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Racial/Ethnic Disparities in Intensive Care Admissions in a Pregnant and Postpartum Population, Hawai'i, 2012-2017

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Abstract

Objective: Maternal morbidity and mortality is a global concern despite advances in medical care and technology and improved economic resources of nations worldwide. The primary objective of our study was to describe racial/ethnic disparities in severe maternal morbidity by using admission to an intensive care unit (ICU) as a marker. The secondary objective was to evaluate associations between patient characteristics, including obstetric outcomes, and severe maternal morbidity.

Methods: This retrospective cohort study used a large inpatient database to identify pregnancy and postpartum hospitalizations in Hawai'i from January 2012 through September 2017. We evaluated associations between sociodemographic and clinical characteristics and race/ethnicity by using χ^2 tests. We used multivariable logistic regression to assess associations between race/ethnicity and ICU admission. We used a post hoc analysis to assess associations between ICU admission and obstetric outcomes by race/ethnicity.

Results: After adjustment, we found a significantly higher ICU admission rate among Asian (adjusted odds ratio [aOR] = 1.30; 95% CI, 1.04-1.62; P = .02), Filipino (aOR = 1.45; 95% CI, 1.17-1.79; P < .001), and Native Hawaiian/Other Pacific Islander (aOR = 1.39; 95% CI, 1.15-1.68; P < .001) women compared with non-Hispanic White women. Multiple clinical characteristics and outcomes were associated with ICU admission, such as preexisting chronic conditions and pregnancy-induced hypertensive disorders.

Conclusion: We found that severe maternal morbidity represented by ICU admission is higher among Asian, Filipino, and Native Hawaiian/Other Pacific Islander women than among non-Hispanic White women in Hawai'i. Our findings reemphasize the need for health care providers to be vigilant in caring for members of racial/ethnic minority groups and managing their comorbidities.

Keywords

severe maternal morbidity, Pacific Islander, intensive care unit, pregnancy complications

Maternal mortality and morbidity is a global concern despite advances in medical care and technology and improved economic resources of nations worldwide.[1] In 2017, of the estimated 295 000 deaths per day among women globally, approximately 800 died of complications resulting from pregnancy or childbirth.[2,3] The maternal mortality rate has remained high in the United States during the past 20 years, with 17.4 deaths per 100 000 births in 2018.[4] The Centers for Disease Control and Prevention collects national data from state-run maternal mortality review panels to determine the demographic characteristics, preventability, and cause of each maternal death.[5] These data showed that during 2008-2017, approximately 1 in 3 deaths among women during or within a year of pregnancy were pregnancy-related.

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Women in racial/ethnic minority groups, especially non-Hispanic Black women, die at a much higher rate than non-Hispanic White women.[6,7]

Maternal mortality and morbidity exist on a continuum—from little to no morbidity to severe morbidity, "near-miss" events, and maternal death.[8] One way to reduce maternal mortality is to examine indicators of maternal health, such as maternal morbidity and severe maternal morbidity.[8-10] Because health institutions and medical societies lack a common definition for severe maternal morbidity, determining rates has been challenging.[11,12] Neither the American College of Obstetricians and Gynecologists nor the Society for Maternal–Fetal Medicine has endorsed a precise definition for severe maternal morbidity.[12] However, different definitions share the notion that severe maternal morbidity is an unintended outcome resulting in short-term or long-term consequences to a woman's health.[12] We propose that a woman who is admitted to an intensive care unit (ICU) in the perinatal period may be presumed to have severe maternal morbidity, for which treatment and/or monitoring in the ICU is necessary. ICU admission has been used as a marker for severe maternal morbidity in multiple studies.[10,13-17]

Severe maternal morbidity disproportionately affects racial/ethnic minority women[18-21]; leading causes of pregnancy-related deaths vary by race/ethnicity.[5] Studies of racial/ethnic disparities often aggregate data on the Asian/Pacific Islander population,[18-21] which may limit their application to the unique population in Hawai'i, where a large population of Asian/Pacific Islander people comprises distinct ethnicities. Disparities in obstetric outcomes exist among racial/ethnic minority women in Hawai'i.[22,23] Native Hawaiian/Other Pacific Islander women have higher rates than non-Hispanic White women of postpartum hemorrhage,[24] preeclampsia,[25] gestational diabetes,[26] and delivery complications.[27]

Studies on severe maternal morbidity in Hawai'i are scarce, and the possible associations between severe maternal morbidity and race/ethnicity remain to be clarified. The primary objective of our study was to describe racial/ethnic disparities in severe maternal morbidity during pregnancy and the postpartum period in Hawai'i by using admission to an ICU as a marker. The secondary objective was to evaluate for associations between patient characteristics, including obstetric outcomes, and severe maternal morbidity.

Methods

Sample

We used the Hawai'i Health Information Corporation (HHIC) inpatient database to conduct a retrospective cohort study of de-identified discharge data on all pregnancy and postpartum hospitalizations in Hawai'i from January 2012 through September 2017. The HHIC inpatient database is the largest health care database in Hawai'i[28]; it has detailed all-visit discharge data from all hospitals in Hawai'i, including data on all payers and the following data on patients: race/ethnicity, sex, age, health insurance type, and *International Classification of Diseases, Clinical Modification* (9th and 10th editions) primary and secondary diagnoses and procedure codes.[29,30] The data set indicated 685 131 discharges. We included hospitalizations (n = 95 508) of pregnant and postpartum (within 6 weeks) women aged 12-52 according to All Patient Refined–Diagnosis-Related Group (APR–DRG) hospital codes[31] (Table 1). We excluded records of patients who did not report race/ethnicity (n = 5109). Our final sample consisted of 1340 discharges. The University of Hawai'i John A. Burns School of Medicine Privacy Board reviewed this project and granted an institutional review board exemption.

Table 1. List of All Patient Refined–Diagnosis-Related Group (APR–DRG) codes included in a study of racial/ethnic disparities in intensive care unit admissions in a pregnant and postpartum population, Hawaii, 2012-2017[a]

APR–DRG code	Code description
540	Cesarean delivery
541	Vaginal delivery with sterilization and/or dilation and curettage
542	Vaginal delivery with complication procedures except sterilization and/or dilation and curettage
544	Dilation and curettage, aspiration curettage, or hysterotomy for obstetric diagnoses
545	Ectopic pregnancy
546	Other OR procedure for obstetric diagnoses except delivery diagnoses
560	Vaginal delivery
561	Postpartum and postabortion diagnoses without procedure
563	Threatened abortion
564	Abortion without dilation and curettage, aspiration curettage, or hysterotomy
565	False labor
566	Other antepartum diagnoses

[a]Data source: 3M Health Information Systems.[31]

Outcome Measures

We used APR–DRG codes to identify all pregnancy and postpartum hospitalizations and unit-specific revenue codes to select for ICU admissions, methods similar to those used previously.[14] Patients self-reported race/ethnicity on hospital admission; the HHIC database specifies only 1 primary race/ethnicity. The 7 largest groups were Native Hawaiian, Japanese, Filipino, Chinese, Other Pacific Islander, Other Asian, and non-Hispanic White, accounting for more than

90% of the inpatient database. To separate Asian, Native Hawaiian, and other Pacific Islander people as distinct ethnicities, we created the following racial/ethnic cohorts: non-Hispanic White, Asian (including Chinese, Japanese, Other Asian), Filipino, Native Hawaiian/Other Pacific Islander, Hispanic or Latino, non-Hispanic Black, and "Other" (consisting of American Indian and "other"). We collected data on additional patient demographic characteristics, including maternal age, health insurance type, and county of residence. We extracted data on clinical characteristics and obstetric outcomes by using codes from the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM)[29] and the *International Classification of Diseases, Tenth Revision, Clinical Modification* (ICD-10-CM).[30] Consistent with the approach of other studies, we selected these codes because these diagnoses are associated with outcomes of pregnancy morbidity.[15,18,19,32]

Statistical Analysis

We summarized the categorical variables for patient demographic and clinical characteristics as frequency and percentage. We used the Cochran–Armitage test to assess trends in ICU admission. We evaluated bivariate associations between ICU admission and demographic and clinical variables by using Pearson χ^2 or Fisher exact tests. We built a logistic regression model to assess for associations, adjusting for demographic and clinical variables. We calculated unadjusted odds ratios (ORs), adjusted odds ratios (aORs), and 95% CIs to demonstrate the magnitude of associations. We also evaluated associations between ICU admission and obstetric outcomes by race/ethnicity by using Pearson χ^2 or Fisher exact tests. Finally, we applied a Bonferroni adjustment ($P < .0125$) in a post hoc analysis to assess each pairwise comparison, setting non-Hispanic White as the reference group. We conducted all analyses using SAS version 9.4 (SAS Institute, Inc); we set significance at $P < .05$.

Results

The mean incidence of ICU admission was 14 per 1000 hospital discharges, and ICU admission ranged from 1.2% to 1.6% of pregnancy/postpartum hospitalizations per year (Table 2). We found no evidence of an increasing or decreasing trend from 2012 to 2017 (z = 1.88, $P = .06$).

We found several significant associations between ICU admission and patient demographic characteristics (Table 3). Asian (OR = 1.41; 95% CI, 1.15-1.72), Filipino (OR = 1.78; 95% CI, 1.48-2.15), Native Hawaiian/Other Pacific Islander (OR = 2.03; 95% CI, 1.71-2.41), and non-Hispanic Black (OR = 2.38; 95% CI, 1.51-3.58) women had higher rates of ICU admission than non-Hispanic White women. After we controlled for confounding variables, Asian (aOR = 1.30; 95% CI, 1.04-1.62), Filipino (aOR = 1.45; 95% CI, 1.17-1.79), and Native Hawaiian/Other Pacific Islander (aOR = 1.39; 95% CI, 1.15-1.68) women had higher rates of ICU admission than non-Hispanic White women. Non-Hispanic Black women did not have higher rates of ICU admission than non-Hispanic White women after adjustment.

Table 2. Total pregnant/postpartum hospitalizations and intensive care unit (ICU) admissions annually in a study of racial/ethnic disparities in ICU admissions in a pregnant and postpartum population, Hawaii, 2012-2017[a]

Year	No. of available discharge records (N = 685 131)	No. of pregnant/ postpartum hospitalizations (n = 90 399)	No. of ICU admissions (% of hospitalizations) (n = 1340)
2012	120 448	15 998	225 (1.4)
2013	119 254	16 057	185 (1.2)
2014	118 149	15 797	247 (1.6)
2015	121 288	15 840	246 (1.6)
2016	118 597	15 411	234 (1.5)
2017[b]	87 395	11 296	167 (1.5)

[a]Data source: Hawai'i Health Information Corporation.[28]
[b]Data available only through September 2017.

In the adjusted model, advanced maternal age was associated with higher rates of ICU admission. Women aged 35-39 (aOR = 1.36; 95% CI, 1.13-1.62) and 40-44 (aOR = 1.54; 95% CI, 1.18-1.99) had higher rates of ICU admission than women aged 25-29. Women with Medicaid/Medicare insurance had higher rates of ICU admission than women with private health insurance (aOR = 1.69; 95% CI, 1.49-1.96). We also found differences in ICU admission by county of residence. Compared with residents in Central Honolulu, residents in West Honolulu (OR = 1.38; 95% CI, 1.10-1.73) and Waianae (OR = 1.81; 95% CI, 1.41-2.32) were 30% and 80% more likely, respectively, to have an ICU admission. However, after we accounted for possible confounders, these associations were no longer significant (West Honolulu aOR = 1.14 [95% CI, 0.89-1.46]; Waianae aOR = 1.29 [95% CI, 0.99-1.70]).

Many clinical characteristics and obstetric outcomes were associated with significantly higher ICU admissions after controlling for possible confounders (Table 4). After adjustment, substance use disorder (aOR = 2.10; 95% CI, 1.61-2.74), multiple gestation (aOR = 1.97; 95% CI, 1.35-2.79), and assisted conception (aOR = 2.07; 95% CI, 1.43-2.93) were associated with at least 2 times increased likelihood for ICU admission. Moreover, having a pregnancy-induced hypertensive disorder was significantly associated with increased likelihood of ICU admission (OR = 6.53; 95% CI, 5.84-7.29), which remained significant after adjustment (aOR = 4.75; 95% CI, 4.20-5.36). In addition, postpartum hemorrhage was associated with a more than 5 times

Table 3. Associations between patient demographic characteristics and admission to an intensive care unit (ICU) in a study of racial/ethnic disparities in ICU admissions in a pregnant and postpartum population, Hawaii, 2012-2017[a]

Characteristic	Characteristic is present, no. (%)	Characteristic is absent, no. (%)	Odds ratio (95% CI) [*P* value][b]	Adjusted odds ratio (95% CI) [*P* value][b,c]
Race/ethnicity				
Non-Hispanic White	177 (0.9)	19 652 (99.1)	1 [Reference]	1 [Reference]
Asian[d]	214 (1.2)	16 881 (98.8)	1.41 (1.15-1.72) [<.001]	1.30 (1.04-1.62) [.02]
Filipino	290 (1.6)	18 092 (98.4)	1.78 (1.48-2.15) [<.001]	1.45 (1.17-1.79) [<.001]
Native Hawaiian/Other Pacific Islander	580 (1.8)	31 787 (98.2)	2.03 (1.71-2.41) [<.001]	1.39 (1.15-1.68) [<.001]
Hispanic/Latino	36 (1.2)	3001 (98.8)	1.33 (0.91-1.89) [.12]	1.10 (0.73-1.60) [.64]
Non-Hispanic Black	24 (2.1)	1121 (97.9)	2.38 (1.51-3.58) [<.001]	1.50 (0.91-2.34) [.09]
Other[e]	19 (1.2)	1558 (98.8)	1.35 (0.81-2.12) [.21]	1.22 (0.69-2.01) [.47]
Maternal age, y				
12-14	0	44 (100.0)	—[g]	—[g]
15-19	77 (1.5)	4946 (98.5)	1.28 (0.99-1.64) [.05]	1.09 (0.83-1.41) [.54]
20-24	256 (1.4)	18 691 (98.6)	1.13 (0.95-1.33) [.16]	1.08 (0.90-1.28) [.41]
25-29	298 (1.2)	24 550 (98.8)	1 [Reference]	1 [Reference]
30-34	327 (1.3)	25 137 (98.7)	1.07 (0.92-1.26) [.39]	1.05 (0.89-1.25) [.54]
35-39	272 (1.8)	14 649 (98.2)	1.53 (1.30-1.81) [<.001]	1.36 (1.13-1.62) [.001]
40-44	95 (2.4)	3792 (97.6)	2.06 (1.63-2.60) [<.001]	1.54 (1.18-1.99) [.001]
45-52	15 (5.0)	283 (95.0)	4.37 (2.46-7.18) [<.001]	—[g]
Health insurance type				
Medicaid/Medicare	705 (1.9)	36 275 (98.1)	1 [Reference]	1 [Reference]
Private	579 (1.1)	50 532 (98.9)	0.59 (0.53-0.66) [<.001]	0.59 (0.51-0.67) [<.001]
Self-pay	14 (0.9)	1504 (99.1)	0.48 (0.27-0.78) [.007]	0.51 (0.27-0.88) [.03]
Other[f]	42 (1.1)	3781 (98.9)	0.57 (0.41-0.77) [<.001]	0.64 (0.44-0.89) [.01]
County of residence				
Hawai'i Hilo–North	42 (0.9)	4733 (99.1)	0.59 (0.41-0.84) [.004]	0.52 (0.35-0.74) [<.001]
Hawai'i Kona	64 (1.2)	5304 (98.8)	0.81 (0.59-1.09) [.16]	0.99 (0.71-1.36) [.93]
Hawai'i South	42 (1.0)	3967 (99.0)	0.71 (0.49-1.00) [.05]	0.59 (0.40-0.85) [.006]
Kauai East	39 (1.5)	2617 (98.5)	0.99 (0.68-1.42) [.97]	1.24 (0.83-1.80) [.28]
Kauai North and West	25 (1.1)	2203 (98.9)	0.76 (0.48-1.15) [.21]	0.99 (0.62-1.54) [.97]
Maui Molokai-Lanai-and East	19 (0.6)	3006 (99.4)	0.42 (0.25-0.67) [<.001]	0.48 (0.28-0.77) [.004]
Maui West and Central	49 (0.6)	8586 (99.4)	0.38 (0.27-0.53) [<.001]	0.40 (0.28-0.56) [<.001]
Oahu, Aiea–Pearl City	112 (1.6)	7066 (98.4)	1.06 (0.82-1.37) [.67]	1.01 (0.77-1.33) [.92]
Oahu, Central Honolulu	121 (1.5)	8075 (98.5)	1 [Reference]	1 [Reference]
Oahu, East Honolulu	62 (1.3)	4600 (98.7)	0.88 (0.65-1.20) [.44]	0.94 (0.67-1.29) [.69]
Oahu, Ewa	232 (1.7)	13 653 (98.3)	1.13 (0.91-1.42) [.27]	1.02 (0.81-1.30) [.85]
Oahu, Kaneohe–Kailua	105 (1.4)	7545 (98.6)	0.93 (0.71-1.21) [.58]	1.11 (0.84-1.47) [.46]
Oahu, North Shore	67 (1.3)	5125 (98.7)	0.87 (0.64-1.17) [.37]	0.89 (0.65-1.22) [.48]
Oahu, Waianae	136 (2.6)	5022 (97.4)	1.81 (1.41-2.32) [<.001]	1.29 (0.99-1.70) [.06]
Oahu, West Honolulu	206 (2.0)	9990 (98.0)	1.38 (1.10-1.73) [.006]	1.14 (0.89-1.46) [.29]

[a]Data source: Hawai'i Health Information Corporation.[28]
[b]Comparison between patients with characteristic and patients without characteristic; *P* values determined by Pearson χ^2 test; $P < .05$ considered significant.
[c]Adjusted odds ratios were estimated while adjusting for all characteristics in the table.
[d]Includes Chinese, Japanese, other Asian.
[e]Includes American Indian.
[f]Includes US Department of Defense, miscellaneous.
[g]Not applicable because numbers were too small to calculate.

Table 4. Associations between clinical characteristics and obstetric outcomes with admission to intensive care unit (ICU) in a study of racial/ethnic disparities in ICU admissions in a pregnant and postpartum population, Hawaii, 2012-2017[a]

Characteristic	Characteristic is present, no. (%)	Characteristic is absent, no. (%)	Odds ratio (95% CI) [*P* value][b]	Adjusted odds ratio (95% CI) [*P* value][b,c]
Clinical characteristics				
Obesity	235 (3.4)	6764 (96.6)	2.68 (2.32-3.09) [<.001]	1.13 (0.96-1.33) [.15]
Smoking	189 (2.3)	7909 (97.7)	1.75 (1.48-2.03) [<.001]	0.95 (0.77-1.16) [.62]
Substance use disorder	106 (3.5)	2930 (96.5)	2.61 (2.12-3.18) [<.001]	2.10 (1.61-2.74) [<.001]
HIV/AIDS	3 (8.6)	32 (91.4)	6.45 (1.55-18.04) [.002]	—[d]
Preexisting diabetes[e]	110 (6.7)	1521 (93.2)	5.32 (4.33-6.48) [<.001]	2.15 (1.68-2.74) [<.001]
Chronic hypertension	125 (4.6)	2572 (95.4)	3.58 (2.95-4.30) [<.001]	1.58 (1.26-1.97) [<.001]
Chronic heart disease	40 (19.0)	171 (81.0)	16.53 (11.51-23.17) [<.001]	13.66 (8.93-20.41) [<.001]
Chronic respiratory disease	140 (2.6)	5257 (97.4)	1.93 (1.61-2.29) [<.001]	1.41 (1.16-1.70) [<.001]
Chronic renal disease	33 (23.9)	105 (76.1)	22.11 (14.68-32.43) [<.001]	9.08 (5.48-14.63) [<.001]
Chronic liver disease	4 (11.1)	32 (88.9)	8.61 (2.56-21.73) [<.001]	—[d]
Assisted conception	55 (5.3)	966 (94.7)	4.00 (3.00-5.23) [<.001]	2.07 (1.43-2.93) [<.001]
Multiple gestation	47 (3.9)	1145 (96.1)	2.88 (2.11-3.83) [<.001]	1.97 (1.35-2.79) [<.001]
Mode of delivery				
Spontaneous vaginal delivery	556 (1.0)	55 506 (99.0)	0.47 (0.42-0.52) [.007]	0.50 (0.44-0.56) [<.001]
Cesarean delivery	164 (2.2)	7313 (97.8)	1.62 (1.36-1.90) [<.001]	1.31 (1.09-1.57) [<.001]
Obstetric outcomes				
Gestational diabetes	131 (1.4)	8955 (98.6)	1.00 (0.83-1.20) [.96]	0.79 (0.64-0.96) [.02]
Pregnancy-induced hypertensive disorder	554 (5.8)	8973 (94.2)	6.53 (5.84-7.29) [<.001]	4.75 (4.20-5.36) [<.001]
Chorioamnionitis	136 (2.2)	6176 (97.8)	1.57 (1.31-1.87) [<.001]	1.18 (0.97-1.43) [.08]
Postpartum hemorrhage	384 (7.3)	4860 (92.7)	7.21 (6.38-8.14) [<.001]	5.83 (5.10-6.66) [<.001]
Placental abruption	58 (4.8)	1157 (95.2)	3.55 (2.69-4.61) [<.001]	2.12 (1.55-2.83) [<.001]
Placenta previa	14 (4.6)	294 (95.4)	3.28 (1.83-5.41) [.003]	2.49 (1.29-4.43) [.004]
Ectopic pregnancy	10 (5.6)	170 (94.4)	4.06 (2.00-7.30) [<.001]	6.43 (3.01-12.08) [<.001]

[a]Data source: Hawai'i Health Information Corporation.[28]
[b]Comparison between patients with characteristic and patients without characteristic; *P* values determined by Pearson χ^2 test; $P < .05$ considered significant.
[c]Adjusted odds ratios were estimated while adjusting for all characteristics in the table.
[d]Not applicable because the numbers were too small to calculate.
[e]Includes type 1 diabetes and type 2 diabetes.

increased likelihood for ICU admission after adjustment (aOR = 5.83; 95% CI, 5.10-6.66).

We found associations between ICU admissions and obstetric outcomes by race/ethnicity (Table 5). We observed significant differences between various racial/ethnic groups and non-Hispanic White women. Filipino women who were obese were admitted to the ICU at significantly higher rates than non-Hispanic White women who were obese (OR = 2.31; 95% CI, 1.29-4.12). Among women with multiple gestation, Asian women were admitted to the ICU at a higher rate than non-Hispanic White women (OR = 5.14; 95% CI, 1.46-18.11). Native Hawaiian/Other Pacific Islander women with a substance use disorder had lower ICU admission rates than non-Hispanic White women with a substance use disorder (OR = 0.36; 95% CI, 0.23-0.58). Native Hawaiian/Other Pacific Islander women who had chronic hypertensive disease, chronic heart disease, gestational diabetes, chorioamnionitis, or cesarean delivery were admitted to the ICU at a higher rate than non-Hispanic White women with these clinical factors (Table 5). Lastly, Asian, Filipino, and Native Hawaiian/Other Pacific Islander women with a pregnancy-induced hypertensive disorder or postpartum hemorrhage were admitted to the ICU at a higher rate than non-Hispanic White women with a pregnancy-induced hypertensive disorder or postpartum hemorrhage (Table 5).

Discussion

In Hawai'i, rates of severe maternal morbidity, measured as ICU admission in our study, were higher among Asian, Filipino, and Native Hawaiian/Other Pacific Islander women

Table 5. Associations between admission to intensive care unit (ICU) and obstetric outcomes, by race/ethnicity, in a study of racial/ethnic disparities in ICU admissions in a pregnant and postpartum population, Hawaii, 2012-2017[a]

Characteristic	Non-Hispanic White	Asian	Filipino	Native Hawaiian/Other Pacific Islander	Other	*P* value[b]
Clinical characteristics						
Obesity	18 (2.0)	14 (3.0)	34 (4.5)[c]	156 (3.6)	12 (2.6)	.04
Smoking	42 (2.8)	17 (1.4)	28 (2.2)	90 (2.4)	10 (2.3)	.19
Substance use	37 (6.1)	9 (3.7)	13 (4.1)	38 (2.3)[c]	7 (3.9)	<.001
Assisted conception	5 (2.8)	25 (5.8)	10 (6.3)	4 (3.9)	3 (5.3)	.54
Multiple gestation	3 (1.1)	14 (5.4)[c]	8 (5.1)	11 (3.0)	4 (4.3)	.04
Preexisting diabetes[d]	7 (5.0)	12 (6.1)	15 (4.1)	67 (8.1)	6 (7.1)	.13
Chronic hypertensive disease	7 (2.0)	15 (3.3)	31 (4.4)	62 (6.2)[c]	6 (4.6)	.01
Chronic heart disease	2 (5.9)	3 (7.1)	3 (9.1)	30 (35.7)[c]	1 (6.7)	<.001
Chronic respiratory disease	16 (1.8)	11 (1.3)	23 (2.4)	77 (3.3)	11 (3.2)	.02
Chronic renal disease	2 (18.2)	3 (21.4)	10 (31.2)	12 (18.5)	3 (25.0)	.69
Mode of delivery						
Spontaneous vaginal delivery	47 (0.4)	92 (0.9)[c]	126 (1.1)	246 (1.3)[c]	30 (0.9)[c]	<.001
Cesarean delivery	22 (1.4)	27 (1.9)	34 (2.2)	68 (2.8)[c]	11 (2.5)	.04
Obstetric outcomes						
Gestational diabetes	7 (0.6)	29 (1.4)	29 (1.1)	54 (2.0)[c]	5 (1.1)	.005
Pregnancy-induced hypertensive disorders	65 (4.1)	80 (6.3)[c]	142 (6.4)[c]	219 (5.8)[c]	33 (5.7)	.03
Chorioamnionitis	10 (1.2)	26 (1.5)	42 (2.2)	51 (3.3)[c]	7 (3.3)	.004
Postpartum hemorrhage	36 (4.3)	79 (8.4)[c]	88 (7.3)[c]	161 (8.3)[c]	14 (5.4)	.003
Placental abruption	10 (5.3)	8 (4.2)	14 (4.9)	23 (5.0)	1 (1.5)	.83
Placenta previa	2 (3.0)	5 (7.2)	—[e]	5 (6.5)	2 (15.4)	.02
Placenta accreta	3 (4.2)	6 (9.4)	4 (6.3)	10 (7.4)	—[e]	.71
Ectopic pregnancy	—[e]	1 (5.3)	3 (7.0)	5 (8.9)	—[e]	.38

[a]Data source: Hawai'i Health Information Corporation.[28] All values are number (percentage) unless otherwise indicated.
[b]*P* values determined by Pearson χ^2 test; significance set at $P < .05$.
[c]Significant at $P < .0125$ based on Bonferroni correction.
[d]Includes type 1 diabetes and type 2 diabetes.
[e]No data available.

than among non-Hispanic White women. After we controlled for possible confounding variables, we found that race/ethnicity remained an independent risk factor for ICU admission. Multiple clinical characteristics and obstetric outcomes, such as chronic disease, also correlated with ICU admission.

Despite the lack of a common definition on how to measure severe maternal morbidity, studies have documented its rise in in the United States.[12,33] Several groups have independently offered their ideas on how to evaluate severe maternal morbidity. The Centers for Disease Control and Prevention developed a list of indicators of severe maternal morbidity[33]; a research group identified clinical diagnoses associated with severe morbidity[34]; and the American College of Obstetricians and Gynecologists and the Society for Maternal–Fetal Medicine indicated that the use of ICU admission or transfusion of 4 or more units of blood is not an adequate indicator of severe maternal morbidity.[12] A unified, multi-institution definition of severe maternal morbidity would help in defining specific variables of severe maternal morbidity.

Our study used ICU admission as a marker of severe maternal morbidity, an approach that is supported by other studies.[10,13-17] Pollock et al[13] reviewed 40 eligible studies in the United States and other countries of pregnancy and postpartum ICU admissions and noted an incidence of ICU admission of 0.7 to 13.5 per 1000 deliveries. We found an incidence of 14 ICU admissions per 1000 hospitalizations. Consistent with previous studies,[14,32] we found a significant proportion of ICU admissions to be complicated by obstetric

diagnoses of a pregnancy-induced hypertensive disorder or postpartum hemorrhage. Nonetheless, state-to-state comparison of ICU admissions is not a reliable way to measure national severe maternal morbidity, because the criteria or threshold for ICU admission and racial/ethnic composition varies from state to state. Although other studies may report similar rates of ICU admission[35] or similar obstetric complications,[14,32] the generalizability of our findings to other states or the nation is limited. We highlight that pregnant/postpartum women admitted to the ICU warrant high-acuity care because of their high risk for severe morbidity and/or mortality, complicated by their comorbidities and complex management.

The American College of Obstetricians and Gynecologists and the Society for Maternal–Fetal Medicine consensus on severe maternal morbidity deemed that neither ICU admission nor transfusion of 4 or more units of blood is a quality metric for measuring severe maternal morbidity, because underlying morbidities of a woman often manifest during pregnancy.[12] Taking this notion into consideration, we hypothesized that chronic disease may confound admission to the ICU. According to the World Health Organization, the primary causes of maternal death are hemorrhage, infection, and indirect causes, mostly as a result of interactions between preexisting medical conditions and pregnancy.[2,3] In the United States, preexisting chronic disease has become increasingly prevalent in the pregnant population, complicating more pregnancies annually and contributing to the prevalence of severe obstetric morbidity.[36-38] In our adjusted model, chronic disease was associated with an increase in ICU admission. This association has important clinical and political implications, particularly as it relates to extending Medicaid health coverage for at least 12 months postpartum, especially to women with chronic disease.[39]

One strength of our study was that Hawai‘i has large populations of Asian and Native Hawaiian/Other Pacific Islander people, which allowed us to separate data, instead of the common occurrence of these populations being aggregated.[18-21] We recognize that Asian and Native Hawaiian/Other Pacific Islander people are distinctly different from each other and hypothesize that morbidity may vary by race/ethnicity. We noted significant racial/ethnic differences in ICU admission and obstetric outcomes. Similar to our study, other studies found disparities by racial/ethnic minority groups in obstetric outcomes and pointed out the risk of aggregating subgroups into a larger Asian/Other Pacific Islander group.[22,23,40,41] Native Hawaiian/Other Pacific Islander women had high rates of postpartum hemorrhage,[24] preeclampsia,[25] gestational diabetes,[26] and delivery complications.[27] Those findings were corroborated in our study. We emphasize that our findings by no means imply causality or that race/ethnicity is a fixed risk factor. The research of race/ethnicity is inherently complex because of the multiple factors involved in its construction and, when associated with health outcomes, the interplay of other factors such as genetics, access to care, socioeconomic status, and structural racism[42] needs to be considered. Furthermore, the self-reporting of race/ethnicity does not capture the effects of racism and discrimination.[43] Nonetheless, at a time when racial/ethnic minority health is a critical issue, our findings reemphasize the need for greater attention when caring for members of these racial/ethnic minority groups and managing their associated comorbidities.

We noted higher rates of ICU admission among residents in West Honolulu and Waianae, which may have been due to a higher proportion of Native Hawaiian/Other Pacific Islander people residing in these areas than in other areas of Hawai‘i. However, after adjustment, this association was no longer substantiated. Similarly, after adjustment, non-Hispanic Black women were no longer associated with higher rates of ICU admission. Non-Hispanic Black women in Hawai‘i may be more likely to access care at federally funded hospitals than other types of hospitals; because some of the data from these federally funded hospitals are confidential, representation of this racial/ethnic minority group was inadequate, limiting our study’s comparability with similar studies nationally.

Another strength of this study was its access to a large inpatient hospital database that included all of Hawai‘i, allowing for a comprehensive capture of patient data. We were able to construct a multivariable regression model to isolate race/ethnicity as an independent factor and account for region of residence, chronic disease, and age, which allowed us to comment on associations with confidence.

Limitations

Our study had several limitations. First, the retrospective cohort design may have led to selection, misclassification, and confounding biases. Second, the validity of using APR–DRG codes alone to identify pregnancy admission has not been established. Third, we relied on ICD-9-CM and ICD-10-CM codes for some clinical variables and outcomes. The transition from ICD-9-CM to ICD-10-CM occurred during the study period, which may have affected the coding of diagnoses. Fourth, we recognize that ICU admission is not an all-encompassing measure of severe maternal morbidity; some morbid diagnoses may have been missed or overstated. Moreover, multiple objective and subjective criteria are used to decide whether to admit a patient to the ICU for lifesaving interventions and monitoring. Markers of severe maternal morbidity exist other than the markers used in our study. Fifth, although we had intended to identify the primary diagnoses for admission to the ICU, we were limited from elucidating these factors because of the limitation of fixed variables built within a statewide inpatient database. Sixth, we could not ascertain a reason for the lower rate of ICU admissions in 2013. Because the HHIC database captures and aggregates data from multiple institutions, we could not determine whether institutional factors contributed to the

lower ICU rate for that year. Seventh, the database does not permit the identification of multiple admissions for a single patient, so we could not track multiple admissions. Lastly, our study did not specify the timing of ICU admission (antepartum vs intrapartum vs postpartum). The most recent data on maternal mortality demonstrated that approximately 34% of deaths occurred on the day of delivery or within a week after delivery, 19% occurred 7-42 days postpartum, and 24% occurred in the later postpartum period (43-365 days postpartum).[5] The timing of ICU admission is important: even after the 6-week postpartum period, maternal morbidity and mortality occurs.

Conclusion

We found that severe maternal morbidity represented by ICU admission is higher among Asian, Filipino, and Native Hawaiian/Other Pacific Islander women than among non-Hispanic White women in Hawai'i. After adjustment, race/ethnicity was an independent risk factor for ICU admission. Multiple clinical characteristics and obstetric outcomes were also associated with increased ICU admission, particularly chronic disease. In examining possible associations between race/ethnicity and ICU admission for certain clinical factors, we noted higher rates of ICU admission among several races/ethnicities, namely Asian, Filipino, and Native Hawaiian/Other Pacific Islander women than among non-Hispanic White women in Hawai'i. Generalizing our findings to other populations warrants careful consideration given the limitations of our study. Nonetheless, our study demonstrates important findings for a unique racial/ethnic population that merit consideration when caring for similar populations. Our study also adds to the limited data available on severe maternal morbidity in Hawai'i and fills an important research gap in the study of racial/ethnic minority groups and severe maternal morbidity by ICU admission.

Authors' Note

A list of *International Classification of Diseases, Ninth Revision, Clinical Modification* and *International Classification of Diseases, Tenth Revision, Clinical Modification* codes for clinical characteristics and obstetric outcomes is available upon request from the corresponding author.

Declaration of Conflicting Interests

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