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Maternal Outcomes by Race for Women Aged 40 Years or Older

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Abstract

OBJECTIVE—To clarify how race is associated with adverse maternal outcomes and risk for women aged 40 years or older.

METHODS—This retrospective cohort study used the Nationwide Inpatient Sample (NIS) for the years 1998 to 2014. Women aged 40 to 54 years were included. Race and ethnicity were categorized as non-Hispanic white, non-Hispanic black, Hispanic, Asian or Pacific Islander, Native American, other, and unknown. Temporal trends in severe maternal morbidity and overall comorbid risk by race in women aged 40 years were evaluated as were common pregnancy complications including preeclampsia, gestational diabetes, and cesarean delivery. Adjusted models were created to assess factors associated with severe morbidity.

RESULTS—A total of 1,724,694 deliveries were included in this analysis. Severe maternal morbidity increased over the study period from 1.6% in 1998–2000 to 3.0% from 2013–2014. Black women had the highest rates of severe morbidity at both the beginning (2.4% in 1998–2000) and the end (4.9% in 2013–2014) of the study period. During this same period, comorbid risk based on medical conditions and other factors increased overall and individually by race. Black women also experienced the absolute largest increase from 1998–2003 to 2010–2014 in risk for acute renal failure, disseminated intravascular coagulation, transfusion, and hysterectomy. Pregnancy complications including preeclampsia, cesarean delivery, and gestational diabetes were more common at the end compared to the beginning of the study for black, white, and Hispanic women. The adjusted risk ratio for overall severe morbidity for black compared to white race was 1.81 (95% CI 1.76–1.87). Black women had a substantially higher risk of death than white women (RR 4.71, 95% CI 3.36–6.61), while Hispanic women were at more than twice the risk of death (RR 2.13, 95% CI 1.48–3.07) as white women.

DISCUSSION—While black women older than 40 years were at increased risk for adverse outcomes and severe morbidity, this differential was of smaller magnitude than reported mortality risk.

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INTRODUCTION

Births to women aged 40 years and older have increased over recent decades with the birthrate for women 40 to 44 years approximately doubling between 1990 and 2014.¹ Over that same period births to women 45 to 49 years of age approximately quadrupled.² While many women aged 40 years and over will have uncomplicated pregnancies, pregnancy for women in their 40s is associated with increased risk for adverse outcomes including preterm birth, pre-eclampsia, gestational diabetes, cesarean delivery, and maternal mortality and severe morbidity.^{3–9}

Maternal race is another major factor in risk for maternal mortality and severe morbidity and other adverse outcomes.^{3,9,10} Data from the Centers for Disease Control and Prevention's (CDC) Pregnancy Mortality Surveillance System (PMSS) demonstrated increasing mortality risk for all women over recent decades with risk highest among non-Hispanic black women across maternal age categories. From 2011 to 2013 the mortality risk for non-Hispanic black was 3.4 times that of non-Hispanic white women, and for non-Hispanic black women aged 40 years or older the maternal mortality rate was 191.6 per 100,000 live births, more than ten times the national average.⁹ Black women are also at increased risk for severe morbidity based on CDC criteria.³

While the role of maternal racial disparities in risk for severe morbidity and mortality is well characterized, how race is related specifically to severe morbidity and other adverse outcomes besides mortality for women 40 years of age is unclear. The objectives of this study were to determine how race is associated with adverse maternal outcomes for women aged 40 years by characterizing: (i) temporal trends in severe maternal morbidity and overall comorbid risk by race in women aged 40 years, and (ii) characterize trends in common pregnancy complications including pre-eclampsia, gestational diabetes, and cesarean delivery.

MATERIALS AND METHODS

We conducted a retrospective cohort study. The Nationwide Inpatient Sample (NIS) from the Agency for Healthcare Research and Quality for the years 1998 to 2014 was used for this analysis. The NIS is the largest publically available, all-payer inpatient database in the United States and contains a sample of approximately 20% of all hospitalizations nationally. These hospitalizations are selected to generate a sample that is representative for the entire US, and includes academic, community, nonfederal, general and specialty-specific centers. In 2010, approximately 8 million hospital stays from a total of 45 states were included in the NIS.^{11,12} For this analysis, index delivery hospitalizations were captured with International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis codes 650 and V27.x. These criteria ascertain >95% of delivery hospitalizations.¹³ Because the data is de-identified, the Columbia University institutional review board deemed this analysis exempt.

Women aged 40–54 years were included. The primary exposure evaluated was self-reported maternal race and ethnicity as categorized by the NIS: non-Hispanic white, non-Hispanic

black, Hispanic, Asian or Pacific Islander, Native American, or other. The primary outcome of this study was severe maternal morbidity as defined by the CDC. The CDC definition of severe maternal morbidity includes 21 diagnoses including shock, stroke, heart failure, transfusion, and other conditions all identified using ICD-9-CM codes (Appendix 1, available online at <http://links.lww.com/xxx>).¹⁴ Women were considered to have had severe maternal morbidity if they had any codes for any one of these conditions. As an additional sensitivity analysis, because the most common diagnosis in the severe morbidity composite is transfusion (ICD-9-CM 99.0x) severe morbidity analysis analyzed excluding transfusion and restricted to the remaining 20 conditions representative of non-transfusion severe morbidity.

We evaluated five sets of secondary outcomes. First, we evaluated temporal trends by race for diagnoses of preeclampsia, cesarean delivery, and gestational diabetes. Second, we evaluated temporal trends by race of specific diagnoses within the CDC composite severe morbidity outcome including: (i) acute renal failure, (ii) disseminated intravascular coagulation, (iii) acute respiratory distress syndrome, (iv) stroke, (v) transfusion, and (vi) hysterectomy. These diagnoses were chosen because they are relatively common on a population basis and the data use agreement for the NIS precludes display of small cell sizes. Third, we evaluated risk for maternal death. Fourth, we evaluated temporal trends in comorbid risk by race as measured by an obstetric comorbidity index.¹⁵ This comorbidity index provides weighted scores for comorbidity for individual patients based on the presence of specific diagnosis codes and demographic factors present in administrative data. Higher scores are associated with increased risk for severe morbidity. Factors in the comorbidity index include hypertensive diseases of pregnancy, multiple gestation, cardiac conditions, abnormal placentation, substance abuse, pre-existing diabetes, and previous cesarean delivery. In the initial study validating the comorbidity index, patients with the lowest score of 0 had a 0.68% risk of severe morbidity whereas a score of >10 was associated with a risk of severe morbidity of 10.9%.¹⁵ This comorbidity index was subsequently validated in an external population.¹⁶ Because the comorbidity index includes maternal age, we modified this scoring system excluding maternal age for the present analysis. Fifth, we determined if risk for severe morbidity differed by race for women with the same comorbidity index score.

Demographic and hospital characteristics were evaluated by NIS racial categories. Hospital characteristics included bed size (small, medium, or large), location (urban versus rural), region (Northeast, Midwest, South, or West), and teaching status (teaching versus nonteaching). Demographic categories included year of delivery, insurance status (Medicaid, private, Medicare, other, uninsured), and ZIP code income quartile. Demographic comparisons and temporal trends were evaluated using the chi-squared test. Adjusted risk ratios (aRR) for severe morbidity with 95% confidence intervals (CI) as measures of effect accounting for demographic and hospital factors were derived from fitting a log-linear regression model. This model was subsequently repeated including the comorbidity index to account for medical and obstetric risk factors. Population weights within the NIS can be applied to create estimates for the entire US population. These weights were used for this analysis. All analyses were performed with SAS 9.4 (SAS Institute, Cary, NC).

RESULTS

A total of 1,724,694 estimated births to women aged 40 to 54 years were included in this analysis. The number of births to women in this age group increased over the study period from 73,946 in 1998 to 110,710 women in 2014 (Table 1). Ascertainment of race improved in the NIS from 2007 on with the proportion of unknown race decreasing from 26.7% in 2007 to 5.2% in 2014. The majority of women in all NIS racial categories delivered at urban and high-bed number hospitals. White and Asian or Pacific Islander women were more likely to reside in a top quartile income ZIP code than women of other races.

For women aged 40 years old, black women had the highest overall risk of severe maternal mortality with unadjusted risk 104% higher than white women (risk ratio [RR] 2.04, 95% CI 1.98–2.04). Hispanic women (RR 1.28 95% CI 1.24–1.32), Asian or Pacific Islander women (RR 1.29, 95% CI 1.24–1.34), and Native American women (RR 1.20, 95% CI 1.03–1.39) were also at increased risk compared to white women (Table 2). Risk of severe morbidity increased over the study period from 1.6% in 1998–2000 (95% CI 1.5–1.7%) to 3.0% in 2012–2014 (95% CI 2.9–3.1%) ($P<0.01$), with risk among black women highest at both the beginning (2.4% in 1998–2000, 95% CI 2.2%–2.6%) and the end (4.9% in 2013–2014, 95% CI 4.7–5.1%) of the study period (Figure 1A). When the analysis was restricted to severe morbidity excluding transfusion results were similar (Figure 1B); Black women had the highest risk of severe morbidity with and without transfusion for every three year period from 1998 to 2014.

Figure 2 demonstrates proportionate changes in comorbid risk for white, black, Hispanic, and Asian or Pacific Islander women. For all four groups the proportion of women with the lowest score of 0 decreased while the proportions of women with a score of 1–2 and >2 increased. Women with scores >2 increased the most proportionately: 78% for white women, 109% for black women, 111% for Hispanic women, and 45% for Asian or Pacific Islander women. However, women with the highest comorbidity scores (>2) represented a relatively small percentage of the overall population (Appendix 2, available online at <http://links.lww.com/xxx>). Overall black women were least likely to have a comorbidity score of 0 and most likely to have comorbidity scores of 1–2 and >2 .

Risk for severe morbidity increased with comorbidity index score. Risk for severe morbidity was lowest among women with a score of 0 (1.3%, 95% CI 1.3–1.3%), increased for women with a score of 1 or 2 (3.4%, 95% CI 3.4–3.5%), and was highest for women with scores <2 (12.1%, 95% CI 11.7–12.5%). For each of the three comorbidity index score categories (0, 1–2, >2), black women had significantly higher risk for severe morbidity than white women. Risk for severe morbidity with a score of 0 was 2.4% for black women, 1.5% for Asian or Pacific Islander women, 1.4% for Hispanic women, and 1.1% for white women ($p<0.01$). For scores of 1 or 2, risk for severe morbidity was 5.4% for black women, 3.7% for Hispanic women, 3.9% for Asian or Pacific Islander women, and 3.0% for white women ($p<0.01$). For scores of >2 , risk for severe morbidity was 14.2% compared to 13.8% for Hispanic women, 12.2% for Asian or Pacific Islander women, and 11.8% for white women ($p<0.01$) (Figure 3).

Appendixes 3 and 4, available online at <http://links.lww.com/xxx>, demonstrate temporal trends in preeclampsia, gestational diabetes, and cesarean delivery for women aged 40–54 years by race. Incidence of all three outcomes increased significantly for non-Hispanic white, non-Hispanic black, and Hispanic women. Black women were more likely than non-black women to develop preeclampsia (9.1% versus 5.3%, $p<0.01$) with the diagnosis of preeclampsia rising significantly from 8.0% of pregnancies among black women in 1998 ($n=509$ of 6,394, 95% CI 7.3–8.7%) to 11.9% of pregnancies in 2014 ($n=1570$ of 13,140, 95% CI 11.4–12.5%) ($p<0.01$) (Appendix 4, part A, <http://links.lww.com/xxx>). Black women were also the more likely than non-black women to undergo cesarean delivery (50.2% versus 44.8%, $p<0.01$) with the cesarean delivery rate rising 53% for black women from 36.4% in 1998 ($n=2,330$ of 6,394, 95% CI 35.3–37.6%) to 55.6% in 2014 ($n=7,310$ of 13,140, 95% CI 0.55–0.56%) (Appendix 4, part C, <http://links.lww.com/xxx>). While gestational diabetes increased across all groups (Appendix 4, part B, <http://links.lww.com/xxx>), Asian or Pacific Islander and Hispanic women were most likely to receive a diagnosis gestational diabetes and saw the largest absolute increases in risk over the study period (absolute increases of 13.7% to 22.4% for Asian or Pacific Islander women and from 11.2% to 19.3% for Hispanic women respectively between 1998 and 2014).

Trends in select individual severe maternal morbidity diagnoses are demonstrated in Figure 4. For the entire study period black women were significantly more likely than white women to experience acute renal failure ($p<0.01$), acute respiratory distress syndrome ($p<0.01$), stroke ($p=0.03$), transfusion ($p<0.01$), hysterectomy ($p<0.01$), and disseminated intravascular coagulation ($p<0.01$). Black women also experienced the absolute largest increase from 1998–2003 to 2010–2014 in risk for acute renal failure, disseminated intravascular coagulation, transfusion and hysterectomy. For disseminated intravascular coagulation, by the end of the study period risk was similar between black women and white women (55.8 versus 55.0 10,000 per hospitalizations, respectively from 2010 to 2014, $p=0.97$). Stroke amongst black women did not increase change substantially over the study period with incidence of 10.1 per 10,000 deliveries in 1998 to 2003, 7.9 from 2003 to 2009, and 8.8 from 2010 to 2014 ($p=0.57$).

In the adjusted model for severe morbidity, later year of delivery was associated with increased risk for severe morbidity (Table 2). With 1998 as a reference, delivering in 2012, 2013, and 2014 was associated with adjusted risk ratios of 1.90 (95% CI 1.78–2.03), 1.75 (95% CI 1.64–1.87), and 1.89 (95% CI 1.77–2.02), respectively. Black race was associated with an 81% increased risk of morbidity in the adjusted model for the entire study period (aRR 1.81 95% CI 1.76–1.87) with white race as the reference, while deliveries to Hispanic and Asian or Pacific Islander women were associated with increased risks of 16% (aRR 1.16 95% CI 1.12–1.19) and 22% (aRR 1.23 95% CI 1.18–1.28) respectively. Medicare insurance was associated with increased risk for severe morbidity (aRR 1.85, 95% CI 1.70–2.01) compared to private insurance as was Medicaid insurance (aRR 1.11, 95% CI 1.08–1.14). When the adjusted model was repeated including comorbidity, black race retained the significant association with increased risk for severe morbidity (aRR 1.67 95% CI 1.62–1.72). With a score of 0 as a reference, comorbidity scores of 1–2 and >2 were associated with adjusted risk ratios of 2.51 (95% CI 2.45–2.56) and 8.38 (95% CI 8.03–8.75), respectively (Appendix 2, <http://links.lww.com/xxx>).

Overall, there were 231 maternal deaths (13.4 per 100,000, 95% CI 11.8–15.2) including 71 deaths occurring among white women (8.6 per 100,000, 95% CI 6.9–10.9), 64 among black women (40.5 per 100,000, 95% CI 31.7–51.7), 48 among Hispanic women (18.5 per 100,000, 95% CI 13.9–24.5), and 11 among Asian or Pacific Islander women (11.3 per 100,000, 95% CI 5.4–17.4). Risk for death was 371% higher for black compared to white women (RR 4.71, 95% CI 3.36–6.61), while Hispanic women were at more than twice the risk of death (RR 2.13, 95% CI 1.48–3.07) as white women.

DISCUSSION

In this analysis of delivery hospitalizations for women aged 40 years old, risk of severe morbidity increased across all racial groups with the largest absolute increase occurring among black women. A counterintuitive finding relative to mortality risk, which was nearly five times higher for black women compared to white women in our analysis, was that unadjusted risk for severe morbidity was only approximately doubled. Data from the CDC that comprehensively evaluates maternal death in United States found that for black women aged 40 years mortality was three and half times that for white women the same age and more than ten times that of the general population.⁹ The cause of the differential for black women aged 40 years between morbidity and mortality is unclear. Evidence from other specialties suggests that risk for death is not solely dependent on whether a patient experiences a complication, but also on how and where a patient with a complication is managed and cared for, a concept known as failure to rescue.¹⁷ Understanding specific factors related to failure to rescue responsible for maternal mortality among black women may be important in reducing disparities.

Underlying comorbidity may represent another important cause of risk differentials for mortality. In our analysis comorbidity index scores were higher among black women. In addition to measured comorbidity, there are also likely differences in unmeasured comorbidity given under ascertainment with diagnosis codes and that these codes capture the presence or absence of a condition but not severity. Underlying comorbidity may be of particular significance for women aged 40 years and older given assisted reproductive technology (ART), a factor we were not able to reliably measure. ART may be used differentially by women of different race, and women who become pregnant via ART may be a particularly healthy self-selecting group with lesser comorbidity. Of note, we found adjusted and unadjusted risk for severe morbidity to be highest after 2009. The cause of this differential is unclear but we speculate that this differential may in part be secondary to a smaller proportion of relatively lower risk women electing to undergo ART because of consequences of the preceding economic downturn. Minimizing comorbid risk through preconceptual consultation, optimization of medical conditions prior to pregnancy, and interconceptual contraception for at-risk women may be important in reducing overall maternal mortality disparities.

Findings from this analysis demonstrate the complexity and scope of the challenge in reducing risk for women aged 40 years in general and black women aged 40 years in particular. Severe morbidity rose continuously over the study period both across a number of diagnoses and as a composite. Conditions such as preeclampsia, cesarean delivery, and

overall comorbid risk increased, all factors likely associated with the trends noted in severe morbidity. Findings from this analysis support that improving outcomes will likely require a broad range of interventions from improved inter-conceptual reproductive planning, to improved inpatient safety measures, to multi-disciplinary optimization of medical management for at-risk patients. Black women in particular appear to be at disproportionately increased risk relative to measured comorbidity.

In interpreting this analysis there are several limitations that are important to consider. Most importantly, data on race was missing for a large portion of the cohort with >20% having unknown race from 1998 through 2007. If outcomes based on race differed significantly for patients with unknown compared to known race, reported trends may be biased. The Healthcare Cost and Utilization Project provides a number of recommendations for addressing missing data including imputation.¹⁸ We elected not to perform imputation because it was unlikely that missing data on race was random and non-differential across the years of the NIS included in this analysis. To minimize missing data, prior analyses of racial disparities in maternal morbidity have used the Healthcare Cost and Utilization Project's State Inpatient Database including states with high proportions of complete data on race.³ We elected to use the NIS because of the large, nationally representative sample, availability of a 17-year period for analysis, and, over the last three years of the study, low rates of missing data. A second limitation of this analysis is that this administrative dataset does not provide information on hospital resources, infrastructure and staffing, all of which contribute to maternal outcomes and risk. A third limitation is that we are not able to evaluate outpatient management including prenatal care, interdisciplinary care, and access to consultants. A fourth limitation is that for both comorbid exposures and severe morbidity outcomes validity of the outcomes and ascertainment may vary with administrative data by diagnosis code. A fifth limitation is that valid coding regarding assisted reproductive technology interventions prior to the pregnancy is not available. A sixth limitation is that mortality comparisons by race must be interpreted within the context of a large proportion of missing data and a relatively small number of maternal deaths; however, the risk differentials in this dataset align with estimates from the CDC's PMSS which employs a more comprehensive system to evaluate maternal deaths. A seventh limitation is that in adjusting for comorbidity, diagnosis codes generally do not specify condition severity. For example, severity of underlying diabetes, renal failure, and chronic hypertension may represent important risk factors that we are not able to account for in our model. Finally, we are not able to determine the degree to which, or if, prenatal care was attended.

In summary, this analysis found maternal comorbid risk and morbidity increasing for women aged 40 years with risk highest among black women. Additionally, among black women risk was highest for preeclampsia, a number of specific morbidity diagnoses, and mortality, and black women experienced the largest increase in risk for many adverse outcomes. Given that morbidity risk was double for black women while mortality risk was several fold higher, improved understanding of failure to rescue may be important in reducing disparities.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

Severe morbidity by race. Severe morbidity (including transfusion) (**A**) and severe morbidity (excluding transfusion) (**B**). This figure demonstrates severe maternal morbidity based on Centers for Disease Control and Prevention (CDC) criteria with and without transfusion, respectively, for women aged 40–54 years undergoing delivery hospitalizations. Changes in risk all race categories were all statistically significant ($P < .05$). Risk for severe morbidity excluding transfusion among Native Americans is not demonstrated because of small denominators

Figure 2.

Proportionate change in comorbidity index scores. White (A), black (B), Hispanic (C), and Asian or Pacific Islander (D). This figure demonstrates proportionate changes in comorbidity scores for non-Hispanic white, non-Hispanic black, Hispanic, and Asian or Pacific Islander women. The largest proportionate increase over the study period was for women with a comorbidity score >2. For all groups, there was a proportionate decline in women with a comorbidity score of 0.

Figure 3.

Risk for severe morbidity by obstetric comorbidity index score. This figure demonstrates risk for severe morbidity including transfusion by obstetric comorbidity index score for white, Asian or Pacific Islander, Hispanic, and black women over the study period. Risk was significantly higher for black compared white women for scores of 0, 1–2, and >2 ($P<.01$).

Figure 4.

Individual severe morbidity diagnoses per 10,000 delivery hospitalizations by race. This figure demonstrates temporal trends in acute renal failure (A), disseminated intravascular coagulation (B), acute respiratory distress syndrome (C), stroke (D), transfusion (E), and hysterectomy (F) for non-Hispanic white, non-Hispanic black, Hispanic, and all women aged 40–54 years. From 1998 to 2003 compared with 2010 to 2014, black women experienced the largest absolute increases in rates of hysterectomy, transfusion, acute respiratory distress syndrome, and acute renal failure.

Table 1

Patient demographics

	Black	White	Hispanic	Asian/Pacific Islander	Native American	Unknown	Other
<i>All patients</i>	158,075	821,540	259,998	113,037	7,107	295,996	68,941
<i>Year</i>							
1998	6,394	36,206	7,913	3,666	138	17,412	2,217
1999	6,247	38,029	7,302	3,456	217	19,659	2,529
2000	7,457	44,842	9,283	3,750	221	22,861	2,738
2001	6,712	44,770	11,211	4,608	409	21,613	2,984
2002	7,521	45,943	12,756	5,627	179	22,450	3,860
2003	8,122	44,055	13,764	5,383	154	23,799	3,265
2004	9,467	53,265	15,416	6,996	292	22,742	3,108
2005	8,084	53,639	13,660	6,095	447	23,184	4,124
2006	7,837	44,781	16,624	4,534	404	25,230	3,816
2007	9,801	47,161	16,858	6,335	968	31,034	4,079
2008	8,241	51,200	15,763	7,812	397	19,556	4,192
2009	10,367	53,930	18,818	7,964	564	12,600	5,203
2010	11,932	50,053	17,506	8,437	457	9,537	4,287
2011	11,133	52,651	20,254	7,984	405	7,559	4,754
2012	12,565	53,985	19,505	9,630	705	5,160	6,245
2013	13,055	54,025	21,440	10,430	685	5,810	5,485
2014	13,140	53,005	21,925	10,330	465	5,790	6,055
<i>Hospital bed size</i>							
Small	13,791	95,930	26,474	8908	817	24,884	6,136
Medium	44,082	209,337	69,971	30,309	1,475	69,987	18,467
Large	99,736	514,564	162,790	73,604	4,720	200,568	44,017
Unknown	467	1,710	763	216	95	556	321
<i>Insurance status</i>							
Medicare	2,380	6,346	1,282	270	49	2276	246
Medicaid	57,070	96,746	133,617	22,303	2,413	52,626	22,460
Private	87,946	681,479	105,274	83,250	4,088	222,780	39,970

	Black	White	Hispanic	Asian/Pacific Islander	Native American	Unknown	Other
Other	4,073	16,428	4,895	1,797	368	8,666	1,490
Uninsured	6,273	19,295	14,707	5,351	184	8,837	4,643
Unknown	335	1,249	222	66	<10	810	131
Hospital Location							
Rural	3,931	53,336	6,647	1,747	957	30,233	2,288
Urban	114,918	605,481	189,717	80,683	4,201	248,446	48,547
Unknown	39,227	162,725	63,633	30,606	1,950	17,316	18,106
ZIP Income Quartile							
1 st (lowest)	45,815	73,878	72,310	8,863	1,994	32,396	10,832
2 nd	33,487	132,239	60,786	14,508	1,608	59,135	12,215
3 rd	34,803	195,879	61,550	24,716	1,271	73,415	16,781
4 th (highest)	38,825	406,996	58,840	63,320	1,885	126,651	26,277
Unknown	5,146	12,550	6,510	1,629	349	4,397	2,836
Hospital Region							
Northeast	46,067	246,471	34,973	21,125	1,499	17,321	23,723
Midwest	16,478	122,309	10,976	6214	769	137,795	8676
South	78,184	244,895	90,376	19,331	2,051	75,073	23,625
West	17,347	207,867	123,671	66,366	2,789	65,805	12,916
Teaching							
Non-teaching	40,286	321,950	99,219	38,329	2420	126,353	22,146
Teaching	78,563	336,866	97,145	44,101	2737	152,326	28,689
Unknown	39,227	162,725	63,633	30,606	1,950	17,316	18,106

Table 2

Risk for severe morbidity (including transfusion) in unadjusted and adjusted models

	RR	95% CI	aRR	95% CI
<i>Year</i>				
1998	1.00	Reference	1.00	Reference
1999	0.85	0.78–0.92	0.87	0.80–0.94
2000	0.87	0.80–0.94	0.89	0.83–0.97
2001	1.03	0.96–1.11	1.06	0.99–1.14
2002	1.12	1.05–1.21	1.14	1.06–1.22
2003	1.11	1.03–1.19	1.10	1.02–1.18
2004	1.18	1.10–1.26	1.17	1.09–1.25
2005	1.16	1.08–1.24	1.16	1.09–1.25
2006	1.15	1.07–1.23	1.12	1.05–1.21
2007	1.26	1.18–1.35	1.23	1.15–1.32
2008	1.28	1.20–1.37	1.26	1.17–1.35
2009	1.46	1.36–1.56	1.40	1.31–1.50
2010	1.72	1.61–1.84	1.63	1.52–1.74
2011	1.80	1.69–1.92	1.71	1.60–1.83
2012	1.83	1.72–1.95	1.90	1.78–2.03
2013	1.69	1.59–1.81	1.75	1.64–1.88
2014	1.82	1.71–1.94	1.89	1.77–2.02
<i>Hospital bed size</i>				
Small	1.00	Reference	1.00	Reference
Medium	1.11	1.07–1.16	1.09	1.05–1.13
Large	1.17	1.13–1.21	1.17	1.13–1.22
<i>Insurance status</i>				
Medicare	2.18	2.01–2.37	1.85	1.70–2.01
Medicaid	1.32	1.29–1.35	1.11	1.08–1.14
Private	1.00	Reference	1.00	Reference
Uninsured	1.25	1.19–1.32	1.13	1.07–1.19
Other	1.07	0.99–1.14	1.00	0.94–1.07
<i>Hospital Location</i>				
Rural	0.96	0.92–1.01	1.08	1.03–1.14
Urban	1.00	Reference	1.00	Reference
<i>Income Quartile</i>				
1 st (lowest)	1.00	Reference	1.00	Reference
2 nd	0.86	0.84–0.89	1.01	0.97–1.04
3 rd	0.75	0.73–0.78	0.91	0.88–0.94
4 th (highest)	0.70	0.68–0.72	0.91	0.88–0.94
<i>Hospital Region</i>				
Northeast	1.00	Reference	1.00	Reference
Midwest	0.84	0.82–0.87	0.91	0.88–0.94

	RR	95% CI	aRR	95% CI
South	1.01	0.99–1.04	0.98	0.95–1.00
West	0.89	0.87–0.92	0.94	0.92–0.97
Teaching				
Non-teaching	1.00	Reference	1.00	Reference
Teaching	1.22	1.20–1.25	1.19	1.16–1.22
Race				
Non-Hispanic black	2.04	1.98–2.10	1.81	1.76–1.87
Non-Hispanic white	1.00	Reference	1.00	Reference
Hispanic	1.28	1.24–1.32	1.16	1.12–1.19
Asian or Pacific Islander	1.29	1.24–1.34	1.23	1.18–1.28
Native American	1.20	1.03–1.39	1.08	0.93–1.25
Unknown	0.90	0.87–0.93	1.00	0.97–1.03
Other	1.24	1.18–1.30	1.13	1.08–1.19

Adjusted model included all factors in this table (year, bed size, insurance status, hospital location, income quartile, hospital region, hospital teaching status, and race). *RR*, risk ratio. *aRR*, adjusted risk ratio