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Trends in Severe Maternal Morbidity After Assisted Reproductive Technology in the United States, 2008–2012

Angela S. Martin, MD,

Michael Monsour, PhD,

Dmitry M. Kissin, MD, MPH,

Denise J. Jamieson, MD, MPH,

William M. Callaghan, MD, MPH,

Sheree L. Boulet, DrPH, MPH

Department of Gynecology and Obstetrics, Emory University, and the Division of Reproductive Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Abstract

OBJECTIVE: To examine trends in severe maternal morbidity from 2008 to 2012 in delivery and postpartum hospitalizations among pregnancies conceived with or without assisted reproductive technology (ART).

METHODS: In this retrospective cohort study, deliveries were identified in the 2008–2012 Truven Health MarketScan Commercial Claims and Encounters Databases. Severe maternal morbidity was identified using International Classification of Diseases, 9th Revision, Clinical Modification diagnosis codes and Current Procedural Terminology codes. Rate of severe maternal morbidity was calculated for ART and non-ART pregnancies. We performed multivariable logistic regression, controlling for maternal characteristics, and calculated adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for severe morbidity. Additionally, a propensity score analysis was performed between ART and non-ART deliveries.

RESULTS: Of 1,016,618 deliveries, 14,761 (1.5%) were identified as pregnancies conceived with ART. Blood transfusion was the most common severe morbidity indicator for ART and non-ART pregnancies. For every 10,000 singleton deliveries, there were 273 ART deliveries or postpartum hospitalizations with severe maternal morbidity compared with 126 for non-ART ($P<.001$). For ART singleton deliveries, the rate of severe morbidity decreased from 369 per 10,000 deliveries in 2008 to 219 per 10,000 deliveries in 2012 ($P=.025$). Odds of severe morbidity were increased for ART compared with non-ART singletons (adjusted OR 1.84, 95% CI 1.63–2.08). Among multiple gestations, there was no significant difference between ART and non-ART pregnancies (rate of severe morbidity for ART 604/10,000 and non-ART 539/10,000 deliveries, $P=.089$; adjusted OR 1.04, 95% CI 0.91–1.20). Propensity score matching agreed with these results.

Corresponding author: Angela S. Martin, MD, Department of Gynecology and Obstetrics, 69 Jesse Hill Jr. Drive, SE, 4th Floor, Glenn Building, Atlanta, GA 30303; amatlac@emory.edu.

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CONCLUSION: Singleton pregnancies conceived with ART are at increased risk for severe maternal morbidity; however, the rate has been decreasing since 2008. Multiple gestations have increased risk regardless of ART status.

Severe maternal morbidity is associated with significant health care cost, family burden, and may herald maternal mortality,¹ the most tragic event in obstetrics. Previously defined as physical and psychological conditions resulting from or aggravated by pregnancy that have an adverse effect on the woman's health,¹ severe maternal morbidity was found to affect more than 60,000 women in the United States every year and has been steadily increasing since 1998: the rate of deliveries with severe maternal morbidity increased from approximately 70 deliveries per 10,000 in 1998–1999 to 160 deliveries per 10,000 in 2010–2011.²

Several obstetric conditions have been associated with severe maternal morbidity.^{3,4} In a recent study, odds of severe maternal morbidity were found to be twofold higher in pregnancies complicated by gestational diabetes, more than threefold higher in pregnancies complicated by hypertensive disorders, and more than 58 times higher in the setting of placenta accreta.³ Many studies have linked assisted reproductive technology (ART) to adverse obstetric outcomes including increased risk of gestational diabetes, hypertensive disorders of pregnancy, placenta previa, antepartum hemorrhage, placental abruption, and cesarean delivery.^{5–7} It is unknown if these associations translate into increased severe maternal morbidity after ART.

The use of ART has doubled over the past decade. In 2013, 1.5% of all neonates born in the United States were conceived with ART.⁸ Given the growing number of pregnancies conceived after ART, it is pertinent to know if there is an increased risk of severe maternal morbidity in this potentially high-risk population. We compared rates of severe maternal morbidity in ART pregnancies with rates among pregnancies conceived without ART during delivery hospitalizations and postpartum readmissions for singleton and multiple gestation pregnancies.

MATERIALS AND METHODS

We used Truven Health MarketScan Commercial Claims and Encounters Databases, which include longitudinal, deidentified health insurance claims data from large employers and health plans across the United States, to conduct a retrospective cohort study. All women 15 years of age or older who had a delivery hospitalization and were continuously enrolled for at least 1 year before delivery through 42 days after delivery (unless death occurred) between January 1, 2008, and November 19, 2012, were identified by International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes and Current Procedural Terminology (CPT) codes. Deliveries were defined as any inpatient hospital admission record including a pregnancy-related diagnosis or procedure code for vaginal or cesarean delivery identified by the ICD-9-CM codes 650, 669.7, V27.x, or procedure codes 72.0–72.9, 73.22, 73.59, 73.6, 74.0–74.2, 74.4, 74.99; Diagnosis-Related Group codes for vaginal or cesarean delivery, 370–375 for version 24 or earlier, or 765–768, 774, 775 for version 25 and later; and CPT codes 59409, 59612

for vaginal delivery and 59514, 59620 for cesarean delivery. Deliveries were identified as a multiple gestation if one or more of following codes were present: 651.x, V27.2–V27.7, V91.x. A postpartum readmission was defined as any admission to the hospital within 6 weeks (42 days) from the delivery admission date.

We excluded deliveries with ICD-9-CM codes indicating a molar pregnancy (630), spontaneous abortion or termination (631, 632, 634.x–638.x, 69.01, 69.51, 74.91, 75.0; Diagnosis-Related Group 380, 381 for version 24 or earlier, 770, 779 for version 25 and later; or CPT codes 59840, 59841, 59850–59852, 59855–59857), ectopic pregnancy (633.x, Diagnosis-Related Group 378 for version 24 and earlier and 777 for version 25 and later), or complication after an abortion, ectopic, or molar pregnancy (639.x). Deliveries were also excluded if the maternal discharge status was listed as death without any severe morbidity present during the admission. Because death without any severe morbidity is unlikely, we felt these deliveries either had an incorrect discharge status or actually did have severe morbidity that was not captured in the database.

Deliveries were classified as ART if a CPT code was present indicating an ART procedure (CPT 58970, 58974, 58976) within 45 weeks before delivery. All remaining deliveries were considered non-ART. See Appendix 1, available online at <http://links.lww.com/AOG/A729>, for a list and description of codes used for inclusion and exclusion criteria and ART identification. Because MarketScan is a publicly available database and does not contain direct personal identifiers, review by the Centers for Disease Control and Prevention institutional review board was not needed.

Characteristics of the ART and non-ART groups were compared using Pearson χ^2 and Fisher exact tests and included maternal age at delivery, parity, comorbid conditions, history of prior cesarean delivery, plurality, and region of delivery. Comorbidities were identified using ICD-9-CM codes reported within 1 year before delivery, or at the time of delivery, in inpatient or outpatient claims and included tobacco use (305.1, 649.0, V15.82, CPT 99406, 99407), pregestational diabetes (250–250.93 and 648.00–648.04), chronic hypertension (401.0, 401.1, 401.9, 402.00–405.99, 642.0, 642.1, 642.2), pre-existing renal disease (250.4, 403, 404, 405.01, 405.11, 405.91, 585.1–585.6, 585.9), cardiovascular disease (412, 414.0, 414.8, 414.9, 429.2), and obesity (649.1, 278.00, 278.01, 278.03). Women were identified as having a comorbid condition based on the presence of at least one inpatient claim or two or more outpatient claims at least 30 days apart, except for tobacco use and obesity, which were present at much lower rates than expected and were therefore included if only one or more outpatient claim was present. Prior cesarean delivery was identified using the ICD-9-CM code 654.2. See Appendix 1 (<http://links.lww.com/AOG/A729>) for a list of codes used to identify comorbidities.

Comorbid conditions may have a part in causing severe morbidity. To assess the magnitude of effect comorbid conditions have on severe morbidity and to evaluate potential bias caused by including comorbid conditions as a covariate in adjusted models, we examined the association of severe morbidity and ART separately for those with and without comorbid conditions. We performed a sensitivity analysis restricted to singleton deliveries among women without any comorbid conditions and with at least one comorbid condition.

Severe maternal morbidity was identified by having at least 1 of the 25 previously established list of ICD-9-CM diagnosis and procedure codes (severe maternal morbidity indicators) published by Callaghan et al⁹ and available on the Centers for Disease Control and Prevention, Department of Reproductive Health web site¹⁰ present at the delivery or postpartum readmission. In addition to the published ICD-9-CM codes, we used CPT codes to identify a severe maternal morbidity indicator (see Appendix 2, available online at <http://links.lww.com/AOG/A730>, for ICD-9-CM and CPT codes). The delivery hospitalization or postpartum readmission also had to meet at least one of the following three criteria to be considered severe maternal morbidity: 1) length of stay equal to or greater than 3 days; 2) discharge status listed as transferred; or 3) discharge status listed as death. This was to exclude less severe complications that likely did not signify severe morbidity.

We calculated rates of having at least one severe maternal morbidity indicator per 10,000 deliveries for ART and non-ART delivery hospitalizations or postpartum readmissions for each year, 2008–2012, and all years combined. Rates were calculated for delivery hospitalizations and postpartum readmissions combined and separately for both singleton and multiple gestation deliveries. For our sensitivity analysis, rates of severe morbidity were calculated for all years combined, 2008–2012, for ART and non-ART singleton deliveries restricted to women without any comorbid conditions and women with at least one comorbid condition. Rates were compared using a Fisher exact test for each year. A Wilcoxon rank-sum test was used to compare the rates between ART and non-ART groups across all years. We then performed linear regression to determine if the rate of severe maternal morbidity significantly increased or decreased for ART and non-ART singleton and multiple gestations from 2008 to 2012. As a result of the large number of comparisons between groups in each statistical comparison, a Holm-Bonferroni correction was applied, resulting in different *P* values denoting statistical significance for each level of analysis.

Using multivariable logistic regression, we calculated crude and adjusted odds ratios (ORs) and 95% confidence intervals (CIs) to examine which patient factors were associated with severe morbidity. Model fitting for the logistic regression used both backward elimination and forward selection. Multivariable logistic regression was also performed for subgroups of women with and without comorbid conditions, comparing odds of severe morbidity between ART and non-ART singleton deliveries. Variables with *P* values <.05 were retained in the final model. Finally, to supplement these results, we performed a propensity score match analysis for singleton and multiple deliveries separately. The matching between ART and non-ART deliveries used 11 covariates, year of delivery, and all covariates (excluding ART) in Table 1. To validate the data obtained from the MarketScan databases, two programmers worked independently until results matched. SAS 9.3 and SUDAAN 11 were used for all analyses.

RESULTS

There were 1,016,618 deliveries identified between 2008 and 2012. Of those, 14,761 (1.5%) were classified as ART pregnancies. Women who delivered after ART were more likely to be 35 years old or older and nulliparous than women who did not use ART. They were less likely to use tobacco, be obese, and have a prior cesarean delivery and more likely to have

chronic hypertension and reside in the North. Of all ART deliveries, 29.8% were multiple gestations compared with 2.2% of non-ART deliveries (Table 1).

Delivery admissions contributed to the majority (greater than 85%) of severe morbidity indicators for singleton and multiple gestations (Appendix 3, available online at <http://links.lww.com/AOG/A731>). The number of severe morbidity indicators and rate of severe morbidity were low among postpartum readmissions for singleton and multiple gestation pregnancies regardless of ART (17/10,000 deliveries among non-ART singletons, 29/10,000 deliveries among ART singletons, 44/10,000 deliveries among non-ART multiples, and 54/10,000 deliveries among ART multiples; Appendix 3, <http://links.lww.com/AOG/A731>). Results from delivery hospitalizations alone were similar to results calculated for delivery hospitalizations or postpartum readmissions combined. No significant difference between ART and non-ART groups was found for either singletons or multiples in any year for postpartum readmissions alone (Appendix 3, <http://links.lww.com/AOG/A731>). Results are therefore only presented for delivery or postpartum readmissions combined.

Rates for the most commonly reported and statistically significant severe morbidity indicators for ART and non-ART pregnancies are shown in Table 2. The three most common severe morbidities among singleton pregnancies were blood transfusion (36 and 77/10,000 non-ART and ART deliveries, respectively) followed by disseminated intravascular coagulation (20 and 46/10,000 non-ART and ART deliveries, respectively) and mechanical ventilation (18 and 33/10,000 non-ART and ART deliveries, respectively). Among multiple gestations, blood transfusion was most common (215 and 200/10,000 non-ART and ART deliveries, respectively) followed by mechanical ventilation (105 and 143/10,000 non-ART and ART deliveries, respectively) and disseminated intravascular coagulation (68 and 98/10,000 non-ART and ART deliveries, respectively). Singleton ART pregnancies had significantly higher rates of blood transfusion, disseminated intravascular coagulation, acute renal failure, and hysterectomy compared with singleton non-ART pregnancies ($P < .001$). Higher rates of internal injuries of the thorax, abdomen, and pelvis and shock were also detected among ART singletons compared with non-ART singletons ($P < .001$). Rates between multiple gestation ART and non-ART pregnancies for each indicator were not significantly different.

For every 10,000 deliveries for all years combined (2008–2012), there were 273 delivery or postpartum readmissions with at least one severe maternal morbidity indicator for singleton pregnancies conceived after ART compared with 126 for singleton non-ART pregnancies ($P < .001$). The rate of having at least one severe maternal morbidity indicator per 10,000 deliveries was significantly higher for singleton ART pregnancies compared with singleton non-ART pregnancies for each year, 2008–2012 ($P < .001$). Considering the entire period, a significant difference between the two groups was detected (Wilcoxon rank-sum test, $P = .008$) (Fig. 1). Using linear regression, we found the rate of severe maternal morbidity in ART singletons significantly decreased from 369 per 10,000 deliveries in 2008 to 219 per 10,000 deliveries in 2012 ($r^2 = 85.2\%$, $P = .025$). There was no trend among non-ART singleton deliveries over time with the rate ranging from 113 to 134 per 10,000 deliveries ($r^2 = 55.9\%$, $P = .147$).

Among multiple gestation pregnancies, the overall rate of having at least one severe maternal morbidity indicator was 604 per 10,000 ART deliveries and 539 per 10,000 non-ART deliveries. Figure 2 shows the rates for multiple gestation pregnancies for each year by ART status. When comparing ART with non-ART deliveries, the rates were not significantly higher in any year or all years combined (Wilcoxon rank-sum test $P=.222$). Linear regression did not show a significant trend of severe maternal morbidity over time for ART or non-ART multiple gestation pregnancies (ART $r^2=11.3\%$, $P=.581$; non-ART $r^2=0.1\%$, $P=.724$).

Patient factors significantly associated with severe morbidity among singleton deliveries are presented in Table 3. ART singletons had significantly higher odds of severe maternal morbidity compared with non-ART singletons after controlling for age, parity, comorbid conditions, prior cesarean delivery, and year of delivery (adjusted OR 1.84, 95% CI 1.63–2.08). Pre-existing renal disease and cardiovascular disease were the factors most strongly associated with severe morbidity (renal disease adjusted OR 5.21, 95% CI 4.20–6.44; cardiovascular disease adjusted OR 5.15, 95% CI 3.54–7.49). Age 35 years or older, nulliparity, pregestational diabetes, chronic hypertension, obesity, and having a prior cesarean delivery were also significantly associated with severe morbidity among singleton deliveries as was age 30–34 years, tobacco use, and selected years of delivery, although the association with these latter factors was weaker.

Patient factors significantly associated with severe morbidity among multiple gestation deliveries are presented in Table 4. ART was not associated with severe morbidity (adjusted OR 1.04, 95% CI 0.91–1.20). Pre-existing renal and cardiovascular disease was both strongly associated with severe morbidity (renal disease adjusted OR 5.66, 95% CI 2.72–11.79; cardiovascular disease adjusted OR 5.04, 95% CI 1.71–14.87). Age 30 years or older and chronic hypertension were the only other patient factors with increased odds of severe morbidity among multiple gestations (age 30–34 years, adjusted OR 1.36, 95% CI 1.05–1.76; age 35–39 years, adjusted OR 1.50, 95% CI 1.15–1.95; age 40–44 years, adjusted OR 1.93, 95% CI 1.44–2.60; age 45 years or older, adjusted OR 3.19, 95% CI 2.23–4.57; chronic hypertension adjusted OR 1.33, 95% CI 1.09–1.62), whereas having a prior cesarean delivery slightly decreased the odds of severe morbidity (adjusted OR 0.82, 95% CI 0.70–0.96).

In our sensitivity analysis of singleton deliveries among women without comorbidities, the rate of severe morbidity was 109 per 10,000 non-ART deliveries compared with 246 per 10,000 ART deliveries. As expected, this rate was lower than the rate seen Table 3. Odds Ratios and 95% Confidence among singleton deliveries to women with at least one comorbid condition (233/10,000 non-ART deliveries compared with 472/10,000 ART deliveries). The adjusted odds of severe morbidity remained significant for ART deliveries compared with non-ART deliveries for both subgroups and was similar for both groups (adjusted OR without comorbidities 1.86, 95% CI 1.62–2.13; adjusted OR with at least one comorbid condition 1.71, 95% CI 1.31–2.24).

After propensity score matching, there were 858,295 non-ART and 10,323 ART singleton deliveries. ART remained significantly associated with severe maternal morbidity (OR 2.37, 95% CI 2.10–2.67; $P<.001$). Among multiple gestations, after propensity score matching,

there were 18,677 non-ART and 4,289 ART deliveries; the association of ART with severe maternal morbidity was similar to results before matching (OR 1.15, 95% CI 1.00–1.33, $P=.05$).

DISCUSSION

Severe maternal morbidity can be tragic and may herald impending mortality. We found the odds of severe maternal morbidity from 2008 to 2012 were 1.8 times higher among singleton ART pregnancies compared with non-ART pregnancies during delivery or postpartum readmissions after controlling for maternal age, parity, comorbid conditions, history of prior cesarean delivery, and year of delivery, suggesting that ART is a risk factor for severe morbidity in singleton pregnancies.

An important question is whether increased risk of severe morbidity among ART singleton pregnancies is the result of maternal characteristics and underlying infertility of women seeking treatments or the ART procedures themselves. We found similar odds of severe morbidity in groups with and without comorbidities, thereby suggesting differences in comorbid conditions among ART and non-ART women do not explain the observed association between ART and severe morbidity. A study examining risk of severe morbidity using an infertile population who ultimately conceived without ART is needed to address confounding factors associated with underlying infertility.

We were encouraged by the decreasing rate of severe morbidity among ART singletons over time, from 369 per 10,000 deliveries in 2008 to 219 per 10,000 deliveries in 2012. This trend could be the result of enhanced techniques, protocols, and medications used in ART. Improved gonadotropin antagonist protocols have greatly reduced ovarian hyperstimulation syndrome,¹¹ and there is evidence that supraphysiologic estrogen may alter early placental development predisposing women to conditions such as preeclampsia.¹² Practices are changing to include more elective single embryo transfers,^{8,13} which may decrease growth restriction and preterm birth among singletons.^{13,14} The mechanism improving perinatal outcomes after elective single embryo transfer may also reduce adverse obstetric conditions such as preeclampsia and placenta previa, ultimately leading to a decrease in severe morbidity. Additionally, characteristics of women seeking ART may be changing, contributing to decreasing risk.

The rate of severe maternal morbidity was more than double among ART multiple gestations and more than four times higher among non-ART multiples compared with ART and non-ART singletons, respectively. Interestingly, rates were not significantly different between ART and non-ART multiple gestations and there was no significant increase in the adjusted odds of severe morbidity. Multiple gestations are at increased risk for many obstetric conditions associated with severe morbidity including gestational diabetes, hypertensive disorders, cesarean delivery, and abruption.¹⁵ Furthermore, it is well established that carrying multiples increases the risk of preterm delivery.¹⁵ Grobman et al³ found severe maternal morbidity to have an inverse relationship with gestational age at delivery. The increased odds of severe morbidity with preterm delivery may in part explain why both ART and non-ART multiples are at increased risk. Regardless of the etiology, these findings

highlight the importance of minimizing multiple gestations when possible, which can be accomplished by elective single embryo transfer with appropriate patient selection.

The strengths of our study include a large, contemporary database with the ability to identify a unique population at risk for severe maternal morbidity. In addition, we were able to control for important maternal characteristics. This study was subject to several limitations. There are inherent limitations when using ICD-9 codes to identify comorbidities and pregnancy conditions and using ICD-9 codes to identify severe morbidity has not been validated against a gold standard such as medical record review. However, there are few true gold standards for severe morbidity, and these are based on expert opinion.^{16,17} MarketScan is a health insurance claims database; therefore, women who paid for ART out of pocket may have been misclassified. Similarly, a woman who conceived spontaneously after an oocyte retrieval or embryo transfer, but within 45 weeks of delivery, would have been considered an ART delivery. This would have equalized the ART and non-ART groups, however, minimizing differences found. Additionally, MarketScan is not a random sample and results may not generalize to the general population. Data were derived from a commercially insured population; thus, women without insurance, or who were publically insured, were not included. Finally, certain potential confounding variables could not be obtained, including ethnicity and socioeconomic status.

Identifying groups at high risk for severe maternal morbidity is an important step in minimizing its potentially devastating occurrence. The results of this study identify singleton ART pregnancies and multiple gestations as high-risk groups. Although further investigations into the reasons for this increased morbidity are needed, regardless of the etiology, health care providers should optimize maternal health before conception, if possible, to help reduce the risk of severe morbidity. In addition, they should have a heightened awareness for signs of impending severe morbidity throughout pregnancy in these high-risk populations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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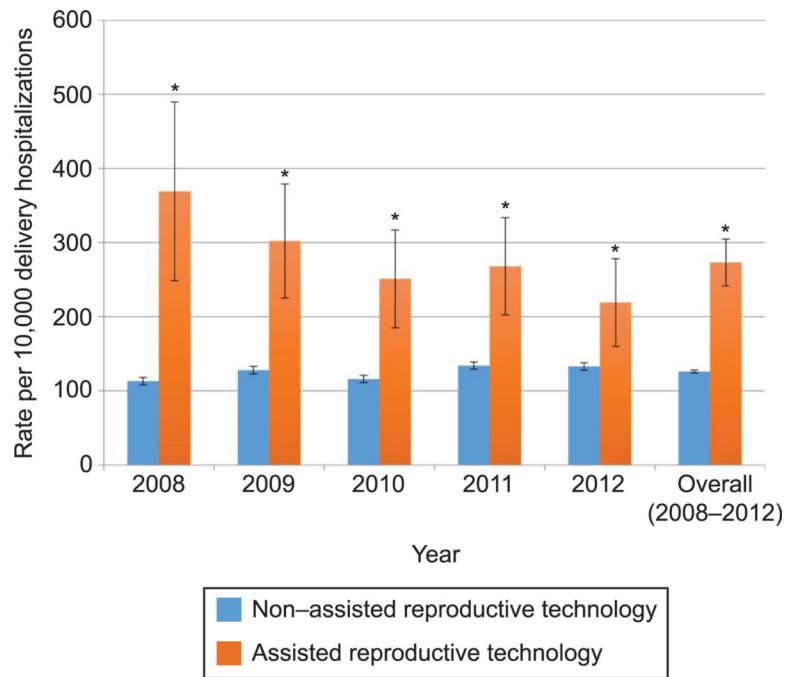


Fig. 1. Rate of severe maternal morbidity for singleton pregnancies during delivery hospitalization or postpartum readmissions per 10,000 deliveries. *Holm-Bonferroni corrected P .001 denotes statistical significance of Fisher exact test for individual years. Wilcoxon rank-sum test P 5.008 (Holm-Bonferroni corrected P .008 denotes statistical significance) over all years combined.

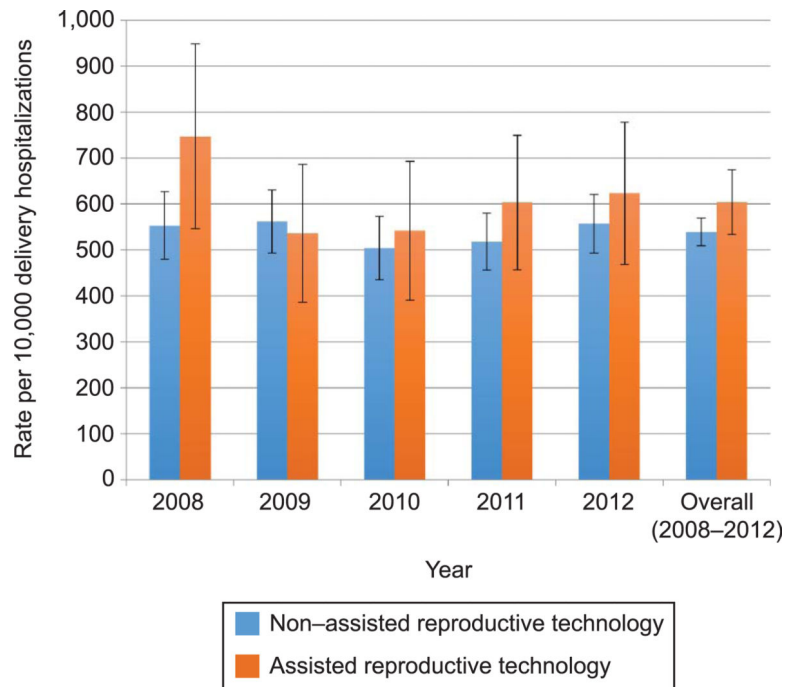


Fig. 2. Rate of severe maternal morbidity for multiple gestation pregnancies during delivery hospitalization or postpartum readmissions per 10,000 deliveries. No statistically significant difference between non-assisted reproductive technology and assisted reproductive technology for any year using Fisher exact test with Holm-Bonferroni corrected P .001. Wilcoxon rank-sum test for all years combined P =.222 (Holm-Bonferroni corrected P .008 denotes statistical significance).

Table 1. Maternal Characteristics by Assisted Reproductive Technology Status Among Liveborn Deliveries 2008–2012

Characteristic	Non-ART	ART	P *
Total	1,001,857 (98.5)	14,761 (1.5)	
Age (y)			<.001
Younger than 25	147,200 (14.7)	90 (0.6)	
25–29	290,808 (29.0)	1,599 (10.8)	
30–34	344,459 (34.4)	5,282 (35.8)	
35–39	175,954 (17.6)	5,166 (35.0)	
40–44	39,543 (3.9)	2,174 (14.7)	
45 or older	3,893 (0.4)	450 (3.1)	
Parity			<.001
Nulliparous	342,860 (34.2)	7,439 (50.4)	
Nonnulliparous	658,997 (65.8)	7,322 (49.6)	
Comorbid condition			
Tobacco use	33,966 (3.4)	159 (1.1)	<.001
Pregestational diabetes	22,925 (2.3)	397 (2.7)	.001
Chronic hypertension	41,136 (4.1)	741 (5.0)	<.001
Pre-existing renal disease	819 (0.1)	7	.246
Cardiovascular disease	289 (0.0)	7	.331
Obesity	60,851 (6.1)	772 (5.2)	<.001
Prior cesarean delivery	165,038 (16.5)	1,961 (13.3)	<.001
Plurality			<.001
Singleton	980,031 (97.8)	10,355 (70.2)	
Multiple	21,826 (2.2)	4,406 (29.8)	
Region of delivery			<.001
Northeast	131,407 (13.1)	3,600 (24.4)	
North-central	251,878 (25.2)	4,829 (32.7)	
South	419,955 (41.9)	4,569 (30.9)	
West	183,538 (18.3)	1,695 (11.5)	
Unknown	15,079 (1.5)	68 (0.5)	

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ART, assisted reproductive technology.

Data are n (%) unless otherwise specified.

* Holm-Bonferroni corrected $P < .001$ denotes statistical significance of Pearson χ^2 and Fisher exact tests.

[†] Not reported owing to small sample size to protect patient confidentiality.

Table 2. Rates of Most Commonly Reported and Statistically Significant Severe Maternal Morbidity Indicators and Overall Rate of Any Indicator During Delivery Hospitalizations or Postpartum Readmissions Per 10,000 Deliveries by Assisted Reproductive Technology Status, 2008–2012

Indicator	Singleton Pregnancies		Multiple Pregnancies		p *	
	Non-ART	ART	Non-ART	ART		
Blood transfusion	36	77	<.001	215	200	.567
Disseminated intravascular coagulation	20	46	<.001	68	98	.042
Mechanical ventilation	18	33	.001	105	143	.034
Adult respiratory distress syndrome	12	21	.009	49	48	1
Eclampsia	11	13	.656	34	41	.488
Heart failure during procedure or surgery	11	23	.001	26	25	1
Hysterectomy	9	27	<.001	38	34	.892
Sepsis	7	15	.004	22	32	.227
Acute renal failure	6	18	<.001	30	32	.881
Puerperal cerebrovascular disorders	6	9	.324	19	18	1
Operations on heart and pericardium	6	12	.041	21	23	.720
Internal injuries of thorax, abdomen, and pelvis	3	14	<.001	10	25	.018
Shock	4	14	<.001	22	16	.585
Overall	126	273	<.001	539	604	.089

ART, assisted reproductive technology.

Data are n unless otherwise specified.

* Holm-Bonferroni corrected *P* .001 denotes statistical significance of Pearson χ^2 and Fisher exact tests.

Table 3.

Odds Ratios and 95% Confidence Intervals for Severe Maternal Morbidity in Delivery and Postpartum Hospitalizations Among Singleton Pregnancies for Selected Characteristics, 2008–2012

Characteristic	OR (95% CI)	aOR* (95% CI)
ART	2.21 (1.96–2.49)	1.84 (1.63–2.08)
Age (y)		
Younger than 25	Referent	Referent
25–29	0.98 (0.92–1.04)	0.96 (0.90–1.02)
30–34	1.14 (1.07–1.2)	1.08 (1.02–1.14)
35–39	1.46 (1.37–1.55)	1.24 (1.17–1.33)
40–44	2.03 (1.87–2.21)	1.61 (1.48–1.75)
45 or older	3.54 (2.97–4.21)	2.64 (2.21–3.15)
Nulliparity	1.21 (1.17–1.26)	1.29 (1.25–1.34)
Tobacco use	1.18 (1.08–1.29)	1.14 (1.04–1.25)
Pregestational diabetes	2.11 (1.94–2.30)	1.32 (1.20–1.44)
Chronic hypertension	3.32 (3.14–3.51)	2.56 (2.42–2.72)
Pre-existing renal disease	12.38 (10.11–15.16)	5.21 (4.20–6.44)
Cardiovascular disease	11.63 (8.19–16.51)	5.15 (3.54–7.49)
Obesity	1.91 (1.81–2.03)	1.46 (1.38–1.55)
Prior cesarean delivery	1.60 (1.54–1.67)	1.56 (1.49–1.63)
Year		
2008	Referent	Referent
2009	1.13 (1.07–1.20)	1.10 (1.04–1.17)
2010	1.03 (0.96–1.09)	0.99 (0.93–1.06)
2011	1.18 (1.12–1.25)	1.13 (1.07–1.20)
2012	1.17 (1.10–1.23)	1.12 (1.05–1.89)

OR, odds ratio; CI, confidence interval; aOR, adjusted odds ratio; ART, assisted reproductive technology.

Bold indicates statistically significant aOR.

* Each odds ratio is adjusted for all other variables in the table.

Table 4.

Odds Ratios and 95% Confidence Intervals for Severe Maternal Morbidity in Delivery and Postpartum Hospitalizations Among Multiple Gestation Pregnancies for Selected Characteristics, 2008–2012

Characteristic	OR (95% CI)	aOR* (95% CI)
ART	1.13 (0.98–1.29)	1.04 (0.91–1.20)
Age (y)		
Younger than 25	Referent	Referent
25–29	1.18 (0.9–1.54)	1.19 (0.91–1.55)
30–34	1.35 (1.05–1.75)	1.36 (1.05–1.76)
35–39	1.49 (1.15–1.94)	1.50 (1.15–1.95)
40–44	1.93 (1.44–2.59)	1.93 (1.44–2.60)
45 or older	3.28 (2.3–4.67)	3.19 (2.23–4.57)
Nulliparity	1.06 (0.95–1.18)	
Tobacco use	1.2 (0.88–1.64)	
Pregestational diabetes	1.34 (1.00–1.80)	
Chronic hypertension	1.50 (1.24–1.81)	1.33 (1.09–1.62)
Pre-existing renal disease	7.32 (3.61–14.85)	5.66 (2.72–11.79)
Cardiovascular disease	6.64 (2.36–18.64)	5.04 (1.71–14.87)
Obesity	1.20 (0.99–1.46)	
Prior cesarean delivery	0.85 (0.73–1.00)	0.82 (0.70–0.96)
Year		
2008	Referent	
2009	0.95 (0.80–1.14)	
2010	0.87 (0.73–1.04)	
2011	0.91 (0.77–1.08)	
2012	0.97 (0.82–1.15)	

OR, odds ratio; CI, confidence interval; aOR, adjusted odds ratio; ART, assisted reproductive technology.

Bold indicates statistically significant aOR.

* Each odds ratio is adjusted for all other variables in the table.