Original Research

Pregnancy-Associated Deaths in Rural, Nonrural, and Metropolitan Areas of Georgia

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OBJECTIVE: To characterize pregnancy-associated deaths and examine the relationship between area of residence and pregnancy-associated deaths and pregnancy-related mortality ratios in Georgia from 2010 to 2012.

METHODS: The cohort of pregnancy-associated deaths was reviewed and categorized as pregnancy-related or resulting from other medical conditions not related to pregnancy, suicide, drug toxicity, homicide, or motor vehicle accident. Georgia Online Analytical Statistical Information System data were used to calculate pregnancy-related mortality ratio by rural, nonrural, and metropolitan Atlanta area and by race. Causes of death and pregnancy-related mortality ratio were compared by area of residence and race using χ^2 tests; a P value $<.05$ was considered significant.

RESULTS: There were 262 pregnancy-associated deaths; 40.1% (n=105) were pregnancy-related. The 2010–2012 pregnancy-related mortality ratio was 26.5 per 100,000 live births and the pregnancy-related mortality ratio did not differ statistically among rural (27.1), nonrural (24.4), and metropolitan Atlanta (27.7) areas (P=.845). Most pregnancy-related deaths were the result of hemorrhage and cardiovascular factors. In aggregate, the pregnancy-related mortality ratio for black women was 49.5 compared with 14.3 for white women ($P<.001$). The gap in pregnancy-related mortality ratio between black and white women was highest for metropolitan Atlanta (51.6 compared with 12.4, $P<.001$), less in nonrural areas (50.3 compared with 12.0, $P<.001$), and comparable in rural areas (39.4 compared with 22.4, P=.281).

CONCLUSION: Although the pregnancy-related mortality ratio was similar for rural, nonrural, and metropolitan Atlanta areas, it was significantly higher for black compared with white women living outside of rural areas.

(Obstet Gynecol 2016;0:1–8)
DOI: 10.1097/AOG.0000000000001456

Maternal mortality is a global indicator of the health and well-being of society. Deaths in women during or within 1 year of pregnancy delivery are pregnancy-associated. A subset of pregnancy-associated deaths aggravated by or related to the pregnancy or its management is deemed pregnancy-related.[1] The pregnancy-related mortality ratio (number of pregnancy-related deaths per 100,000 live births) in the United States declined sharply across the 20th century from an estimated 900 deaths per 100,000 live births at the outset to 7.2 deaths per 100,000 live births in 1987.[2,3] This dramatic improvement has been attributed to better overall standard of living as well as medical advances including antisepsis, blood products, antibiotics, and improved operative and anesthesia techniques.[4] Maternal mortality review committees may also have contributed by increasing awareness that maternal deaths are sentinel, tragic, and often preventable events.[2,5]

The Pregnancy Mortality Surveillance System captures maternal deaths[3] and is used to document trends in pregnancy-related mortality ratio for the United States. There has been a seemingly paradoxical rise in pregnancy-related mortality ratio since the beginning of the 21st century that may not be completely explained by improved case ascertainment nor

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Presented at the Georgia Obstetrical and Gynecological Society Annual Meeting, August 21–24, 2014, Sea Island, Georgia, and at the Society for Maternal-Fetal Medicine's Annual Pregnancy Meeting, February 2–7, 2015, San Diego, California.

The authors thank Dr. Cynthia Berg and Dr. David Goodman for contributing to this work as members of the Georgia Maternal Mortality Review Committee, whereby they provided input on the approach to maternal mortality review and were part of the subcommittee who reviewed pregnancy-associated cases in 2010 and 2011.

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Financial Disclosure
The authors did not report any potential conflicts of interest.

ISSN: 0029-7844/16

by increased maternal medical complications.[2,4,6–8] The pregnancy-related mortality ratio for 2006–2010 was 16.0 deaths per 100,000 live births.[7] Moreover, the burden of maternal mortality is significantly higher for non-Hispanic black women compared with women of other backgrounds.[7] In some areas of the United States, the pregnancy-related mortality ratio surpasses that of developing countries.[9]

Georgia is among the states with the highest pregnancy-related mortality ratios.[10] After 12 years, formal maternal mortality review was reinstituted in 2012 as one potential strategy to improve this health indicator.[11] The goal of this review was to describe the causes of maternal deaths occurring in Georgia from 2010 to 2012 and to evaluate the distribution of deaths by area of residence as a surrogate for adequate access to health care services. Understanding regional differences in pregnancy-associated deaths would serve to enhance and inform recommendations for better targeted interventions to reduce preventable maternal deaths.

MATERIALS AND METHODS

This population-based cohort study included all pregnancy-associated deaths that occurred in Georgia from 2010 to 2012. This investigation was conducted in collaboration with the Georgia Maternal Mortality Review Committee and was approved by the institutional review board of Emory University. A pregnancy-associated death was defined as death in a woman who was pregnant at the time of death or had been pregnant in the 365 days preceding death.[1] The Georgia Office of Health Information for Planning identified deaths that were possibly pregnancy-associated using: 1) death certificates of women ages 10–50 years from 2010 to 2012 that were electronically matched to birth or fetal death certificates from 2009 to 2012; 2) death certificates with a check box indicating the decedent was pregnant at the time of death or had been pregnant in the year preceding death; and 3) death certificates with a cause of death code, assigned by the National Center for Health Statistics, indicating pregnancy (Chapter O of the International Statistical Classification of Diseases and Related Health Problems, 10th Revision manual).

Records provided by the Georgia Office of Health Information for Planning were reviewed to exclude death certificates of men, women who were older than age 50 years or younger than age 10 years, and women whose primary residence was outside of Georgia. The remaining records were considered pregnancy-associated deaths. These were further classified into one of six categories: pregnancy-related; resulting from other medical condition not related to pregnancy; suicide; drug toxicity; homicide; or motor vehicle accident. For the purposes of this analysis, suicide or homicide deaths that occurred during pregnancy or within 1 year postpartum were not considered to be pregnancy-related and were treated as separate categories of pregnancy-associated deaths.[12] Pregnancy-related deaths were defined as those deaths caused directly or indirectly by a complication of pregnancy during or within 1 year of pregnancy.[1] Each pregnancy-related death was further classified by major cause: cardiomyopathy, hypertensive disorder, hemorrhage, infection, pulmonary or venous thromboembolic event, amniotic fluid embolism, other cardiac cause, cerebrovascular accident, other noncardiovascular medical condition, or unknown. Pregnancy-associated deaths in 2010 and 2011 were reviewed by a subcommittee of representatives from the Georgia Maternal Mortality Review Committee and medical records were not available. The subcommittee classified these deaths based on diagnoses listed on the death certificate and information on the birth certificate if available. The 2012 deaths were reviewed by the entire Georgia Maternal Mortality Committee and included information from death and birth certificates, if available, in addition to data obtained from medical record abstraction. Figure 1 provides a graphic representation of the process to identify and classify pregnancy-associated deaths.

A data file was created with variables including age, race, county of residence, county of death, cause of death, and interval from delivery to death. Deaths were categorized as rural (less than 35,000 population), nonrural (greater than 35,000 population), or metropolitan Atlanta by county of residence according to Georgia Department of Public Health designations that were based on population estimates from the 2000 U.S. Census.[13] As a result of a low population, one county in the geographic metropolitan Atlanta area was also considered rural and for this investigation was classified as such.

Descriptive statistics included number and proportion of pregnancy-related and pregnancy-associated deaths by year and area of residence. The number of live births for each area was determined using birth data from the Georgia Department of Public Health Online Analytical Statistical Information System.[13] The pregnancy-related mortality ratio, defined as the number of pregnancy-related deaths per 100,000 live births,[3] was then calculated for the state as well as for rural, nonrural, and metropolitan Atlanta areas and by race. The primary outcome of the study was the pregnancy-related mortality ratio in rural areas compared with nonrural and metropolitan Atlanta areas.

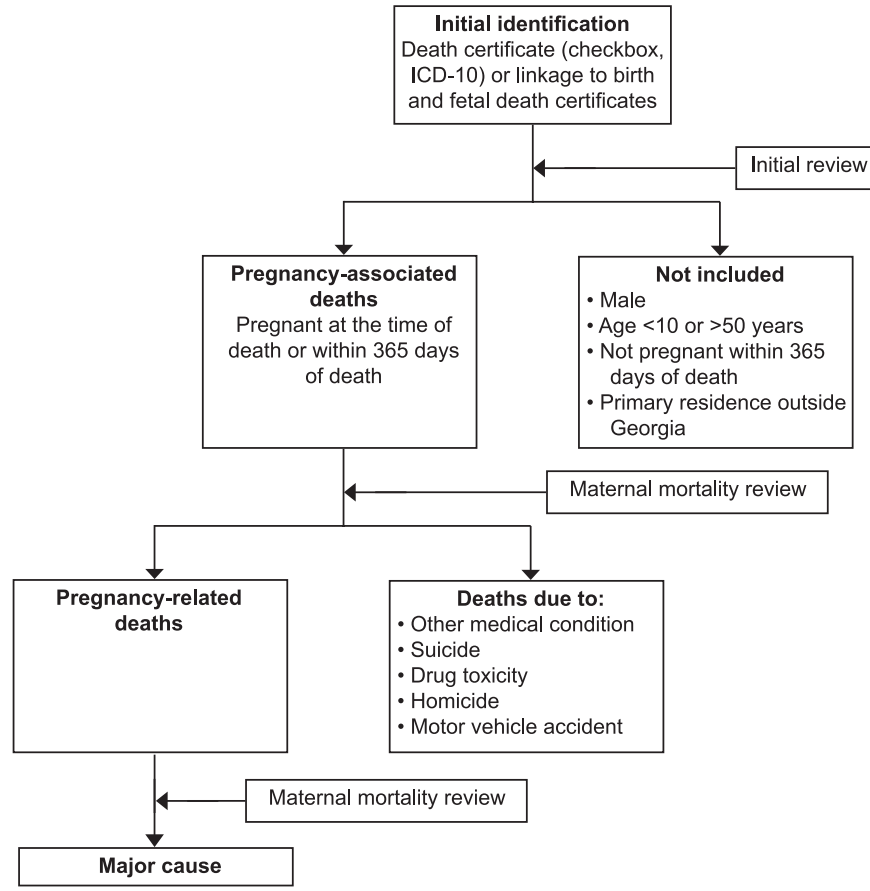

Fig. 1. Description of the process to identify and classify pregnancy-associated deaths. ICD-10, International Statistical Classification of Diseases and Related Health Problems, 10th Revision.

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Secondary outcomes included age, race, cause of death, and interval from delivery to death. Statistical comparisons were made using χ^2 or Fisher exact tests for categorical variables. A P value of $<.05$ was considered statistically significant. SPSS 21 was used for all analyses.

RESULTS

A total of 343 death records were obtained; of these, 129 (37.6%) were identified by check box only, 106 (30.9%) by check box and birth certificate linkage, and 101 (29.4%) by death and birth certificate linkage only. A small number of potential cases (n=7 [2%]) were identified by International Statistical Classification of Diseases and Related Health Problems, 10th Revision code on the birth certificate. After initial screening, 73 were considered not valid cases and eight were from women whose primary residence was outside the state of Georgia. The remaining 262 cases were deemed pregnancy-associated. Of these cases, 40.1% (n=105) were considered pregnancy-related; 20.2% (n=53) were attributed to other medical conditions: 7.6% (n=20) were suicides, 9.9% (n=26) were the result of drug toxicity, 9.9% (n=26) were homicides, and 12.2% (n=32) resulted from motor vehicle accidents. As shown in Figure 2 the number of pregnancy-associated deaths was relatively constant (P=.897) across each year reviewed. The proportion of deaths that was pregnancy-related declined from 51.1% in 2010 to 29.4% in 2012 (P=.013), whereas the proportion attributed to other medical causes increased from 10.0% to 29.4% (P=.005) during this same interval.

Women who died of pregnancy-related causes and other medical conditions tended to be older, whereas women who died as a result of homicide and motor vehicle accidents were younger (Table 1). Black women accounted for 50% (n=131) of the 262 pregnancy-associated deaths. Another 111 deaths occurred in white women (42.4%) and 20 deaths (7.6%) were in women of other races and ethnic origins or were unknown. A greater proportion of deaths from pregnancy-related (61.9% [n=65]), other medical conditions (50.9% [n=27]), and homicides (73.1% [n=19]) occurred among black women. The majority of suicides (80% [n=16]) and deaths from drug

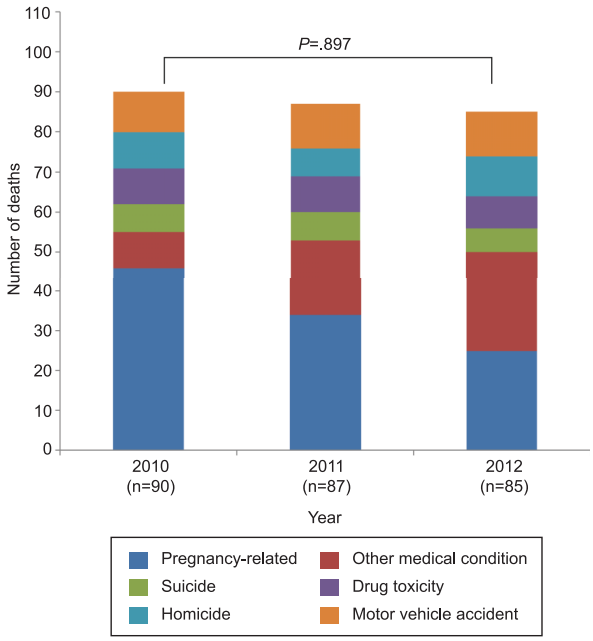

Fig. 2. Number and distribution of pregnancy-associated deaths in Georgia from 2010 to 2012.

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toxicity (88.5% [n=23]) occurred in white women. Most pregnancy-related deaths occurred within 42 days of delivery, whereas other pregnancy-associated deaths occurred later. Overall, the greatest number of pregnancy-associated deaths observed were in women who resided in metropolitan Atlanta (43.9%), whereas the fewest number were in residents of rural areas (21.4%; $P<.001$; Table 2). Pregnancy-related deaths accounted for the highest number of pregnancy-associated deaths in each geographic region. The number of deaths resulting from motor vehicle accidents was nearly double in residents of rural compared with nonrural and metropolitan Atlanta areas. The number of deaths resulting from suicide was similar across geographic areas.

The overall pregnancy-related mortality ratio for Georgia was 26.5 (95% confidence interval [CI] 21.9–32.1) per 100,000 for years 2010–2012. The pregnancy-related mortality ratio decreased from 34.4 (95% CI 25.8–45.9) in 2010, to 25.7 (95% CI 18.4–35.9) in 2011, to 19.2 (95% CI 13.0–28.4) in 2012 but was not statistically significant ($P=.055$). For 2010–2012, the pregnancy-related mortality ratio was comparable across rural, nonrural, and metropolitan Atlanta areas at 27.1 (95% CI 16.9–43.4), 24.4 (95% CI 17.4–34.3), and 27.7 (95% CI 21.3–36.1), respectively ($P=.845$). The pregnancy-related mortality ratio was 49.5 (95% CI 38.9–63.1) per 100,000 for black women compared with 14.3 (95% CI 9.9–20.7) per 100,000 for white women ($P<.001$). We also examined the differences in the pregnancy-related mortality ratio within each geographic stratum and found no difference between black and white women in rural areas (Fisher exact $P=.281$). Small numbers of women in this stratum limit the strength of this finding. However, black women had a significantly higher pregnancy-related mortality ratio compared with white women ($P<.001$ for both metropolitan Atlanta and nonrural areas; Table 3).

The 105 pregnancy related deaths were further subdivided by cause and location (Table 4). For all

Table 1. Distribution and Characteristics of Pregnancy-Associated Deaths in Georgia From 2010 to 2012

Characteristic	Pregnancy-Related (n=105 [40.1])	Other Medical (n=53 [20.2])	Suicide (n=20 [7.6])	Drug Toxicity (n=26 [9.9])	Homicide (n=26 [9.9])	MVA (n=32 [12.2])
Age (y)	30.5±7.1	31.5±7.6	28.9±6.4	27.1±6.4	22.6±3.9	25.7±5.8
Race–ethnicity						
Black	65 (61.9)	27 (50.9)	4 (20.0)	3 (11.5)	19 (73.1)	13 (40.6)
White	28 (26.7)	19 (35.8)	16 (80.0)	23 (88.5)	6 (23.1)	19 (59.4)
African	3 (2.9)	2 (3.8)	—	—	—	—
Hispanic	3 (2.9)	—	—	—	—	—
Other or unknown	6 (5.7)	5 (9.4)	—	—	1 (3.8)	—
PPI (d)	22.6±48	207±110	156±137	165±124	120±116	124±117
PPI group						
42 d or less	87 (82.9)	9 (17.0)	5 (25.0)	6 (23.1)	11 (42.3)	13 (40.6)
Greater than 42 d	15 (14.3)	44 (83.0)	13 (65)	20 (76.9)	15 (57.7)	19 (59.4)
Missing	3 (2.9)	—	2 (10)	—	—	—

MVA, motor vehicle accident; PPI, postpregnancy interval, defined as days from pregnancy delivery to death.
Data are mean±standard deviation or n (%).
Dashes indicate that there were no occurrences.

Table 2. Distribution of Pregnancy-Associated Deaths by Rural, Nonrural, and Metropolitan Atlanta Areas of Georgia From 2010 to 2012

Cause	All (N=262)	Rural (n=56)	Nonrural (n=91)	Metropolitan Atlanta (n=115)
Pregnancy-related	105 (40.1)	17 (30.4)	33 (36.3)	55 (47.8)
Other medical condition	53 (20.2)	9 (16.1)	22 (24.2)	22 (19.1)
Suicide	20 (7.6)	6 (10.7)	8 (8.8)	6 (5.2)
Drug toxicity	26 (9.9)	3 (5.4)	11 (12.1)	12 (10.4)
Homicide	26 (9.9)	6 (10.7)	9 (9.9)	11 (9.6)
Motor vehicle accident	32 (12.2)	15 (26.8)	8 (8.8)	9 (7.8)

Data are n (%).

women, the most common cause of pregnancy-related death was other cardiac causes at 15.2% followed closely by cardiomyopathies at 13.3%; altogether, cardiac deaths accounted for 28.5% of pregnancy-related deaths. When further subdivided by area of residence of the decedent, cardiomyopathies and other cardiac causes accounted for 17.6% of pregnancy-related deaths in rural areas, 42.4% of pregnancy-related deaths in nonrural areas, and 23.6% of pregnancy-related deaths in metropolitan Atlanta. Hypertensive disorders accounted for 29.4% of pregnancy-related deaths in rural areas compared with 3.0% and 12.7% in nonrural areas and metropolitan Atlanta, respectively.

The specific causes for all pregnancy-associated deaths stratified by race and geographic area of residence are shown in Table 5. Among black and white women, suicide accounted for 11.0%, 9.1%, and 6.1% of all pregnancy-associated deaths for rural areas, nonrural areas, and metropolitan Atlanta areas, respectively. Additionally, of the 20 total suicides, 16 (80.0%) occurred in white women and four (19.7%) occurred in rural areas. In rural areas, 27.4% of pregnancy-associated deaths were the result of motor vehicle accidents compared with 9.1% and 9.1% in nonrural and metropolitan Atlanta areas, respectively. More than 50% of all black women who died in metropolitan Atlanta died of pregnancy-related causes compared with 31.8% of all black women in rural areas.

DISCUSSION

Our study examined associations between pregnancy-related and pregnancy-associated deaths by location of residence. Although the pregnancy-related mortality ratio was similar across locations, there were notable differences in the causes of pregnancy-related and pregnancy-associated deaths. In rural areas, hypertensive disorders of pregnancy and hemorrhage were the most common causes of pregnancy-related deaths but less common in nonrural and metropolitan Atlanta. A recent study in California demonstrated that most preventable pregnancy-related deaths were attributed to hypertensive disorders and hemorrhage and were directly related to health care provider factors.[14] Additionally, hemorrhage was associated with the most facility-related factors including inadequate staff knowledge, system issues, and difficulty with coordination of care.[14]

The percentage of pregnancy-related deaths related to cardiac causes, including cardiomyopathies and other cardiac conditions, was higher in nonrural compared with metropolitan Atlanta and rural areas. Low rates of cardiac deaths in rural areas may be the result of population-based differences, specifically lower rates of black women residing in rural areas in Georgia.[13] Main et al[14] demonstrated a 10-fold risk for black women to die of cardiac causes. However, this

Table 3. Pregnancy-Related Mortality Ratios From 2010 to 2012 for Black and White Women in Georgia by Geographic Area of Residence

	Black Women		White Women		
Location	n	PRMR (95% CI)	n	PRMR (95% CI)	χ^2 *P*
Rural	4	22.5 (8.7–57.9)	7	17.4 (8.5–36.0)	.746*
Nonrural	12	27.5 (15.7–48.0)	6	8.0 (3.7–17.5)	<.001
Metropolitan Atlanta	28	40.1 (27.8–58.0)	7	8.7 (4.2–17.9)	<.001

PRMR, pregnancy-related mortality ratio; CI, confidence interval.
PRMR are per 100,000 live births.
* Statistical comparison performed using Fisher exact test.

Table 4. Pregnancy-Related Maternal Deaths by Rural, Nonrural, and Metropolitan Areas of Georgia From 2010 to 2012

Cause	All (n=105)	Rural (n=17)	Nonrural (n=33)	Metropolitan Atlanta (n=55)
Hemorrhage	12 (11.4)	3 (17.6)	3 (9.1)	6 (10.9)
HTN	13 (12.4)	5 (29.4)	1 (3.0)	7 (12.7)
PE or VTE	13 (12.4)	1 (5.9)	6 (18.2)	6 (10.9)
AFE	4 (3.8)	—	—	4 (7.3)
Cardiomyopathy	14 (13.3)	—	7 (21.2)	7 (12.7)
Other cardiac causes	16 (15.2)	3 (17.6)	7 (21.2)	6 (10.9)
CVA	7 (6.7)	—	1 (3.0)	6 (10.9)
Infection	12 (11.4)	2 (11.8)	4 (12.1)	6 (10.9)
Other	10 (9.5)	3 (17.6)	2 (6.1)	5 (9.1)
Unknown	4 (3.8)	—	2 (6.1)	2 (3.6)

HTN, hypertensive disorders; PE, pulmonary embolism; VTE, venous thromboembolism; AFE, amniotic fluid embolism; CVA, cerebrovascular accident.
Data are n (%).

does not account for the difference between metropolitan Atlanta and nonrural areas. This difference may be attributable to lack of subspecialist providers outside of metropolitan Atlanta such as fewer cardiologists, maternal–fetal medicine specialists, and intensivists. Studies in the United States have found higher rates of pregnancy-related mortality in health care provider shortage areas.[10] Further study will be needed to determine whether our findings may be attributed to health care provider knowledge, lack of resources, inadequate experience or deficits in obstetric providers and subspecialists, and the utility of telemedicine for underserved areas.

Although statewide, pregnancy-related deaths appear to be the most common cause of death in the year after pregnancy, based on our data, this

Table 5. Distribution of Pregnancy-Associated Deaths Among Black and White Women in Georgia by Area of Residence From 2010 to 2012

	All (n=163)		Rural (n=36)		Nonrural (n=59)		Metropolitan Atlanta (n=68)	
Pregnancy-Associated Designation	White (n=75)	Black (n=88)	White (n=22)	Black (n=14)	White (n=33)	Black (n=26)	White (n=20)	Black (n=48)
Pregnancy-related (n=65 [39.9])	20 (26.7)	45 (51.1)	7 (31.8)	4 (28.6)	6 (18.2)	12 (46.2)	7 (35.0)	29 (60.4)
Hemorrhage	3	5	2		1	1		4
HTN	1	7		3	1			4
PE or VTE	2	7	1		1	2		5
AFE		1						1
Cardiomyopathy	1	9			1	3		6
Other cardiac causes	4	4	1		1	3	2	1
CVA	1	3				1	1	2
Infection	3	4	1			1	2	3
Other	4	3	2	1		1	2	1
Unknown	1	2			1			2
Other medical condition (n=29 [17.8])	11 (14.7)	18 (20.4)	1 (4.5)	3 (21.4)	8 (24.2)	8 (30.8)	2 (10.0)	7 (14.5)
Suicide (n=13 [7.9])	12 (16.0)	1 (1.1)	5 (22.7)		4 (12.1)	1 (3.8)	3 (15.0)	
Drug toxicity (n=17 [10.4])	15 (20.0)	2 (2.2)	2 (9.1)		8 (24.2)		5 (25.0)	2 (4.2)
Homicide (n=18 [11.0])	6 (8.0)	12 (13.6)	1 (4.5)	4 (28.6)	4 (12.1)	3 (11.5)	1 (5.0)	5 (10.4)
MVA (n=21 [13.4])	11 (14.7)	10 (11.4)	6 (27.3)	3 (21.4)	3 (9.1)	2 (7.2)	2 (10.0)	5 (10.4)

HTN, hypertensive disorders; PE, pulmonary embolism; VTE, venous thromboembolism; AFE, amniotic fluid embolism; CVA, cerebrovascular accident; MVA, motor vehicle accident.
Data are n or n (%). Empty cells had no death for the category.

seems to vary by location of residence. In Georgia, the percentage of black women living in rural areas is approximately 25% compared with 32% in nonrural areas.[14] Our observation may be related to the differences in the racial makeup of the population in rural compared with metropolitan areas as well. The overall pregnancy-related mortality ratio for black women in our study was 49.5 compared with a rate of 14.3 in white women, which is consistent with the Pregnancy Mortality Surveillance System report demonstrating a three- to fourfold higher risk of mortality for black compared with white women.[5]

When stratified by location and race, we found a striking difference in the pregnancy-related mortality ratio for metropolitan Atlanta black women compared with white women, yet this disparity was no longer apparent in rural areas. Small numbers and wide CIs limit the strength of this observation. Notably, the causes of death differed for black and white women. Black women were most likely to die of hypertensive disorders, hemorrhage, venous thromboembolism, and cardiomyopathy, whereas white women died more commonly as a result of suicide or drug overdose. These risks were higher in black women residing in metropolitan Atlanta. This highlights the need for aggressive blood pressure control, antepartum screening for underlying risk factors, and detection of early warning signs for hemorrhage and maternal decompensation.

Among pregnancy-associated deaths, suicide seems to be more prevalent in rural areas. Although not the primary outcome of our investigation, this finding represents an area that warrants further evaluation including availability of social and psychological support services for women in rural areas compared with urban areas. This also highlights the need to educate health care providers in rural and nonrural areas on the need for thorough evaluation of women at risk for postpartum depression as well as access to social and psychiatric services.

Our study does have limitations. Specifically, 2010 and 2011 data were evaluated by a subcommittee without access to abstracted medical records, whereas the 2012 data were reviewed by the full Georgia Maternal Mortality Review Committee, which reviewed the abstracted case summary for each case. This may have contributed to the fewer number of pregnancy-related cases and more deaths being attributed to other medical conditions in 2012. Additionally, patients from 2010 and 2011 with indirect causes of death, identified only by check boxes, could not be confirmed because there was no medical record abstraction.[15,16] Also, because data for deaths in 2010 and 2011 were abstracted from birth and death certificates, we do not have information such as weight, body mass index, number of prenatal visits, and screening for early detection of complications of pregnancy. As the Georgia Maternal Mortality Review Committee continues to review cases, the availability of this information will allow for a more thorough review going forward. From 2010 through 2012 the total number of pregnancy-associated deaths did not change, but the distribution between pregnancy-associated and pregnancy-related deaths changed and was likely the result of having more accurate information for a larger committee to thoroughly review, thus demonstrating the importance of continuing review at a statewide level.

This review sheds light on the most common causes of pregnancy-related deaths throughout the state: cardiac causes, hypertensive disorders, hemorrhage, infection, and venous thromboembolism. Studies have previously noted that up to 40% of these deaths are potentially preventable.[14,17] Our evaluation highlights the disparities in maternal deaths throughout the state, the necessity of providing adequate women's health care, and improved access to prenatal care.

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