Inpatient Maternal Mortality in the United States, 2002–2014

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Background: Although prior studies of inpatient maternal mortality in the United States provide data on the overall rate and trend in inpatient maternal mortality, there are no published reports of maternal mortality data stratified by timing of its occurrence across the pregnancy continuum (antepartum, intrapartum, and postpartum).

Objective: The study objective was to determine whether the maternal mortality rate, trends over time, self-reported race/ethnicity, and associated factors vary based on the timing of the occurrence of death during pregnancy.

Methods: We conducted a cross-sectional analysis of the Nationwide Inpatient Sample database to identify pregnancy-related inpatient stays stratified by timing. Among women in the sample, we determined in-hospital mortality and used International Classification of Diseases, Ninth Revision, Clinical Modification codes to identify comorbidities and behavioral characteristics associated with mortality, including alcohol, drug, and tobacco use. Joinpoint regression was used to calculate rates and trends of in-hospital maternal mortality.

Results: During the study period, there were 7,411 inpatient maternal mortalities among an estimated 58,742,179 hospitalizations of women 15–49 years of age. In-hospital maternal mortality rate stratified by race showed that African Americans died at significantly higher rates during antepartum, intrapartum, and postpartum periods compared to hospitalizations for Whites or Hispanics during the same time period. Although the postpartum hospitalization represents only 2% of pregnancy-related hospitalizations among women aged 15–49 years, hospitalization during this time period accounted for 27.2% of all maternal deaths during pregnancy-related hospitalization.

Discussion: Most in-hospital maternal mortalities occur after hospital discharge from child birth (postpartum period). Yet, the postpartum period continues to be the time period with the least maternal healthcare surveillance in the pregnancy continuum. African American women experience three times more in-hospital mortality when compared to their White counterparts.

Key Words: childbirth • inpatient • maternal mortality • postpartum • United States

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In the United States, the *maternal mortality rate*, defined as the number of maternal deaths per 100,000 live births, has increased from 7.2 to 18 per 100,000 (a 150% increase) between the years 1987 and 2014 (Centers for Disease Control and Prevention, 2014). A recent study reported an increase in the maternal mortality rate from 18.8 per 100,000 live births in 2000 to 23.8 per 100,000 live births in 2014, a 26.6% increase (MacDorman, Declercq, & Thoma, 2017). In contrast, the maternal mortality rate has decreased in most developed countries during the same time (Alkema et al., 2016; Li, Luo, Deng, Jacoby, & de Klerk, 2007; Sullivan, Ford, Chambers, & Slaytor, 2004). Although prior studies of inpatient maternal mortality in the United States provided data on the overall rate and trend in inpatient maternal mortality, to our knowledge, no study has provided maternal mortality data stratified by timing of its occurrence across the pregnancy continuum (antepartum [AP], intrapartum [IP], and postpartum [PP]). Scholarly and popular media reports (Creanga, 2018; Curtin & Hoyert, 2017; Martin & Montagne, 2017; Metcalfe, Wick, & Ronksley, 2018) have drawn attention to racial disparities in rates of maternal mortality, particularly among African American women, who are three to five times as likely to die of maternal causes than White women (Martin & Montagne, 2017; Tucker, Berg, Callaghan, & Hsia, 2007). Although some attribute the disparity to increasing risk factors in this population (obesity, advanced maternal age, hypertension, diabetes), others suggest structural racism as an underlying etiology (Jain

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et al., 2018; Martin & Montagne, 2017). Structural racism refers to the totality of ways in which society enacts racial discrimination through institutions, policies, and systems (Bailey et al., 2017; Krieger, 2014).

The study objective was to determine whether the maternal mortality rate, trends over time, self-reported race/ethnicity, and associated factors vary based on the timing of its occurrence during pregnancy.

METHODS

Using the National Inpatient Sample (NIS) from the Healthcare Cost and Utilization Project (HCUP, 2011, 2015), we conducted a retrospective analysis of all pregnancy-related inpatient hospitalizations from January 1, 2002, to December 31, 2014. The NIS is the largest publicly available all-payer inpatient hospitalization database in the United States. To create the NIS, HCUP uses a cluster sampling method and stratifies hospitalizations from participating nonfederal community hospitals using five characteristics (rural/urban location, number of beds, geographic region, 2teaching status, and ownership). Then, using a simple random sampling approach, 20% of hospitals are selected from each stratum (HCUP, 2011), and all inpatient discharges from hospitals selected using the simple random sampling approach are included in the NIS. In 2012, the NIS sampling approach was revised to include a sample of discharges from all hospitals instead of only the 20% selected using a stratified sampling approach. The NIS has been validated against other databases and is representative of the population of all hospitalizations in the United States on critical hospital and patient characteristics (Hashimoto, Brodt, Skelly, & Dettori, 2014; Murphy, Alavi, & Maykel, 2013).

Study Population

The study population consisted of pregnancy-related inpatient hospitalizations 15–49 years of age, identified using an HCUP-created "NEOMAT" variable. The NEOMAT indicator identifies maternal diagnosis records on the basis of International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes for pregnancy (HCUP, 2015; Weiss & Elixhauser, 2006).

We categorized each maternal pregnancy-related hospitalization as AP, IP, or PP (HCUP, 2015). AP hospitalizations reflect the admission of a pregnant person with no record of childbirth during the same hospitalization. An IP hospitalization reflects all admissions for IP management (birth of fetus) through initial discharge (approximately 1–3 days) after birth. PP hospitalizations are any readmission within the first 42 days after birth of the baby. We used ICD-9-CM diagnosis codes to determine whether each woman had a hospitalization during the AP, IP, or PP period using algorithm previously published by Kuklina and colleagues (Callaghan, Creanga, & Kuklina, 2012; Kuklina et al., 2008). IP hospitalizations were identified using delivery-specific ICD-9-CM diagnosis, procedure and diagnosis-related group (DRG) codes. PP hospitalizations (within 42 days of delivery) were identified using V24 code, PP DRG codes, and presence of the number "4" in the fifth digit of selected ICD-9-CM codes. Pregnancy-related discharges that did not have a code for IP or PP conditions were classified as AP hospitalizations (Callaghan et al., 2012; Kuklina et al., 2008). Supplemental Table S1, http://links.lww.com/NRES/A327, provides the complete list of ICD-9-CM diagnosis, procedure, and DRG codes used in this study. Mortality was identified using the variable disposition status provided by HCUP.

Covariates

Individual-level sociodemographic and behavioral characteristics were also extracted from the NIS databases. Patient age in years was classified into the following categories: 15–24, 25–34, and 35–49. We used median household income in quartiles, calculated by HCUP, as a proxy for participants' socioeconomic status. Type of insurance used was grouped into three categories: government (Medicare and Medicaid), private (commercial carrier, private health maintenance organization, and preferred provider organization), and other sources (e.g., self-pay and charity).

In addition, hospital characteristics such as geographic region (northeast, midwest, south, or west), location, and teaching status (rural, urban nonteaching, urban teaching) were considered. We considered the effect of several individual-level behavioral characteristics, including tobacco, alcohol, and drug use. We also examined distribution of all comorbidities included in the Elixhauser comorbidity index among those who died by timing of death (AP, IP, and PP; Elixhauser, Steiner, Harris, & Coffey, 1998).

Statistical Analyses

The distribution of inpatient maternal mortality diagnoses among AP, IP, and PP discharges were described by sociodemographic, behavioral, hospital, insurance, clinical, and pregnancy-related comorbidities using descriptive statistics such as frequencies and rates. Joinpoint regression was used to examine temporal trends of inpatient maternal mortality during the study period by timing of hospitalization (AP, IP, and PP). We further examined trends in inpatient mortality across the pregnancy continuum stratified by self-reported race/ethnicity (White, African American, and Hispanic). The annual percent change (APC) was calculated to describe the trend within each time interval, as previously described by Clegg, Hankey, Tiwari, Feuer, and Edwards (2009).

All statistical analyses accounted for the complex sampling design of the NIS and were weighted to facilitate the generation of national frequency and prevalence estimates. To account for NIS sampling design changes, we used the NIS trends files, so that trend weights and data elements would be consistently defined over time (Houchens & Elixhauser, 2015). All analyses were conducted by the primary author

using software (SAS 9.4; SAS Institute, Inc., Cary, NC) using a 5% Type I error rate and two-sided hypothesis tests. The study was approved by the institutional review board of the primary author's institution. Data used in this study are available for purchase from HCUP for interested researchers. Upon request, authors are willing to share information related to analytic approach used in this study.

RESULTS

In the United States from 2002 to 2014, there were 7,411 inpatient maternal mortalities among an estimated 58,742,179 hospitalizations among women 15–49 years of age (Table 1). The overall inpatient maternal mortality rate during the study period was 34, 7, and 226 per 100,000 for AP, IP, and PP hospitalizations, respectively. The mean age of women who died versus women who survived during pregnancy-related hospitalization was 28.3 versus 27.1 years ($p < .01$) for AP, 29.9 versus 27.7 years ($p < .01$) for IP, and 30 versus 27.9 years ($p < .01$) for PP hospitalizations. Table 1 presents the distribution of inpatient maternal mortality across the pregnancy continuum by selected demographic, behavioral, and hospital characteristics. Across all pregnancy time periods (AP, IP, and PP), the proportion of women who died during pregnancy-related hospitalization was higher among women who are older (age > 35 years), non-Hispanic African Americans, users of alcohol and abused drugs, and from the southern region of the United States.

Table 2 summarizes the distribution of inpatient maternal mortality across racial groups by selected demographic, behavioral, and hospital characteristics. The distributions of maternal age, alcohol use, and hospital size (occupancy) among women who died during pregnancy-related hospitalization were not statistically different across maternal race groups. However, there was statistically significant difference in rates of tobacco use, drug abuse, household income, and insurance status.

In-hospital maternal mortality rate stratified by race showed that African Americans die at significantly higher rates of 47, 17, and 379 per 100,000 maternal hospitalizations during AP, IP, and PP periods, respectively, compared to 30, 5, and 160 per 100,000 hospitalizations for Whites and 28,6 and 181 per 100,000 hospitalizations for Hispanics during the same time period ($p < .001$). In-hospital mortality rate during IP hospitalization among African Americans is three times higher than that of Whites and Hispanics. When compared to women 15–34 years of age, advanced maternal age women (age ≥ 35 years) experienced significantly higher rates of in-hospital maternal mortality during AP (32 vs. 44 per 100,000), IP (6 vs. 13 per 100,000), and PP (206 vs. 319 per 100,000) hospitalizations ($p < .001$). However, it is important to highlight that the average age at the time of in-hospital maternal death during IP hospitalization was 29.7 years for Whites, 29.7 years for African Americans, and 30.3 years for Hispanics, indicating that age is not a factor for the observed threefold high mortality among African Americans. Although the PP hospitalization represents only 2% of pregnancy-related hospitalizations among women aged 15–49 years, hospitalization during this time period accounted for 27.2% of all maternal deaths during pregnancy-related hospitalization (Figure 1).

The rate of cesarean section (CS) varied among women who survived to IP discharge (31.7%) compared to those who died during hospitalization (72.8%). The rate of CS among those who died during hospitalization was 77.1% for Whites, 73.8% for African Americans, and 68% among Hispanics. Our data did not allow us to pinpoint the indication(s) for the CS procedures.

Among all in-hospital maternal deaths during the study period, 19.2%, 19.0%, and 20.5% of AP, IP, and PP hospitalization involved three or more indicators for severe maternal morbidity, respectively (Supplemental Table S2, http://links.lww.com/NRES/A328). Among maternal deaths that occurred during AP, IP, and PP hospitalizations, acute myocardial infarction was present in 41.3%, 52.4%, and 62.9%, respectively. Next to acute myocardial infarction, the most frequently reported indicator of severe maternal morbidity indicator during AP, IP, and PP hospitalizations were amniotic fluid embolism (8.75%), conversion of cardiac rhythm (4.54%), and pulmonary edema/acute heart failure (7.08%), respectively. Our data, seen in Table 3), indicate that comorbidities such as fluid and electrolyte imbalance, coagulopathy, anemia related to blood loss, hypertension, and neurological disorders are the most commonly reported comorbidities among women who died during pregnancy-related hospitalization.

Between 2002 and 2014, we found a statistically significant 3.6% annual reduction (APC = −3.6 [−6.1, −1.2]) in inpatient maternal mortality during the IP period. However, the inpatient maternal mortality rate remained steady among AP and PP hospitalizations (Figure 2). Further trend analyses stratified by race showed that inpatient maternal mortality during IP hospitalization decreased more among African Americans (APC = −4.7 [−8.0, −1.3]) when compared to Whites (APC = −3.3 [−6.0, −0.5]; Supplemental Figure S1, http://links.lww.com/NRES/A329, and Supplemental Figure S2 http://links.lww.com/NRES/A330). Hispanic women experienced a statistically significant 8.7% annual reduction in maternal mortality during PP hospitalization from 2002 to 2014 (APC = −8.7, [−16.2, −0.6]; Supplemental Figure S3, http://links.lww.com/NRES/A331).

DISCUSSION

The major new findings of this study are (a) although IP deaths during hospitalization decreased by 3.6% annually between 2002 and 2014 for all women and by 4.7% annually for non-Hispanic African American women, African American women are still three times more likely to die during IP hospitalization than White women; (b) the PP period, a time with the least

TABLE 1. Demographics, Behavioral, and Hospital Characteristics of Pregnancy-Related Deaths Stratified by Timing of Pregnancy: National Inpatient Sample (2002–2014)

			In-hospital pregnancy-related mortality by timing of pregnancy								
			Antepartum			Intrapartum			Postpartum		
Characteristics	[a]*n*	C%	*n*[a]	C%	R%	*n*[a]	C%	R%	*n*[a]	C%	R%
All	58,742,179	100	1,798	100	0.03	3,600	100	0.01	2,013	100	0.23
Age (years)											
13–24	19,918,381	33.91	618	34.37	0.03	872	24.21	0.00	462	22.98	0.15
25–34	30,208,480	51.43	842	46.83	0.03	1,705	47.34	0.01	1,051	52.20	0.24
35–49	8,615,318	14.67	338	18.80	0.04	1,024	28.45	0.01	500	24.83	0.32
Race											
Non-Hispanic White	24,716,530	42.08	598	33.29	0.03	1,082	30.04	0.00	572	28.44	0.16
Non-Hispanic African American	6,997,714	11.91	468	26.06	0.05	961	26.70	0.02	639	31.72	0.38
Hispanic	11,029,179	18.78	267	14.86	0.03	623	17.32	0.01	251	12.46	0.18
Other	5,024,250	8.55	166	9.24	0.05	346	9.60	0.01	187	9.30	0.29
Alcohol											
Yes	100,779	0.17	55	3.07	0.14	25	0.70	0.04	14	0.71	0.30
No	58,641,400	99.83	1,743	96.93	0.03	3,575	99.30	0.01	1,999	99.29	0.23
Tobacco											
Yes	2,843,226	4.84	145	8.07	0.04	119	3.30	0.00	124	6.16	0.19
No	55,898,953	95.16	1,653	91.93	0.03	3,482	96.70	0.01	1,889	93.84	0.23
Drug abuse											
Yes	945,170	1.61	208	11.59	0.10	162	4.49	0.02	122	6.05	0.43
No	57,797,010	98.39	1,589	88.41	0.03	3,439	95.51	0.01	1,891	93.95	0.22
Household income											
Highest quartile	12,979,032	22.09	194	10.80	0.02	554	15.39	0.00	317	15.74	0.18
Lowest quartile	15,971,946	27.19	658	36.61	0.04	1,157	32.13	0.01	784	38.93	0.29
2nd quartile	14,554,198	24.78	534	29.70	0.04	991	27.51	0.01	485	24.12	0.22
3rd quartile	14,133,460	24.06	366	20.35	0.03	792	22.00	0.01	382	18.98	0.19
Primary payer											
Government	25,280,366	43.04	842	46.84	0.03	1,830	50.84	0.01	1,080	53.68	0.25
Private	29,628,368	50.44	612	34.02	0.03	1,460	40.54	0.01	726	36.08	0.19
Other	3,833,446	6.53	344	19.14	0.07	310	8.62	0.01	206	10.24	0.28
Region of hospital											
Northeast	9,758,119	16.61	251	13.98	0.03	591	16.41	0.01	325	16.16	0.21
Midwest	12,511,650	21.30	346	19.26	0.03	548	15.21	0.00	339	16.83	0.18
South	22,259,017	37.89	807	44.87	0.04	1,663	46.19	0.01	999	49.61	0.28
West	14,213,394	24.20	393	21.89	0.03	798	22.18	0.01	350	17.40	0.19
Bed size of hospital											
Large	36,224,039	61.67	1,254	69.78	0.04	2,389	66.36	0.01	1,507	74.89	0.26
Small	6,720,614	11.44	118	6.57	0.02	227	6.32	0.00	104	5.18	0.11
Medium	15,544,115	26.46	409	22.77	0.03	968	26.90	0.01	390	19.38	0.17
Location/teaching status of hospital											
Rural	6,649,507	11.32	99	5.52	0.02	210	5.84	0.00	82	4.06	0.10
Urban, nonteaching	23,630,765	40.23	565	31.42	0.03	1,081	30.02	0.01	465	23.12	0.14
Urban, teaching	28,208,496	48.02	1,118	62.17	0.04	2,294	63.71	0.01	1,455	72.28	0.30

Note. C% = column percent; R% = row percent.

[a]Weighted to estimate the national frequency; sum of all groups may not add up to the total because of missing data.

maternal healthcare surveillance, had the highest rate (226/100,000) of maternal mortality compared with the AP period (34/100,000) and IP period (7/100,000); and (c) in-hospital maternal mortality rates significantly vary across racial groups, with African American women experiencing the highest rate of mortality during AP, IP, and PP hospitalizations.

TABLE 2. Demographics, Behavioral, and Hospital Characteristics of In-hospital Maternal Mortality Stratified by Race Group: National Inpatient Sample (2002–2014)

			In-hospital maternal mortality by race group			
Characteristics	***n*[a]**	**%**	**White *n*[a] (%)**	**African American *n*[a] (%)**	**Hispanic *n*[a] (%)**	***p***
All	58,742,179	100%	2,252 (30.4)	2,068 (27.9)	1,141 (15.4)	
Age (years)						.34
13–24	19,918,381	33.91	576 (25.6)	588 (28.5)	283 (24.8)	
25–34	30,208,480	51.43	1083 (48.1)	995 (48.1)	599 (52.5)	
35–49	8,615,318	14.67	594 (26.4)	485 (23.4)	259 (22.7)	
Alcohol (yes)	100,779	0.17	41 (1.8)	25 (1.2)	14 (1.3)	.67
Tobacco (yes)	2,843,226	4.84	214 (9.5)	96 (4.7)	16 (1.4)	<.01
Drug abuse (yes)	945,170	1.61	222 (9.9)	88 (4.2)	55 (4.8)	.01
Household income						<.01
Highest quartile	12,979,032	22.09	585 (26.0)	953 (46.1)	444 (38.9)	
Lowest quartile	15,971,946	27.19	631 (28.0)	507 (24.5)	356 (31.2)	
2nd quartile	14,554,198	24.78	511 (22.7)	384 (18.6)	194 (17.0)	
3rd quartile	14,133,460	24.06	477 (21.1)	155 (7.5)	108 (9.4)	
Primary payer						<.01
Government	25,280,366	43.04	954 (42.4)	1251 (60.5)	707 (61.9)	
Private	29,628,368	50.44	1036 (46.0)	638 (30.9)	260 (22.7)	
Other	3,833,446	6.53	262 (11.6)	179 (8.7)	175 (15.3)	
Region of hospital						<.01
Northeast	9,758,119	16.61	360 (16.0)	451(21.8)	160 (14.0)	
Midwest	12,511,650	21.30	339 (15.0)	185 (8.9)	42 (3.7)	
South	22,259,017	37.89	1069 (47.4)	1248 (60.4)	447 (39.2)	
West	14,213,394	24.20	485 (21.5)	184 (8.9)	492 (43.1)	
Bed size of hospital						.71
Large	36,224,039	61.67	129 (0.9)	101 (1.0)	79 (1.6)	
Small	6,720,614	11.44	543 (2.0)	524 (2.6)	260 (3.0)	
Medium	15,544,115	26.46	1576 (2.2)	1429 (2.7)	791 (3.4)	
Location/teaching status of hospital						<.01
Rural	6,649,507	11.32	193	46	6	
Urban, nonteaching	23,630,765	40.23	712	490	445	
Urban, teaching	28,208,496	48.02	1343	1518	679	

Note. $p \leq .05$ considered statistically significant. *n* = sample size.
[a]Weighted to estimate the national frequency; sum of all groups may not add up to the total because of missing data.

Our study assessed rates of maternal mortality that occurred in an inpatient hospital setting only. Findings in this study underscore that the PP period is the deadliest time for pregnant women with 226 maternal deaths occurring per 100,000 PP hospitalizations. The recent guideline by the American College of Obstetricians and Gynecologists (2018) emphasized the need for PP care, urging providers to focus on individualized early fourth trimester care. Previously we

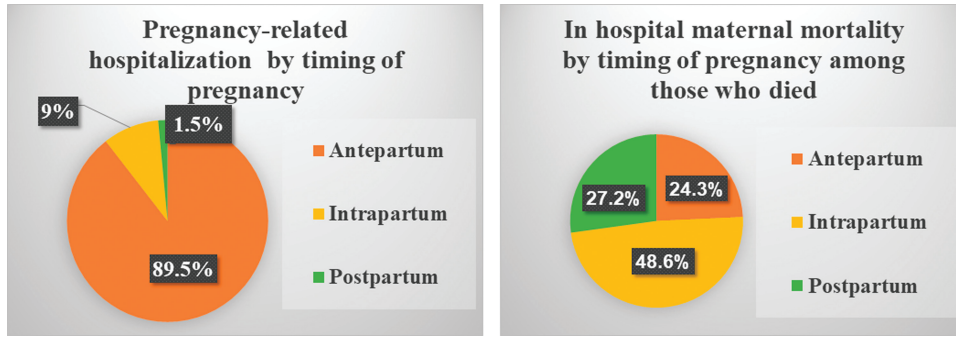

FIGURE 1. Distribution of pregnancy-related hospitalizations and in-hospital mortality in the United States (National Inpatient Sample: 2002–2014).

TABLE 3. Summary of Percent Distribution of Elixhauser Comorbidities by Timing of Pregnancy Among Women Aged 15–49 Years Who Died During Pregnancy-Related Hospitalization in the United States (Nationwide Inpatient Sample 2002–2014)

	Timing of pregnancy-related hospitalization at the time of in-hospital mortality		
Elixhauser comorbidity	**AP (%)**	**IP (%)**	**PP (%)**
AIDS/HIV	2.3	1.5	0.2
Alcohol abuse	2.8	0.7	0.7
Anemia deficiency	11.1	9.8	14.8
Depression	5.0	1.1	3.9
Diabetes without complication	4.8	3.7	6.4
Diabetes with complication	1.0	0.5	1.4
Drug abuse	10.5	4.1	6.3
Hypertension	10.0	12.4	21.6
Hypothyroidism	3.0	1.6	3.4
Liver disease	2.4	1.6	1.6
Lymphoma	-	0.6	0.2
Fluid and electrolyte disorders	39.7	30.3	43.5
Metastatic cancer	1.6	1.6	2.1
Neurological	13.0	12.2	15.6
Obesity	7.2	6.3	12.2
Paralysis	2.1	1.2	4.9
Peripheral vascular disease	0.6	2.0	1.5
Psychoses	3.5	0.8	1.2
Pulmonary circulation disorder	5.3	3.6	5.1
Renal failure	3.0	1.9	6.7
Tumor without metastasis	0.9	1.3	—
Peptic ulcer disease	—	—	—
Valvular disease	3.3	1.8	5.7
Weight loss	4.7	3.8	6.5
Rheumatoid arthritis	1.6	1.7	2.9
Blood loss anemia	11.4	23.3	17.0
Congestive heart failure	5.0	3.7	20.4
Chronic lung disease	8.2	6.1	6.3
Coagulopathy	23.1	31.8	26.4

Note. AP = antepartum; IP = intrapartum; PP = postpartum; AIDS = acquired immune deficiency syndrome; HIV = human immunodeficiency disease. Dash (-) indicates that the counts per cell are less than 10 and hence percentages are not reported per HCUP data use agreement.

have shown that women were at increased risk of cardiac pregnancy complications that are deadly during the PP period (Mogos et al., 2018). Thus, the recent guideline regarding early fourth trimester care has the potential to save maternal lives by providing care during a time of least healthcare surveillance for women at increased risk of PP mortality.

On the other hand, the relatively lower rate of mortality during IP hospitalization, a time when the mother and fetus are intensely monitored, is encouraging. The observed decline in inpatient maternal mortality during the IP period could be due to improved IP monitoring, presence of obstetric in-house healthcare providers, and availability of in-house anesthesia service in most labor and delivery units (Mogos, Salemi, Spooner, McFarlin, & Salihu, 2016). However, surveillance of high-risk women during IP hospitalization before discharge needs to be emphasized as one of the focal points for intervention to decrease maternal mortality during PP period. Improved patient education is also needed so that women and their families can recognize early warning signs of severe morbidity such as fatigue, myocardial infarction, and heart failure.

The threefold high mortality rate experienced by African American women during the IP period is consistent with several studies that show significant racial disparities in maternal morbidity and mortality among U.S. women (Creanga, Bateman, Kuklina, & Callaghan, 2014; Creanga et al., 2015; Liese et al., 2019; Louis, Menard, & Gee, 2015). Demonstrated Black–White differences in maternal death could be the result of multifaceted factors (Moaddab et al., 2018; Rosenberg, Geller, Studee, & Cox, 2006; Tucker et al., 2007). Because of the limited nature of our data set, we were not able to test the effect of specific risk factors in the observed racial disparity.

Hispanic women experienced a significant decline in inpatient maternal mortality during PP hospitalization. Because of the nature of our data, we are not able to elucidate reasons

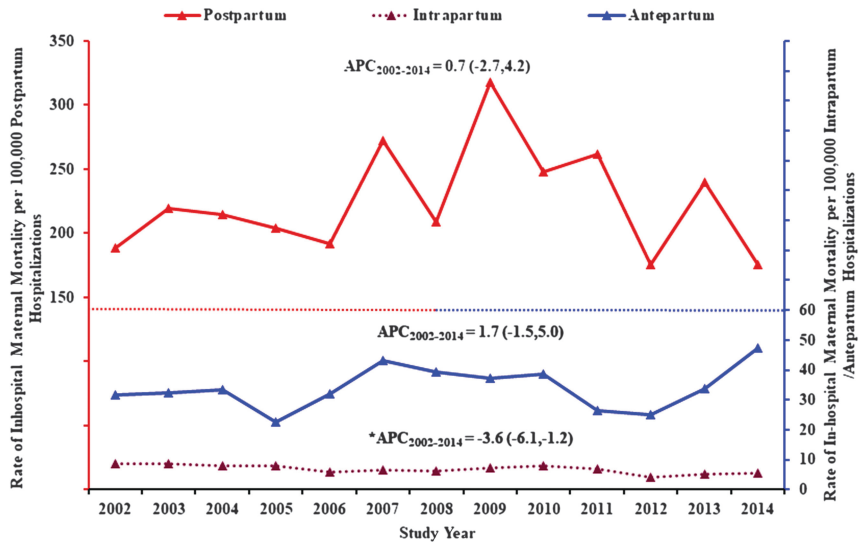

FIGURE 2. Trend in inpatient maternal mortality by timing in the pregnancy continuum in the United States: National Inpatient Sample (2002–2014). APC = annual percent change.

behind the observed reduction in inpatient maternal mortality among Hispanic women. Previously, it has been reported that strong social support was associated with better PP outcomes (Clark, Christmas, Frye, Meyers, & Perlin, 2014; Keller et al., 2014; Mann, Mannan, Quinones, Palmer, & Torres, 2010; Negron, Martin, Almog, Balbierz, & Howell, 2013). Overall, the observed racial disparity in inpatient maternal mortality suggests that specifically targeted quality improvement efforts are needed to reduce inpatient maternal mortality and eliminate associated disparity (Adams & Thomas, 2018; Negron et al., 2013). In the era of personalized healthcare, different interventions may be needed based on racial, ethnic, and health risk factors, rather than using generalized care plans to be used in all circumstances.

Because we used the NIS data to estimate prevalence, our data can only be generalized to maternal mortality in an inpatient setting. We also acknowledge that our prevalence estimates of maternal mortality may be underestimated because our data do not include mortalities that might have occurred in an emergency department, home, or outpatient setting; however, the use of a large, multiyear, nationally representative hospital discharge database is the primary strength of the current study. The NIS data contain hospital discharge data containing demographic, behavioral, hospital, and clinical variables from roughly 1,000 U.S. community hospitals with approximately 8 million discharge records annually, allowing us to adjust for multiple potential confounders in a multivariate model. The current study has other limitations that relate to our use of cross-sectional administrative data. The first limitation is that the databases lack data on some important variables, including gestational age and any treatment received by patients. Therefore, for example, we did not assess when exactly during the AP period (first, second, or third trimester) the death occurred. Also, we could not assess effectiveness of various treatments or procedures that might have occurred during the hospitalization. Second, identification of cases, behaviors, and clinical diagnoses using ICD-9-CM codes is subject to errors in coding. Third, not all states report race–ethnicity data, and there is variation in reporting. The data set used in this study has missing race–ethnicity for one fourth of the study population. Although racial–ethnic disparities were not considered in this study, our ability to fully control for the variable race was limited. Finally, the NIS data do not provide information about the main cause of death.

CONCLUSION

This study provides an estimate of the prevalence of inpatient maternal mortality in relation to the timing of delivery and indicates that trends in inpatient maternal mortality vary across racial groups. We have assessed these trends over a 13-year period and noted persistence of racial disparity in maternal mortality. In the past 5 years, there has been increased media attention on issues of maternal mortality and associated racial disparity. The authors hope that such an increased attention on the topic combined with ongoing efforts by perinatal quality collaboratives and maternal care providers from various states will lead to reducing maternal mortality and associated racial disparity. Future studies focusing on in-hospital mortality should try to disentangle unique factors contributing to maternal mortality and associated racial disparity.

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