or other electronic nicotine products] in the past 2 years?”</i> | Yes, No |
| Pre-pregnancy use | <i>“During the 3 months before you got pregnant, on average, how often did you use e-cigarettes or other electronic nicotine products?”</i> | More than once a day, once a day, 2-6 days a week, 1 day or less a week, or no use of e-cigarettes |
| Pregnancy use | <i>“During the last 3 months of your pregnancy, on average, how often did you use e-cigarettes or other electronic nicotine products?”</i> | More than once a day, once a day, 2-6 days a week, 1 day or less a week, or no use of e-cigarettes |

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Appendix 3. Sources of Exposure, Outcome and Covariate Variables – Pregnancy Risk Assessment Monitoring System, 2016-2018

| Category | Variable | Source of information | |
|------------|---|-----------------------|---------------------|
| | | Birth Certificate | PRAMS Questionnaire |
| Exposures | Pre-pregnancy e-cigarette use | | ● |
| | Prenatal e-cigarette use | | ● |
| | Pre-pregnancy cigarette smoking | | ● |
| | Prenatal cigarette smoking | | ● |
| Outcomes | Preterm birth | ● | |
| | Small-for-gestational age | ● | |
| | Birthweight (and Low Birthweight) | ● | |
| Covariates | Maternal age | ● | |
| | Marital status | ● | |
| | Urban-rural maternal residence* | ● | |
| | Race/ethnicity | ● | |
| | Maternal education | ● | |
| | Accessed WIC services during pregnancy [†] | ● | |
| | Insurance status used for prenatal care | | ● |
| | Multivitamin use [‡] | | ● |
| | Parity | ● | |
| | Pregnancy intention [¶] | | ● |
| | Adequacy of prenatal care ^{**} | ● | |
| | Prenatal care in 1 st trimester | | ● |
| | Presence of ≥1 obstetric risk factor ^{††} | ● | |
| | Body mass index/obesity ^{‡‡} | ● | |

* As defined by 2013 National Center for Health Statistics Urban-Rural Classification Schemes for Counties (https://www.cdc.gov/nchs/data_access/urban_rural.htm)

[†] Accessed a Special Supplemental Nutrition Program for Women, Infants and Children (WIC) service during pregnancy.

[‡] Self-reported use of a multivitamin at least once per week.

[¶] Pregnancy intention was derived from questionnaire responses and defined as intended at time of conception or sooner vs. later, never, or uncertain about intention.

^{**} Adequacy of prenatal care is based on the Adequacy of Prenatal Care Utilization (APNCU) Index, derived from birth certification information on when prenatal care began and the number of prenatal care visits.

^{††} Presence of an obstetric risk factor (yes/no) was derived from risk factors collected in the birth certificate, including pre-pregnancy diabetes, gestational diabetes, pre-pregnancy hypertension, gestational hypertension, hypertension eclampsia, previous preterm birth, infertility treatment, receipt of fertility enhancing drugs, use of assisted reproductive technology, or previous cesarean section.

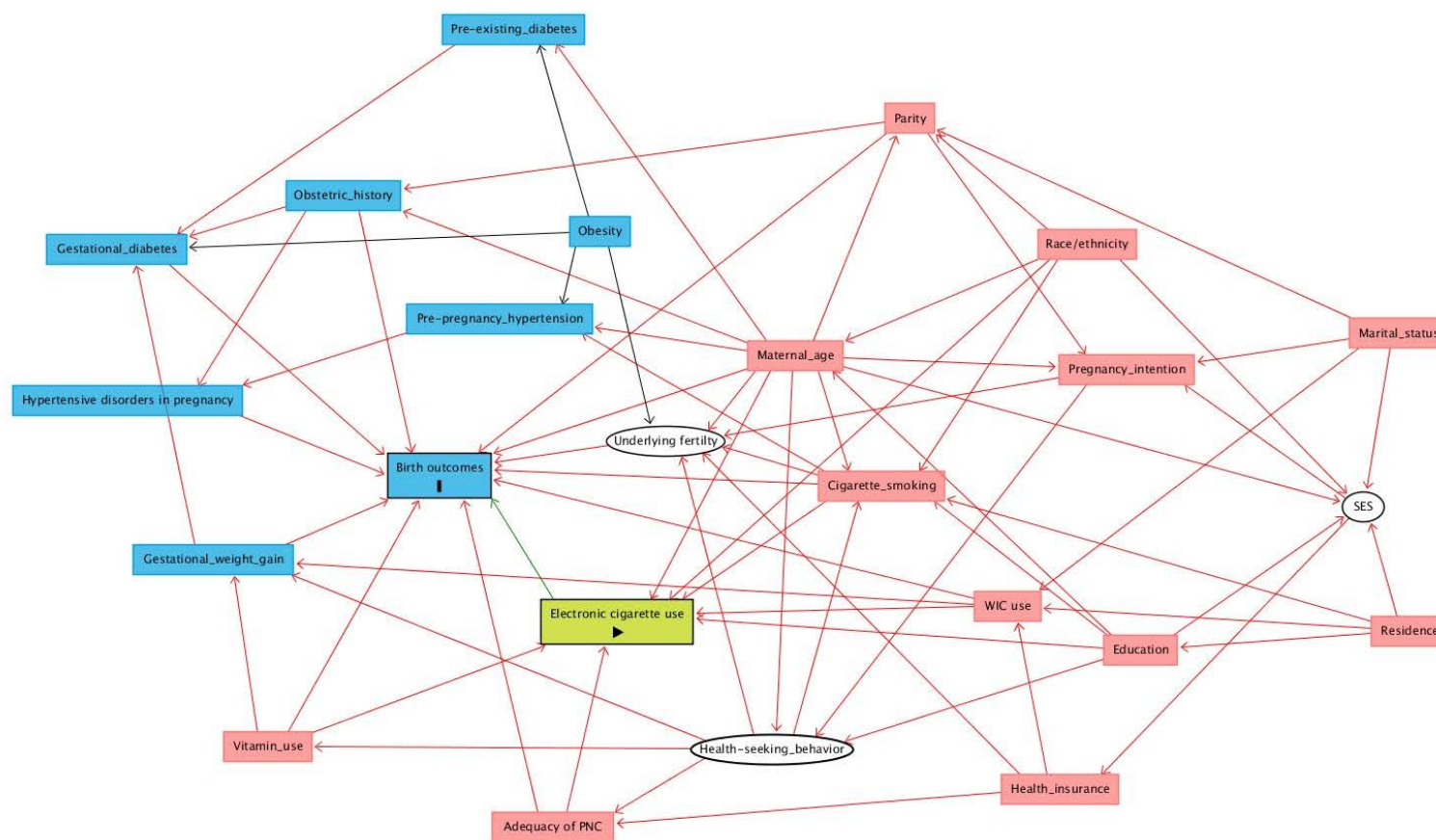
^{‡‡} Body mass index was estimated from height and weight provided in the birth certificate.

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Appendix 4. Directed acyclic graph outlining potential relationship between prenatal electronic cigarette use and birth outcomes. *Green box* indicates exposure. *Blue boxes* indicate outcome variable or ancestor to outcome. *White boxes* indicate unobserved variables. *Red lines* indicate potential biasing pathways. *Green link* indicates causal pathway. Minimum adjustment set derived from this DAG includes maternal age, Race/ethnicity, Education, Adequacy of prenatal care (PNC, based on the Adequacy of Prenatal Care Utilization (APNCU) Index), WIC (Special Supplemental Nutrition Program for Women, Infants and Children) use during pregnancy, multivitamin use, and combustible cigarette smoking.

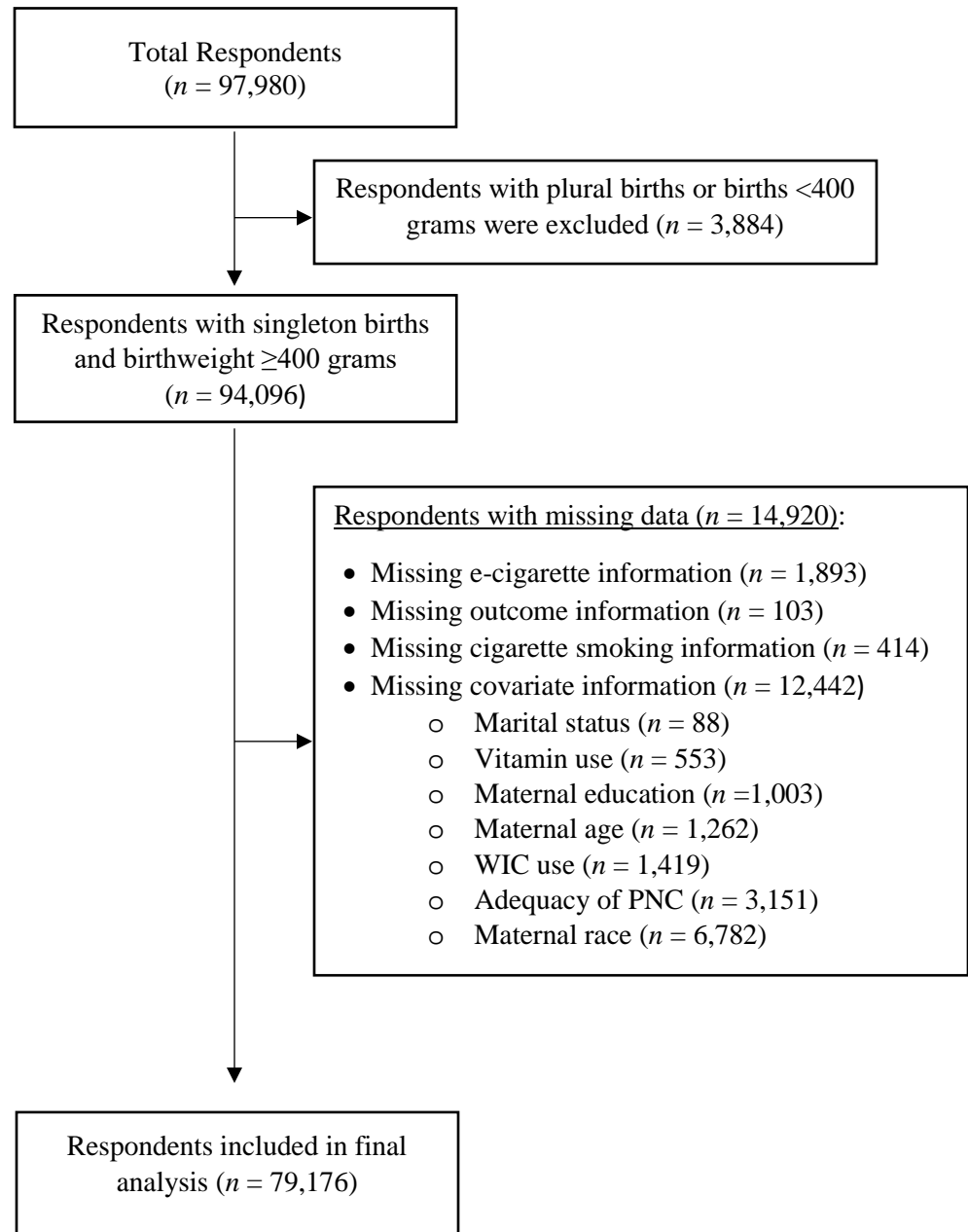


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Appendix 5. Selection of respondent data for analysis from the Phase-8 Pregnancy Risk Assessment Monitoring System, 37 States and New York City,* United States, 2016–2018. Missing data for variables not mutually exclusive.



*PRAMS sites included in this analysis are: Alaska (2016-2018), Alabama (2017), Arkansas (2016), Colorado (2016-2018), Connecticut (2016-2018), Delaware (2016-2018), Georgia (2017-2018), Hawaii (2016), Iowa (2016-2017), Illinois (2016-2017), Kansas (2017-2018), Kentucky (2017-2018), Louisiana (2016-2018), Massachusetts (2016-2018), Maryland (2016-2017), Maine (2016-2017), Michigan (2016-2018), Missouri (2016-2018), Montana (2017), North Carolina (2017), North Dakota (2017), Nebraska (2016,2018), New Hampshire (2016-2017), New Jersey (2016-2018), New Mexico (2016-2018), New York (2016-2017), New York City (2016-2018), Oklahoma (2016-2017), Pennsylvania (2016-2018), Rhode Island (2016-2018), South Dakota (2017-2018), Texas (2016), Utah (2016-2018), Virginia (2016-2018), Washington (2016-2018), Wisconsin (2016-2018), West Virginia (2016-2018), and Wyoming (2016-2018).

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Appendix 6. Site-Specific Prevalence of Electronic Cigarette (E-cigarette) Use – Pregnancy Risk Assessment Monitoring System, 37 States and New York City, 2016-2018 (n*=79,176)

| State/City | Year(s) of data included in analysis | Non-use of e-cigarettes [†] (n*=76,113) | E-cigarette use prior to pregnancy [†] (n*=2,157) | E-cigarette use during pregnancy [†] (n*=906) |
|----------------------|--------------------------------------|--|--|--|
| | | Weighted % (95% CI) [‡] | Weighted % (95% CI) [‡] | Weighted % (95% CI) [‡] |
| Total | 2016-2018 | 96.2 (96.0-96.4) | 2.7 (2.6-2.9) | 1.1 (1.0-1.2) |
| By state/city | | | | |
| Alaska | 2016-2018 | 95.5 (94.2-96.5) | 3.8 (2.9-5.1) | 0.7 (0.4-1.3) |
| Alabama | 2017 | 95.2 (93.3-96.5) | 3.5 (2.4-5.1) | 1.3 (0.7-2.5) |
| Arkansas | 2016 | 90.7 (86.8-93.5) | 6.2 (3.9-9.5) | 3.1 (1.7-5.8) |
| Colorado | 2016-2018 | 96.3 (95.4-97.0) | 2.7 (2.1-3.4) | 1.0 (0.7-1.5) |
| Connecticut | 2016-2018 | 97.4 (96.5-98.1) | 2.1 (1.5-3.0) | 0.4 (0.2-0.9) |
| Delaware | 2016-2018 | 96.5 (95.6-97.2) | 2.9 (2.2-3.7) | 0.6 (0.4-1.1) |
| Georgia | 2017, 2018 | 96.8 (95.3-97.7) | 2.1 (1.3-3.2) | 1.2 (0.7-2.2) |
| Hawaii | 2016 | 94.4 (91.4-96.5) | 4.6 (2.8-7.6) | 0.9 (0.4-2.4) |
| Iowa | 2016, 2017 | 94.9 (93.1-96.3) | 3.9 (2.7-5.5) | 1.2 (0.6-2.3) |
| Illinois | 2016, 2017 | 96.9 (96.0-97.7) | 2.2 (1.6-3.0) | 0.9 (0.5-1.5) |
| Kansas | 2017, 2018 | 95.4 (93.9-96.6) | 3.6 (2.6-5.0) | 1.0 (0.5-1.8) |
| Kentucky | 2017, 2018 | 92.9 (90.7-94.6) | 3.5 (2.4-5.1) | 3.6 (2.4-5.3) |
| Louisiana | 2016-2018 | 95.9 (94.9-96.7) | 2.9 (2.2-3.8) | 1.2 (0.8-1.8) |
| Massachusetts | 2016-2018 | 97.4 (96.5-98.1) | 2.0 (1.4-2.9) | 0.6 (0.3-1.2) |
| Maryland | 2016, 2017 | 97.5 (96.5-98.2) | 1.7 (1.1-2.5) | 0.8 (0.5-1.5) |
| Maine | 2016, 2017 | 95.0 (93.4-96.3) | 3.1 (2.1-4.6) | 1.9 (1.2-2.8) |
| Michigan | 2016-2018 | 96.7 (96.0-97.4) | 2.3 (1.8-2.9) | 1.0 (0.7-1.4) |
| Missouri | 2016-2018 | 93.9 (92.7-94.9) | 4.4 (3.5-5.4) | 1.7 (1.2-2.5) |
| Montana | 2017 | 94.2 (92.2-95.7) | 3.6 (2.4-5.3) | 2.2 (1.3-3.6) |
| North Carolina | 2017 | 97.0 (95.4-98.1) | 2.1 (1.2-3.6) | 0.9 (0.5-1.9) |
| North Dakota | 2017 | 97.3 (94.8-98.6) | 2.7 (1.4-5.2) | 0 (---) |
| Nebraska | 2016, 2018 | 95.8 (94.5-96.8) | 3.4 (2.5-4.6) | 0.8 (0.4-1.4) |
| New Hampshire | 2016, 2017 | 94.8 (92.6-96.4) | 3.6 (2.3-5.4) | 1.7 (0.8-3.3) |
| New Jersey | 2016-2018 | 97.5 (96.8-98.0) | 2.2 (1.7-2.8) | 0.4 (0.2-0.6) |
| New Mexico | 2016-2018 | 94.9 (94.0-95.6) | 3.6 (2.9-4.3) | 1.6 (1.2-2.1) |
| New York | 2016, 2017 | 96.5 (95.0-97.6) | 2.7 (1.8-4.2) | 0.7 (0.4-1.5) |
| New York City | 2016-2018 | 98.9 (98.5-99.2) | 0.9 (0.6-1.3) | 0.2 (0.1-0.4) |
| Oklahoma | 2016, 2017 | 94.3 (92.7-95.5) | 4.0 (3.0-5.3) | 1.7 (1.1-2.7) |
| Pennsylvania | 2016-2018 | 94.8 (93.7-95.7) | 3.6 (2.9-4.6) | 1.6 (1.1-2.2) |
| Rhode Island | 2016-2018 | 96.8 (95.8-97.6) | 2.5 (1.9-3.4) | 0.7 (0.4-1.2) |
| South Dakota | 2017, 2018 | 96.3 (95.0-97.4) | 2.9 (2.0-4.2) | 0.7 (0.4-1.5) |

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| | | | | |
|---------------|-----------|------------------|----------------|---------------|
| Texas | 2016 | 96.3 (95.0-97.3) | 2.9 (2.1-4.1) | 0.8 (0.4-1.4) |
| Utah | 2016-2018 | 95.0 (94.2-95.7) | 3.5 (2.9-4.2) | 1.5 (1.1-2.0) |
| Virginia | 2016-2018 | 96.5 (95.2-97.5) | 2.9 (2.1-4.1) | 0.6 (0.3-1.3) |
| Washington | 2016-2018 | 96.0 (94.9-96.9) | 2.7 (2.0- 3.6) | 1.3 (0.8-2.0) |
| Wisconsin | 2016-2018 | 96.8 (95.6-97.7) | 1.9 (1.3-2.8) | 1.3 (0.8-2.2) |
| West Virginia | 2016-2018 | 92.9 (91.5-94.2) | 4.2 (3.3-5.4) | 2.8 (2.1-3.8) |
| Wyoming | 2016-2018 | 93.5 (91.7-94.9) | 4.8 (3.6-6.4) | 1.7 (1.1-2.8) |

* Reflects unweighted sample size.

† Non-use of e-cigarettes were respondents who reported using no e-cigarettes in the 3 months prior to pregnancy or during the last 3 months of pregnancy. E-cigarette use prior to pregnancy was defined as self-reported use of e- cigarettes in the 3 months prior to pregnancy but not during the last 3 months of pregnancy. E-cigarette use during pregnancy was defined as any self-reported use of e- cigarettes in the last 3 months of pregnancy.

‡ Weighted percentage and corresponding 95% confidence intervals.

Appendix 7. Characteristics of Respondents by Self-Reported Cigarette Smoking and Electronic Cigarette (E-cigarette) Use During the Last 3 Months of Pregnancy – Pregnancy Risk Assessment Monitoring System, 37 States and New York City,* 2016-2018 (n[†]=79,176)

| Characteristic | Dual use [‡] (n [†] =588) | E-cigarette only use [‡] (n [†] =254) |
|---|--|--|
| | Weighted % (95% CI) [¶] | Weighted % (95% CI) [¶] |
| All | 0.7 (0.6-0.8) | 0.3 (0.2-0.4) |
| Maternal age | | |
| 18-24 years | 32.0 (26.2-38.4) | 36.3 (27.9-45.7) |
| 25-29 years | 35.2 (29.3-41.6) | 27.9 (20.2-37.2) |
| 30-34 years | 23.8 (18.8-29.7) | 22.2 (15.6-30.6) |
| 35-39 years | 8.6 (5.7-12.8) | 12.6 (7.2-21.3) |
| ≥40 years | 0.4 (0.2-0.8) | 0.9 (0.2-3.6) |
| Maternal race/ethnicity** | | |
| White, non-Hispanic | 90.7 (87.3-93.3) | 74.3 (65.5-81.6) |
| Black, non-Hispanic | 5.6 (3.6-8.7) | 10.5 (5.9-18.0) |
| Hispanic | 3.3 (2.0-5.3) | 13.0 (7.9-20.5) |
| Asian, non-Hispanic | 0.3 (0.1-1.4) | 1.2 (0.4-3.2) |
| American Indian, Hawaiian, Alaskan Native, multiple races, or unspecified non-White, non-Hispanic race | 0.1 (0.0-0.3) | 1.0 (0.2-5.0) |
| Married^{††} | 28.7 (23.3-34.9) | 43.1 (34.1-52.5) |
| Maternal education** | | |
| <12 years | 25.5 (20.0-32.0) | 13.8 (8.1-22.5) |
| 12 years | 41.8 (35.6-48.4) | 32.5 (24.7-41.4) |
| 13-15 years | 29.7 (24.4-35.6) | 39.8 (31.0-49.3) |
| ≥16 years | 2.0 (1.4-6.1) | 13.9 (8.4-22.2) |
| Rural residence^{††} | 29.9 (24.4-36.1) | 19.2 (13.2-27.1) |
| Insurance type used for prenatal care (PNC)^{††} | | |
| Private | 12.7 (8.9-18.0) | 27.2 (19.9-36.0) |
| Public | 82.5 (76.8-86.9) | 66.5 (57.0-74.8) |
| Other | 4.4 (2.4-7.8) | 4.7 (1.5-14.0) |
| None | 0.4 (0.2-0.8) | 1.6 (0.5-5.6) |
| Accessed WIC during pregnancy^{††} | 61.6 (55.1-67.8) | 45.4 (36.2-54.9) |
| Any obstetric risk factor identified^{¶¶} | 13.3 (9.8-17.8) | 20.3 (14.4-27.8) |
| Obese^{†††} | 22.2 (17.3-28.0) | 27.1 (19.8-35.9) |
| Parity | | |
| Primiparous | 32.0 (26.1-38.6) | 39.6 (30.9-49.1) |
| 1 prior birth | 27.8 (22.6-33.7) | 31.4 (23.5-40.5) |
| 2 prior births | 21.7 (16.8-27.5) | 19.8 (12.9-29.0) |
| ≥3 prior births | 18.5 (14.0-23.9) | 9.2 (5.2-15.7) |
| Intended pregnancy^{***} | 34.3 (28.4-40.8) | 45.2 (35.9-54.8) |
| First Prenatal Care (PNC) visit in first trimester | 91.2 (87.0-94.1) | 93.7 (88.4-96.7) |

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| | | |
|---|------------------|------------------|
| Adequacy of PNC^{†††} | | |
| Adequate plus | 25.4 (20.4-31.3) | 29.3 (21.5-38.5) |
| Adequate | 36.6 (30.6-43.1) | 51.4 (42.1-60.7) |
| Intermediate | 10.5 (7.1-15.4) | 8.5 (4.5-15.2) |
| Inadequate | 27.4 (22.0-33.7) | 10.8 (6.8-16.8) |
| Multivitamin use^{¶¶¶} | 24.8 (19.8-30.5) | 30.7 (22.7-40.1) |
| Smoked combustible cigarettes 3 months prior to pregnancy^{****} | 99.7 (98.5-99.9) | 57.1 (47.8-65.8) |
| Frequency of e-cigarettes use^{****} | | |
| Daily | 34.5 (28.7-40.8) | 61.5 (52.1-70.1) |
| Less than daily | 65.5 (59.2-71.3) | 38.5 (29.9-47.9) |

*PRAMS sites included in this analysis are: Alaska (2016-2018), Alabama (2017), Arkansas (2016), Colorado (2016-2018), Connecticut (2016-2018), Delaware (2016-2018), Georgia (2017-2018), Hawaii (2016), Iowa (2016-2017), Illinois (2016-2017), Kansas (2017-2018), Kentucky (2017-2018), Louisiana (2016-2018), Massachusetts (2016-2018), Maryland (2016-2017), Maine (2016-2017), Michigan (2016-2018), Missouri (2016-2018), Montana (2017), North Carolina (2017), North Dakota (2017), Nebraska (2016,2018), New Hampshire (2016-2017), New Jersey (2016-2018), New Mexico (2016-2018), New York (2016-2017), New York City (2016-2018), Oklahoma (2016-2017), Pennsylvania (2016-2018), Rhode Island (2016-2018), South Dakota (2017-2018), Texas (2016), Utah (2016-2018), Virginia (2016-2018), Washington (2016-2018), Wisconsin (2016-2018), West Virginia (2016-2018), and Wyoming (2016-2018).

† Reflects unweighted sample size.

† Dual use was defined as self-reported use of e-cigarettes AND combustible cigarettes during the last 3 months of pregnancy; E-cigarette only use was defined as self-reported use of e-cigarettes but no combustible cigarette use during the last 3 months of pregnancy.

¶ Weighted percent and corresponding 95% confidence intervals; overall percentages reflect row percentages and percentages by characteristics reflect column percentages.

** Chi-squared test significant at $P < .01$

†† Chi-squared test significant at $P < 0.05$

†† WIC, the Special Supplemental Nutrition Program for Women, Infants and Children; Chi-squared test significant at $P < 0.01$

¶¶ Presence of an obstetric risk factor (yes/no) was derived from risk factors collected in the birth certificate, including pre-pregnancy diabetes, gestational diabetes, pre-pregnancy hypertension, gestational hypertension, hypertension eclampsia, previous preterm birth, infertility treatment, receipt of fertility enhancing drugs, use of assisted reproductive technology, or previous cesarean section; Chi-squared $P < .05$.

*** Obesity was defined as a body mass index ≥ 30 based on pre-pregnancy height and weight.

††† Pregnancy intention was derived from questionnaire responses and defined as intended at time of conception or sooner vs. later, never, or uncertain about intention.

††† PNC, prenatal care; Adequacy of prenatal care was assessed using the Adequacy of Prenatal Care Utilization (APNCU) Index, derived from birth certification information on when prenatal care began and the number of prenatal care visits; Chi-squared test significant at $P < 0.001$

¶¶¶ Self-reported use of a multivitamin at least once per week.

**** Chi-squared test significant at $P < 0.001$.

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