

Addressing the Cardiovascular Contribution to Maternal Mortality

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No Financial Disclosures

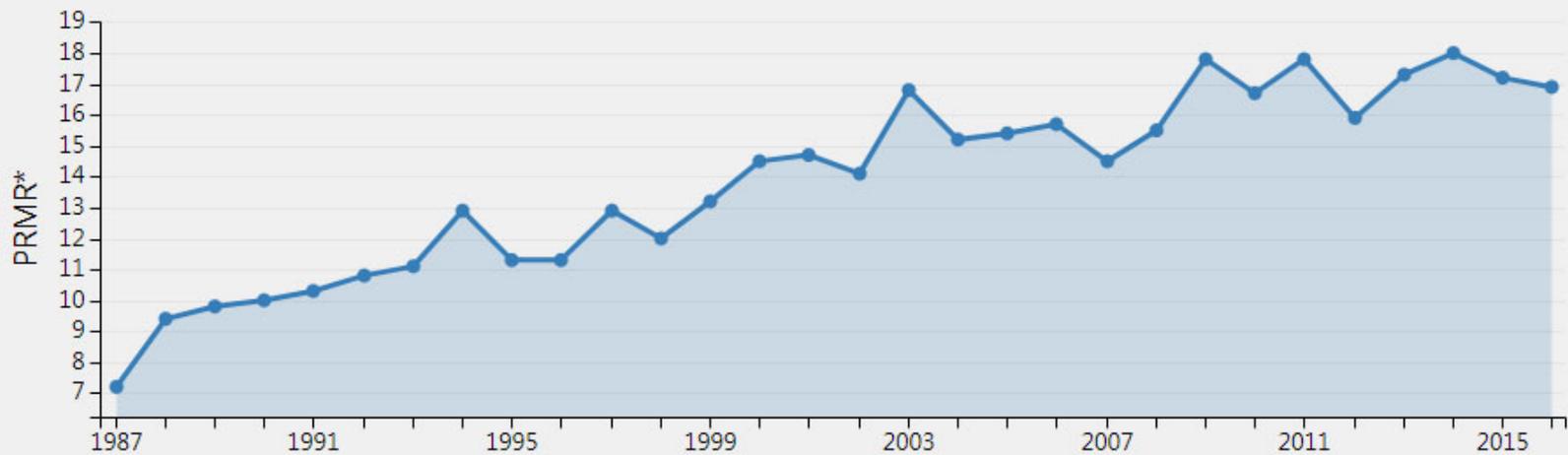


Objectives

- Identify key factors related to maternal cardiovascular mortality
- Understand how social determinants of health contribute to maternal cardiovascular morbidity and mortality
- Identify key research priorities for reducing maternal cardiovascular morbidity and mortality

Maternal Mortality in America

Trends in pregnancy-related mortality in the United States: 1987-2016



*Number of pregnancy-related deaths per 100,000 live births per year

Maternal Mortality in Kentucky

Figure 1: Total Number of Maternal* Deaths and Rate of Death; Kentucky, 2013-2019

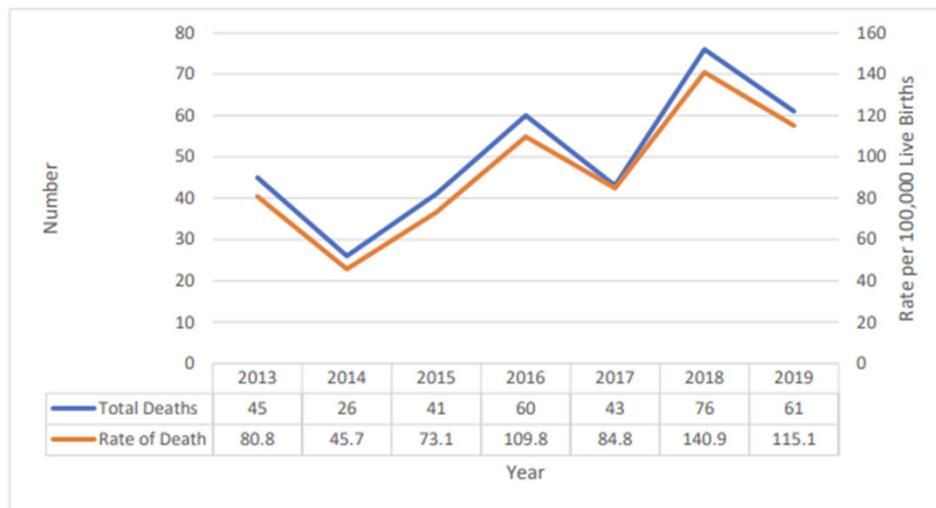
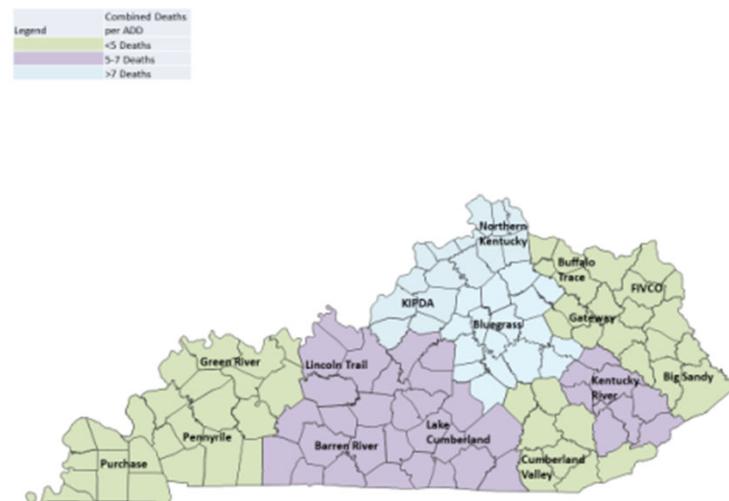


Figure 2: Total Number of Maternal Deaths Reviewed by Area Development District 2017-2018



Cardiovascular Disease is the LEADING CAUSE of Maternal Mortality

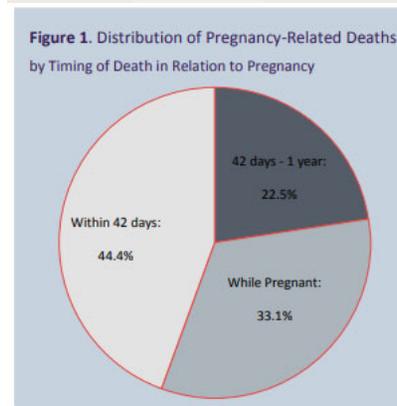
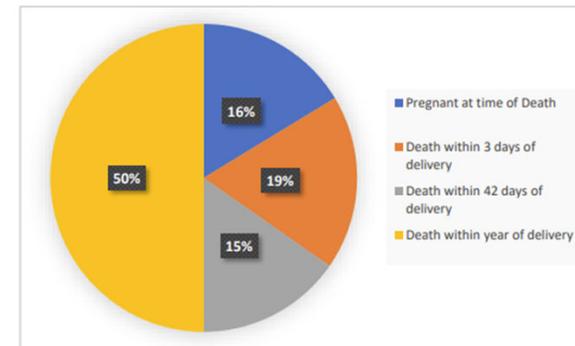
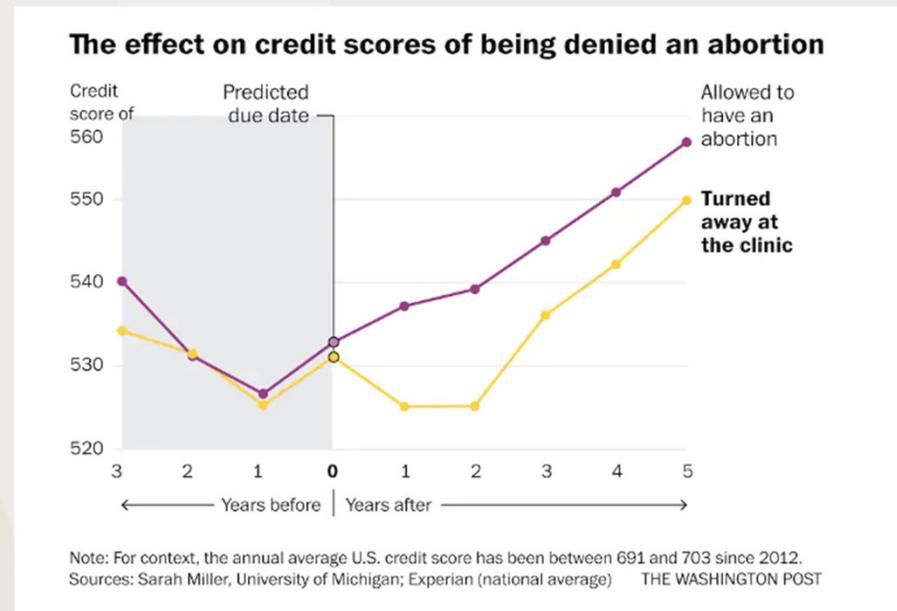


Figure 14: Timing of Maternal Deaths 2018 Cohort

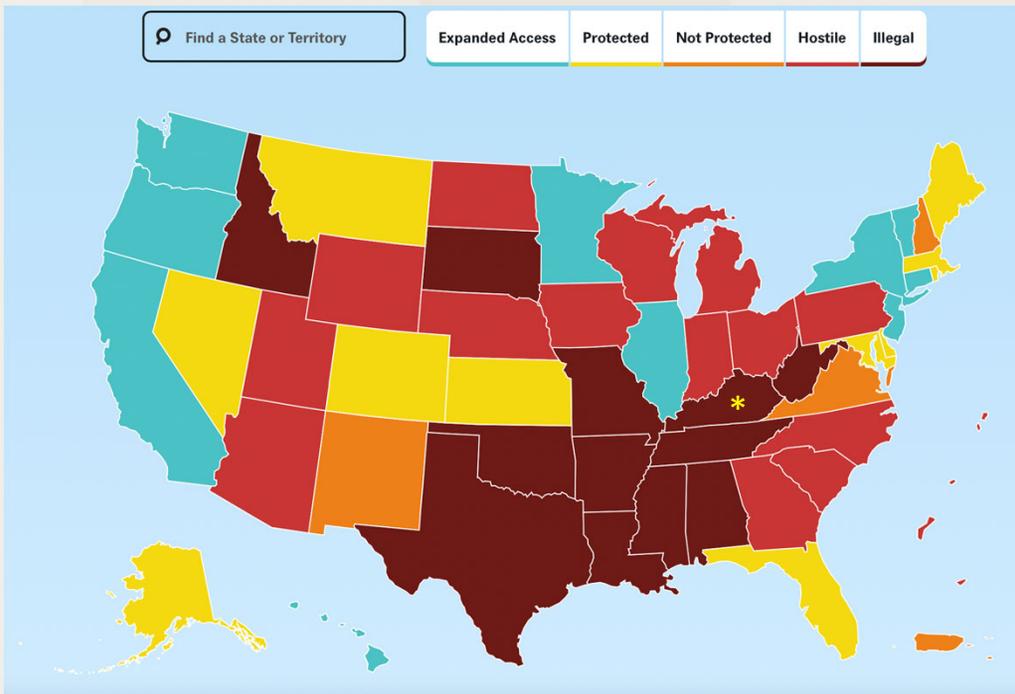


Implications of Abortion Bans (to name a few)

- Anticipated Increase in Maternal Mortality
 - 21% Total Increase
 - 33% Increase among Black women
- Increase in poverty for women
- Increase in racial and geographic health and economic disparities



Abortion Access in the United States



- Approximately **half** of pregnancies in the US are **unplanned**
- Many women do not recall discussing contraception and pregnancy planning with their cardiologist
 - Only 43-57% report discussing with cardiologist
 - Among women 14-25 on teratogenic medications (category D or X), contraception provision documented in 28% of clinic visits

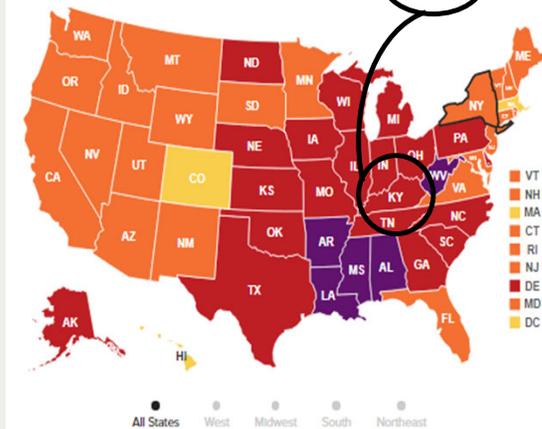
Rising Burden of Chronic Disease

Adult Obesity Rate by State, 2016

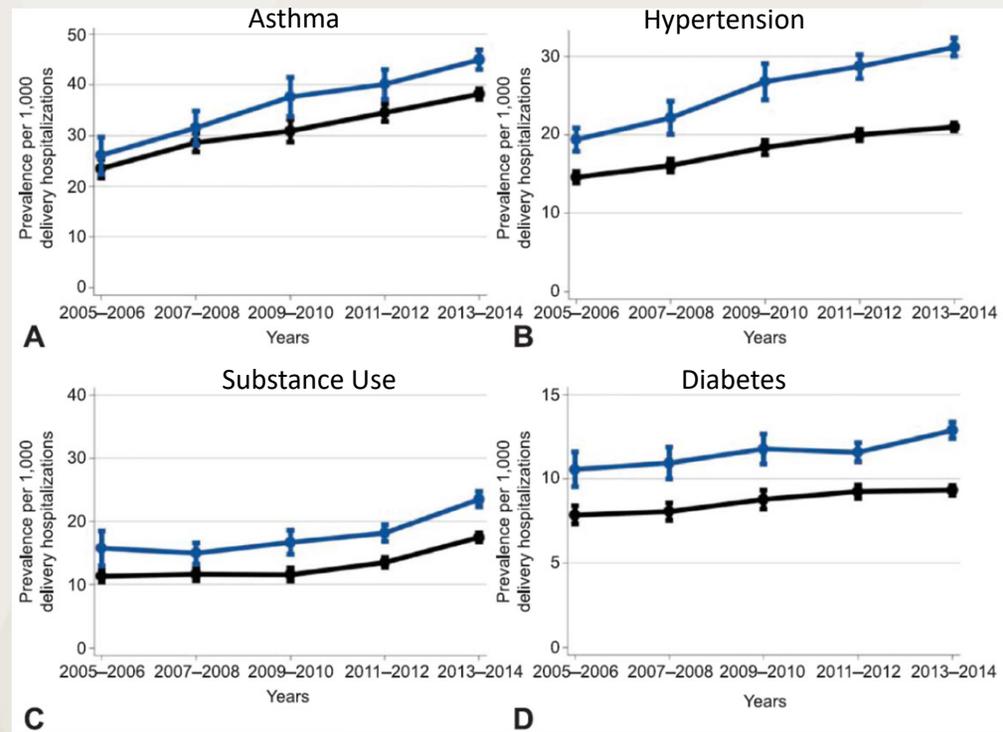
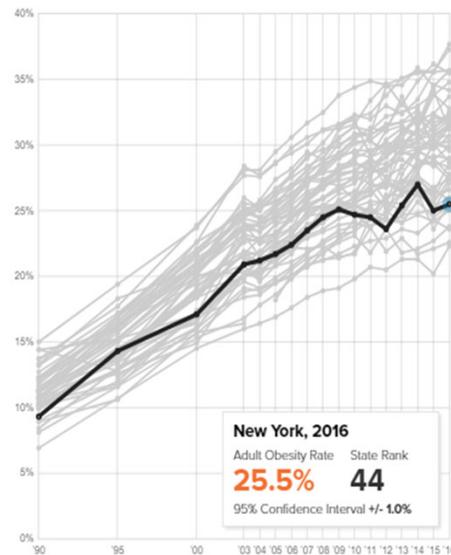
Select years with the slider to see historical data. Hover over states for more information. Click a state to lock the selection. Click again to unlock.

Percent of obese adults (Body Mass Index of 30+)

0 - 9.9% 10 - 14.9% 15 - 19.9% 20 - 24.9% 25 - 29.9% 30 - 34.9% 35%+



Adult obesity rates, 1990 to 2016

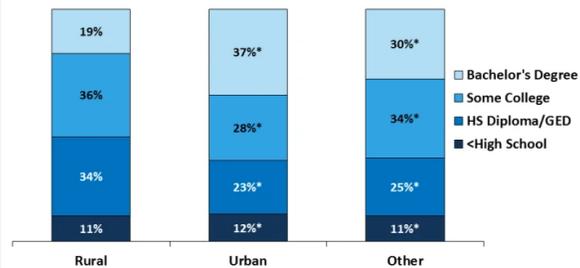


— Bottom quartile — 26th-100th percentile

Cardiovascular Risk Factors: Increasing Rurality/Risk

Figure 3

Education Among Nonelderly Adults by Geographic Area, 2015

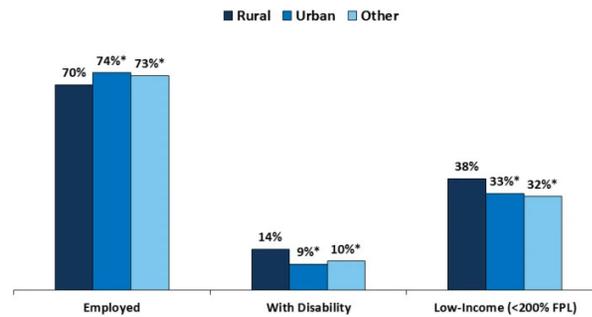


NOTE: Includes nonelderly individuals ages 19-64. Totals may not sum to 100% due to rounding. * Indicates statistical difference from the rural population at the p < 0.05 level.
SOURCE: KFF analysis of 2015 American Community Survey, 1-Year Estimates.

Figure 3: Education Among Nonelderly Adults by Geographic Area, 2015

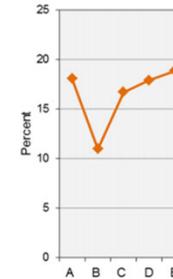
Figure 4

Employment Status, Income, and Disability by Geographic Area, 2015



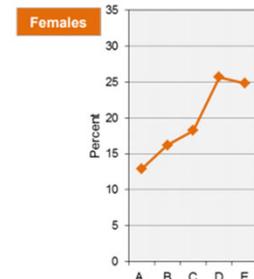
NOTE: Employment status and disability includes nonelderly adults ages 19-64. Income includes nonelderly individuals ages 0-64.
* Indicates statistically significant difference from the rural population at the p < 0.05 level.
SOURCE: KFF analysis of 2015 American Community Survey, 1-Year Estimates.

Percent of Population Living in Poverty

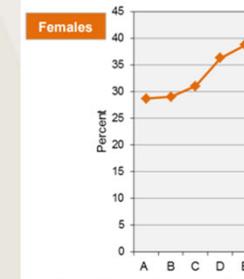


A Large central Metropolitan counties
B Large fringe Metropolitan counties
C Small metro Nonmetropolitan counties
D Micropolitan Nonmetropolitan counties
E Non-core Nonmetropolitan counties

Tobacco Use

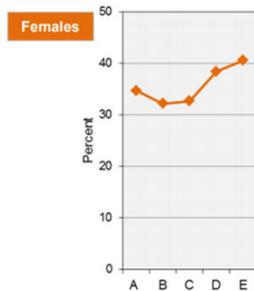


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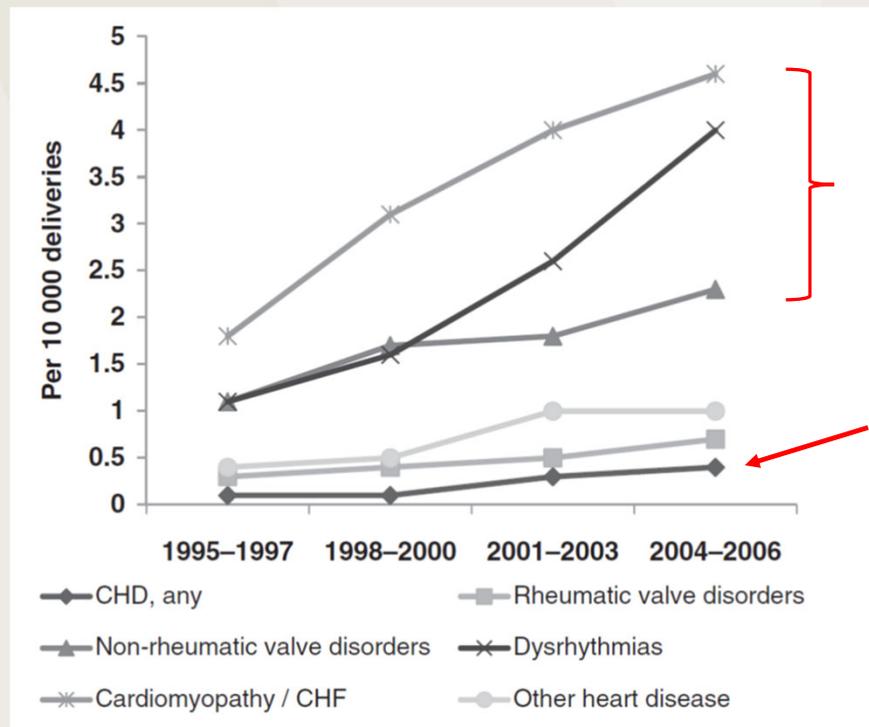
Obesity



A Large central Metropolitan counties
B Large fringe Metropolitan counties
C Small metro Nonmetropolitan counties
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E Non-core Nonmetropolitan counties

Physical Inactivity

Postpartum Hospitalizations for Chronic Heart Disease



Acquired disease (CHF, Arrhythmia, Valvular Disease)

Congenital Disease

Pregnancy Outcomes in Women With Heart Disease

The CARPREG II Study

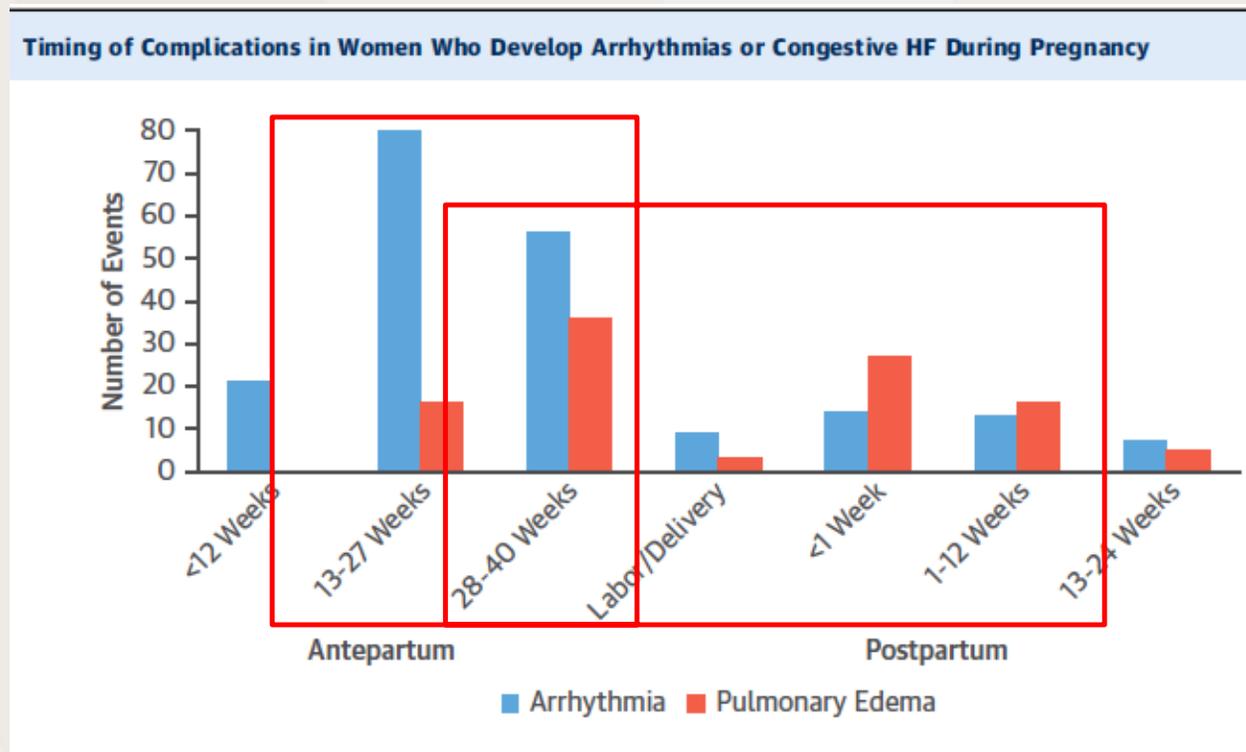
Candice K. Silversides, MD, MS,^{a,b} Jasmine Grewal, MD,^c Jennifer Mason, RN,^{a,b} Mathew Sermer, MD,^{a,b} Marla Kiess, MD,^c Valerie Rychel, MD,^d Rachel M. Wald, MD,^{a,b} Jack M. Colman, MD,^{a,b} Samuel C. Siu, MD, SM, MBA^{a,b,e}

Cardiac diagnosis	
Congenital heart disease	1,235 (63.7)
Acquired heart disease	443 (22.9)
Isolated cardiac arrhythmias	260 (13.4)
High-risk cardiac lesions	
High-risk left-sided valve disease/LVOT obstruction	294 (15.2)
At least mild systemic ventricular systolic dysfunction	263 (13.6)
Pulmonary hypertension	58 (3.0)
High-risk aortopathy	52 (2.7)
Mechanical heart valve	43 (2.2)
Coronary artery disease	38 (2.0)

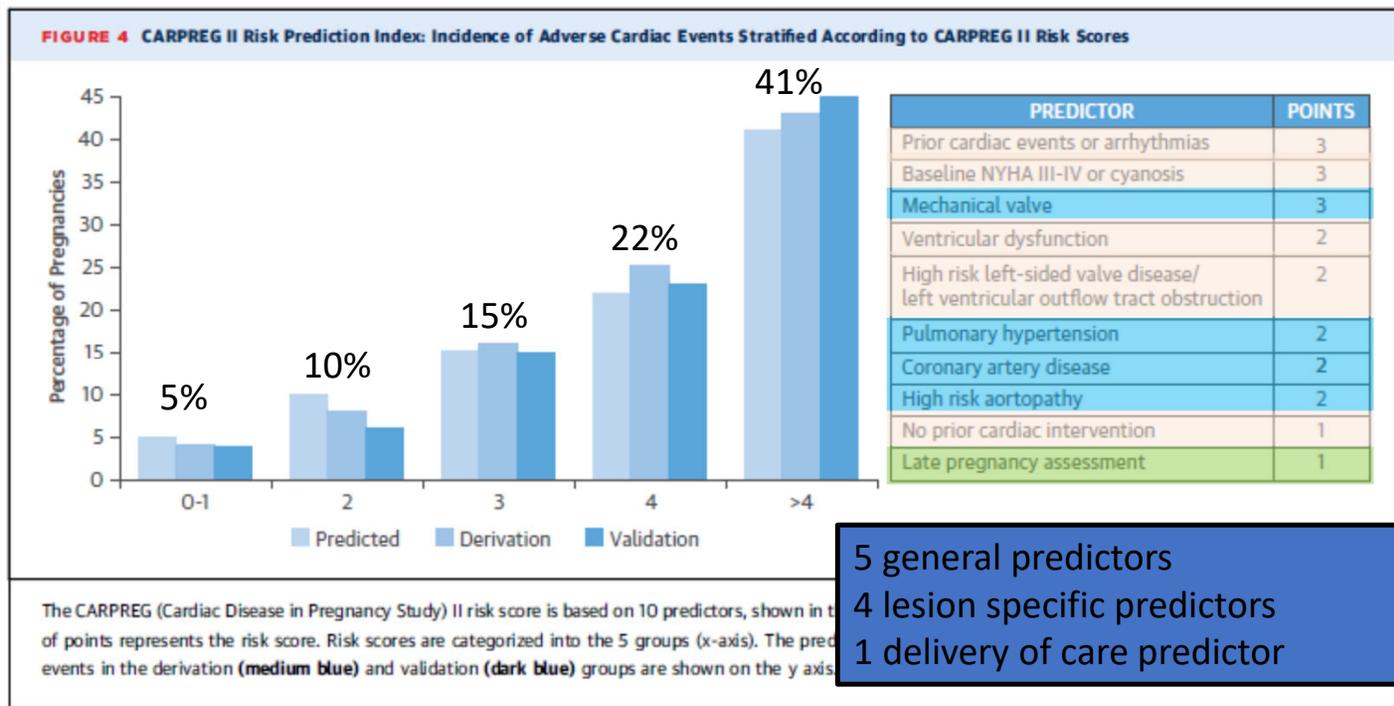
TABLE 2 Incidence of Adverse Cardiac Event Rates During Pregnancy (N = 1,938)

Any maternal cardiac events	307 (15.8)
Maternal cardiac death	6 (0.3)
Maternal cardiac arrest	8 (0.4)
Arrhythmias	181 (9.3)
Any left- or right-sided HF	120 (6.2)
Left-sided HF	106 (5.5)
Right-sided HF	19 (1.0)
Stroke	13 (0.7)
Myocardial infarction	8 (0.4)
Dissection	7 (0.4)
Cardiac thromboembolism	6 (0.3)

CARPREG II Complications



CARPREG II Risk Model



5 general predictors
 4 lesion specific predictors
 1 delivery of care predictor

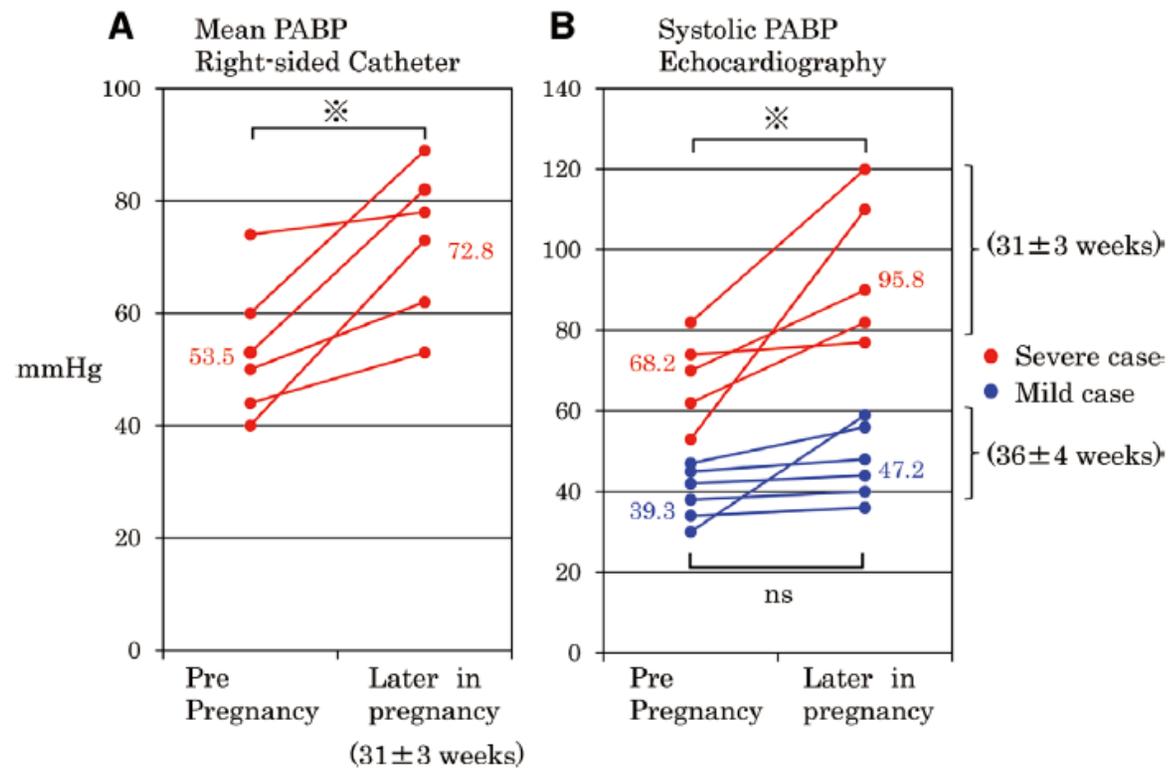
Modified World Health Organization (mWHO)

TABLE 3 Modified WHO Risk Stratification Model

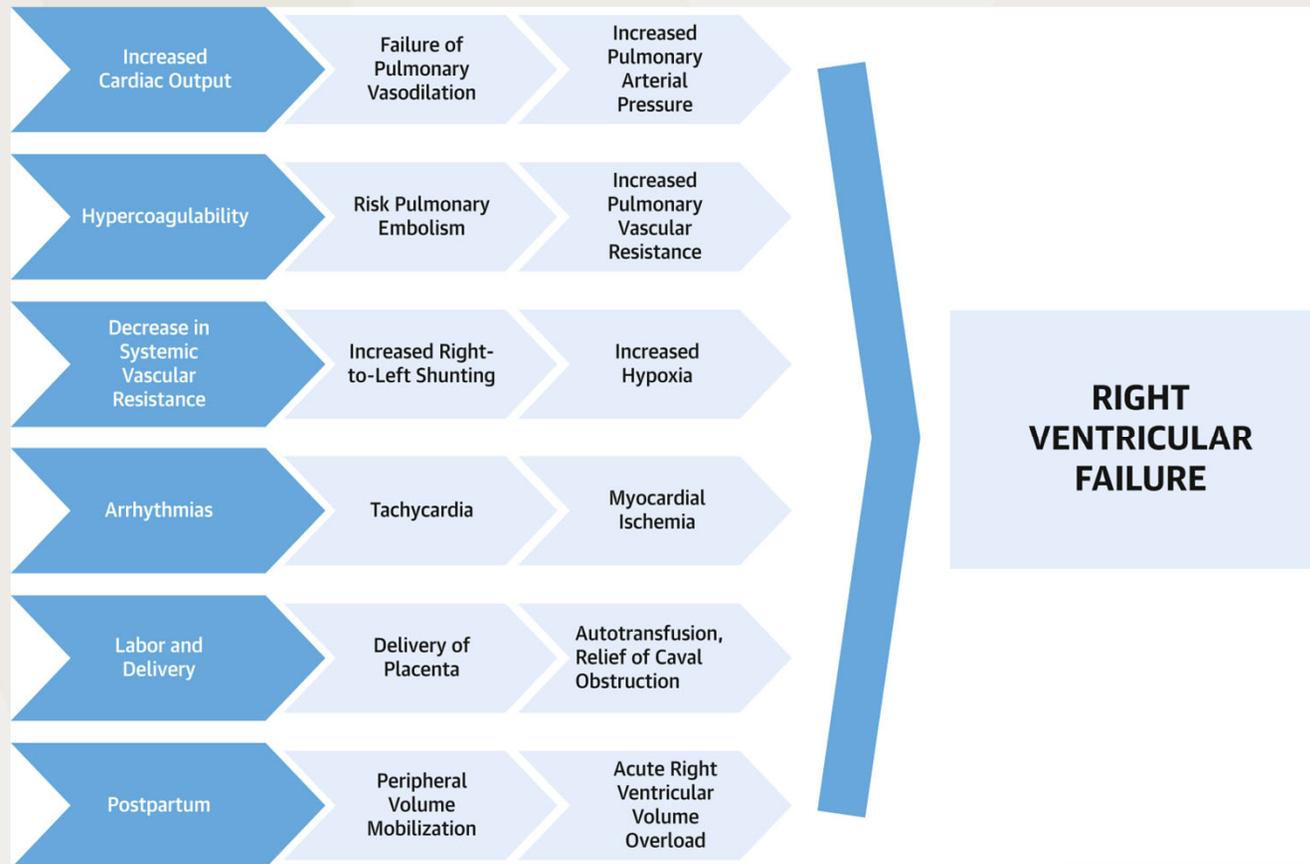
Modified WHO Class	Conditions	Predicted Risk, %
I—No higher risk than the general population	Uncomplicated, small or mild lesions including pulmonary stenosis, VSD, PDA, and mitral valve prolapse with no more than trivial mitral regurgitation Successfully repaired simple lesions including ostium secundum ASD, VSD, PDA, and TAPVD Isolated PVCs and PACs	2.5-5
II—Small increased risk of maternal morbidity and mortality	Unoperated ASD Repaired tetralogy of Fallot Most arrhythmias Coarctation of the aorta without significant gradient or aneurysm (repaired or unrepaired) Long QT syndrome	5.7-10.5
II to III	Mild LV impairment Hypertrophic cardiomyopathy Marfan syndrome without aortic dilation Heart transplant Native or tissue valve disease not considered WHO class IV Bicuspid aortic valve without aortic dilatation	10-19

III—Significant risk of maternal morbidity and mortality	Mechanical valve Systemic RV Post-Fontan operation Cyanotic heart disease Other complex congenital heart repair Aortic dilation without known fibrinogen disease Coarctation of the aorta with residual gradient or aneurysm (repaired or unrepaired) Marfan syndrome with aortic root dilation <45 mm or following aortic replacement Bicuspid aortic valve with aortic root dilation 45 to 50 mm	19-27
IV—Pregnancy contraindicated	Pulmonary arterial hypertension of any cause Severe left ventricular dysfunction (LVEF <30% or NYHA functional class III to IV) Previous peripartum cardiomyopathy with any residual impairment of LV function Severe left heart obstruction (AVA <1 cm ² or peak gradient >50 mm Hg; MVA <1.5 cm ²) Marfan syndrome with aortic dilation >45 mm Bicuspid aortic valve with aortic dilation >50 mm	40-100

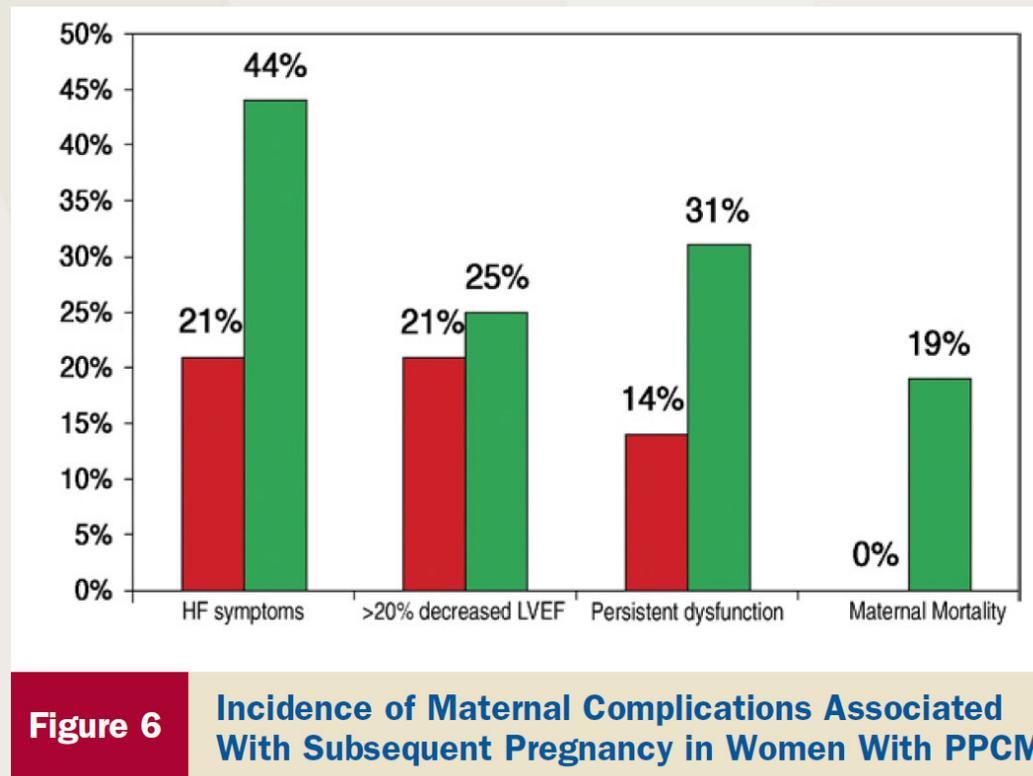
Pulmonary Arterial Hypertension and Pregnancy – A Moving Target



RV Failure in Pregnant Patients with PAH

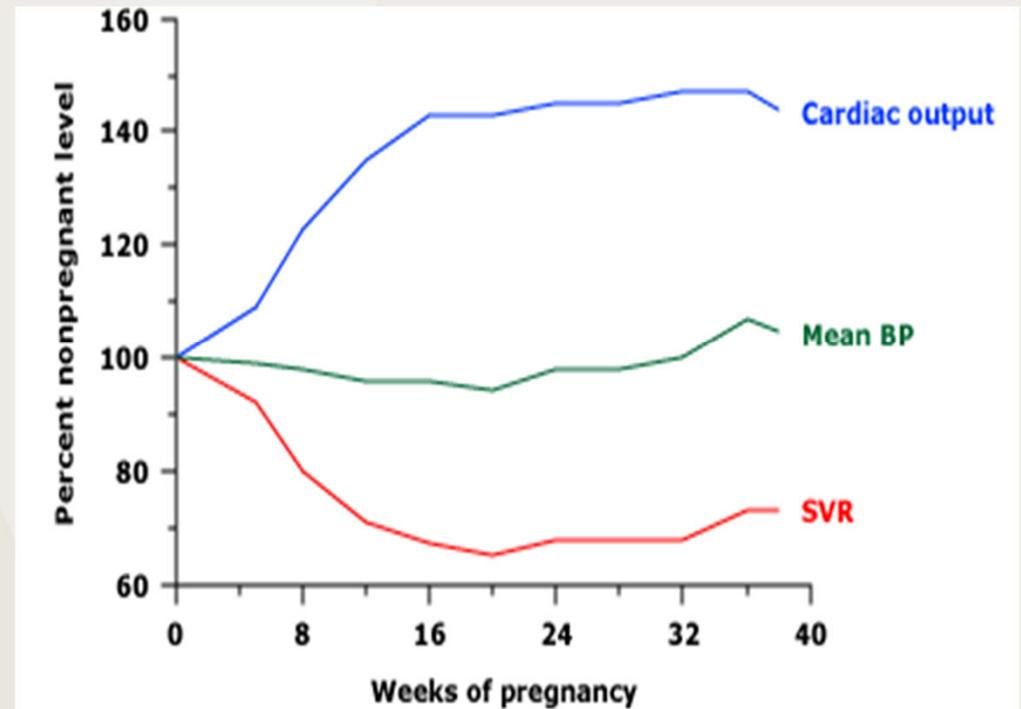


PPCM: Subsequent Pregnancies

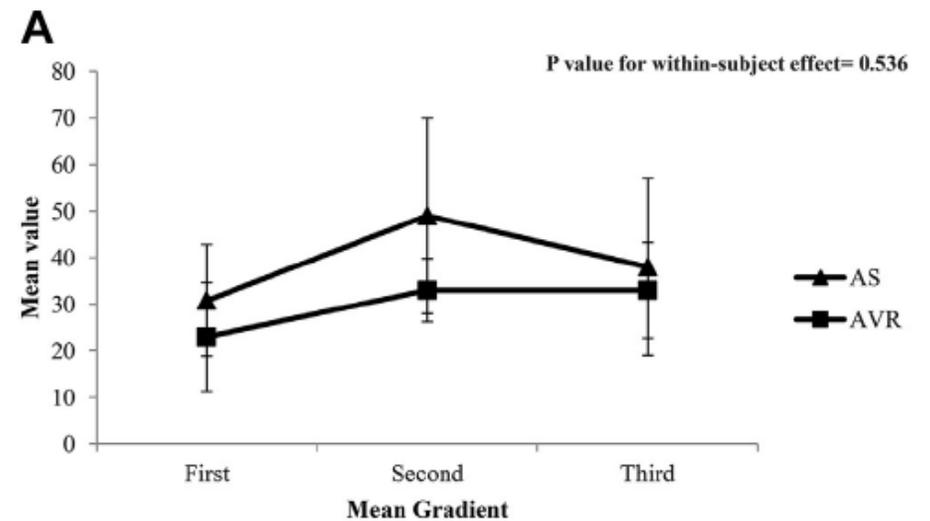
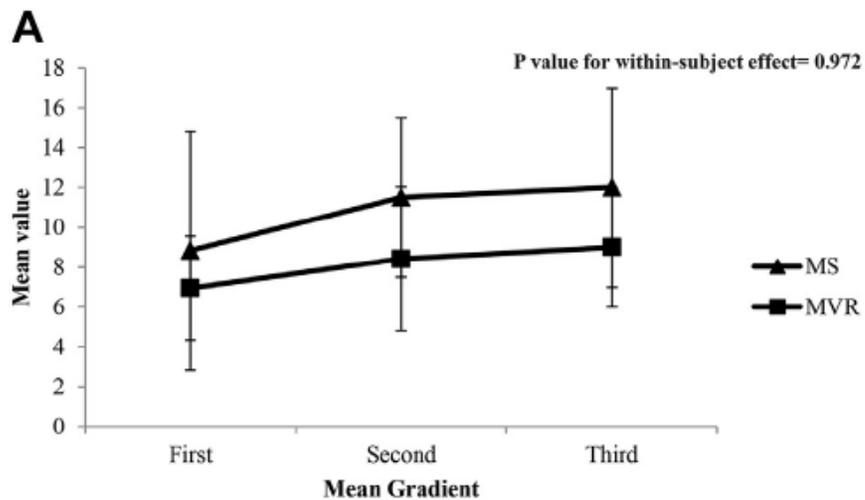


Valve Stenosis in Pregnancy

- Increased CO and HR will increase pressure gradient
- **Valve area will NOT change over 9 months ... but pressure gradient WILL!**



Valve Gradients During Pregnancy



Pregnancy Itself = Risk Factor

- Pro-thrombotic state
- Increased levels estrogen/progesterone/relaxin
- Increased incidence of
 - Aortic and coronary dissection
 - Plaque Rupture
 - Stroke
 - Embolic Phenomena
- Do not return to baseline until ~12 weeks post-partum

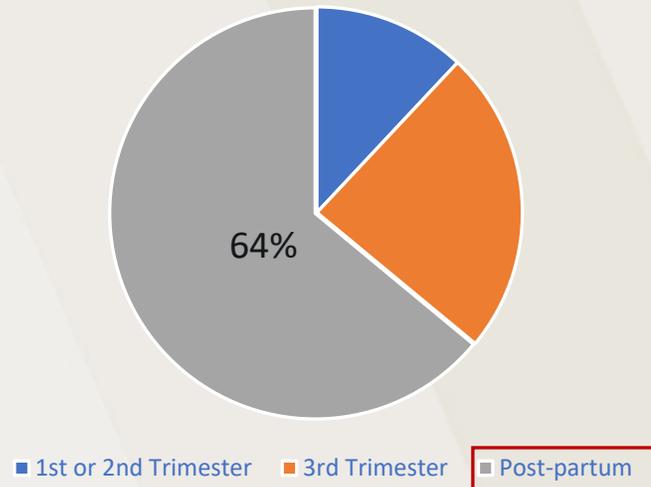


Post-Partum = THE WEEDS!



Post-partum Acquired Cardiac Events

Coronary Artery Dissection



Cardiac Events in Marfan Syndrome

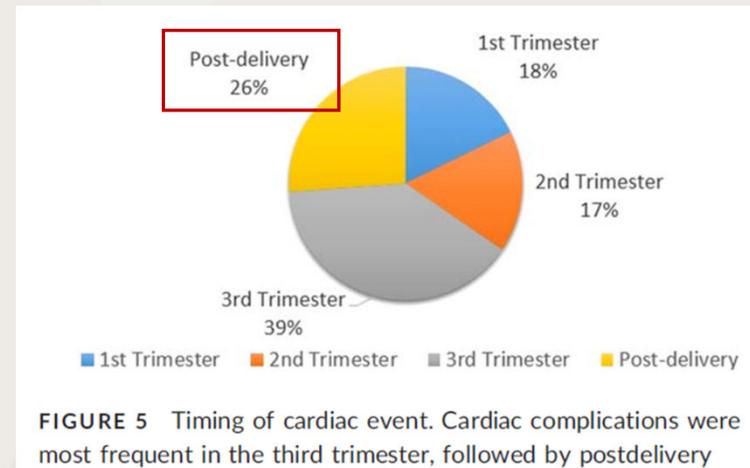


FIGURE 5 Timing of cardiac event. Cardiac complications were most frequent in the third trimester, followed by postdelivery

Maternal Mortality is Preventable

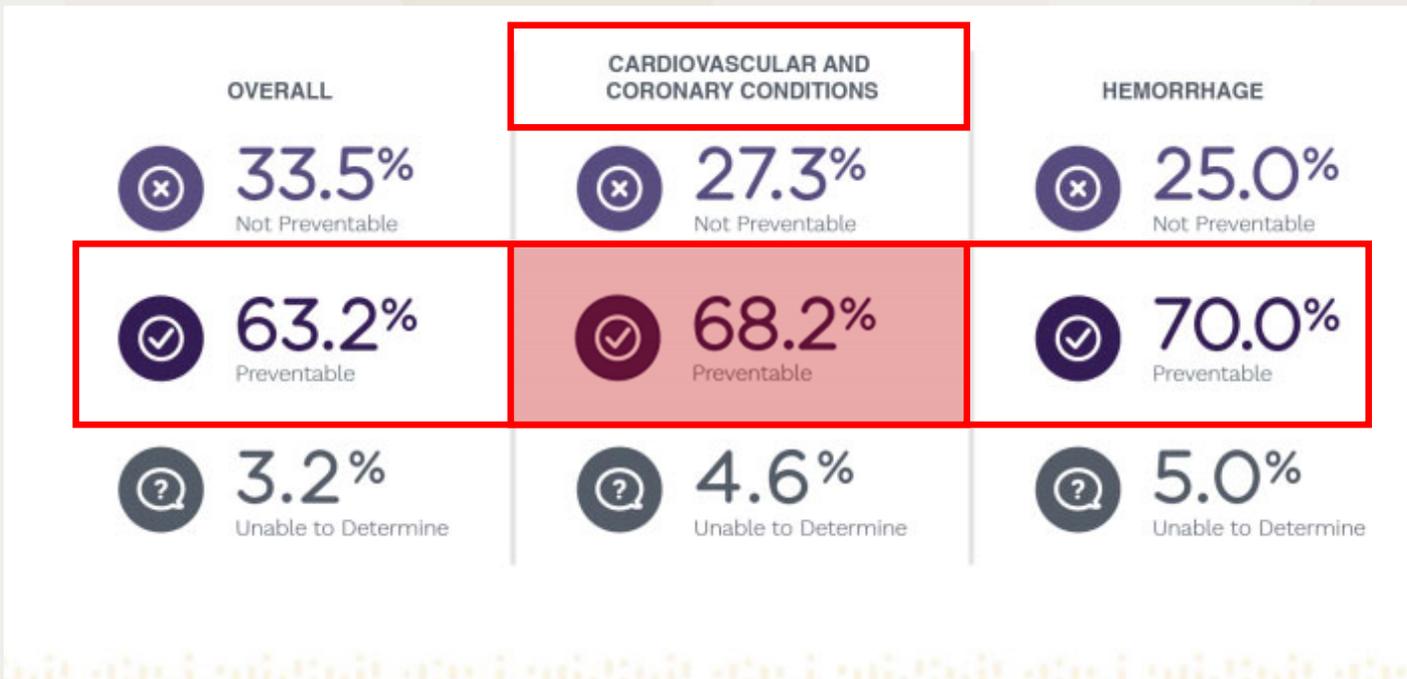
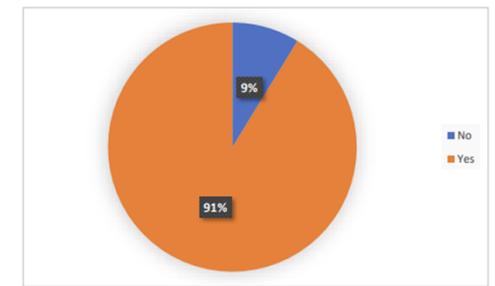


Figure 16: Was the Death Preventable? 2018 Cohort*

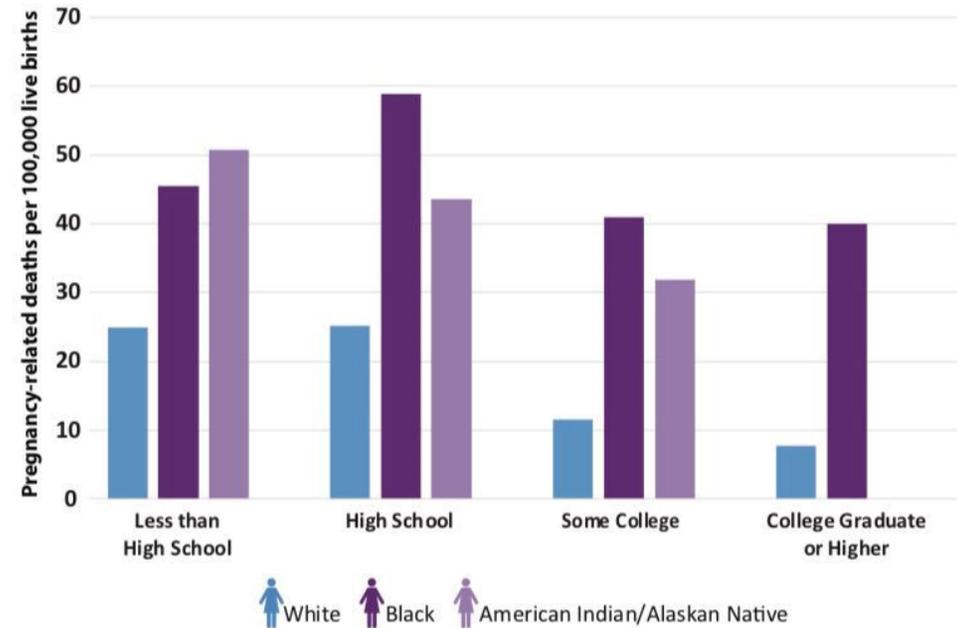
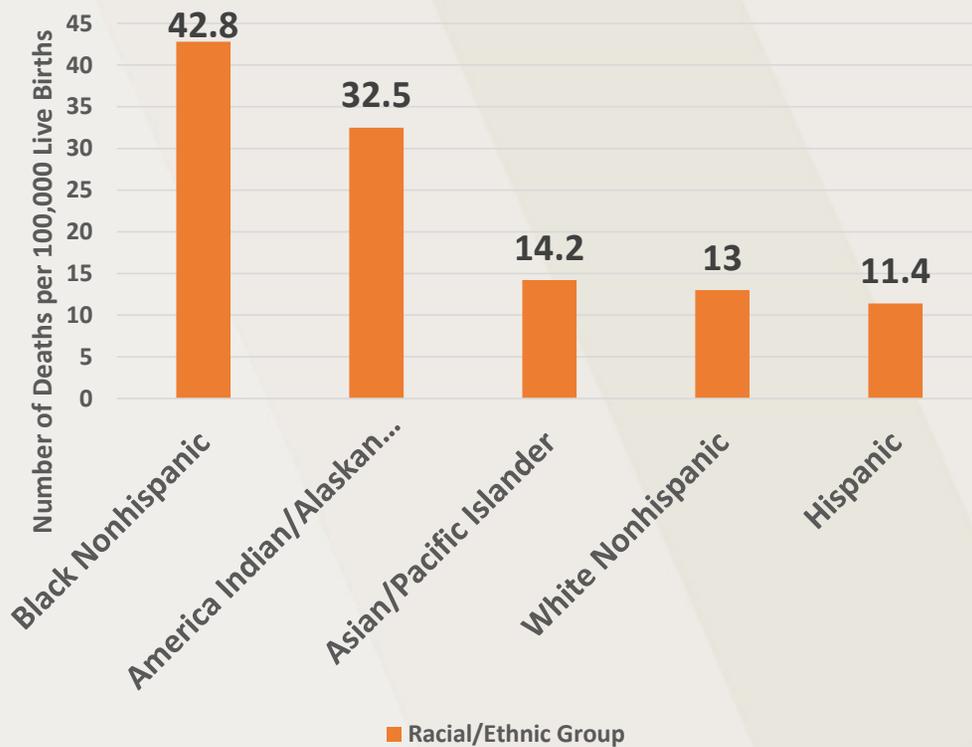


*88% of Kentucky's pregnancy related deaths were considered preventable.

4 Key Factors Related to Maternal Cardiovascular Mortality

- Race/Ethnicity
 - Black women have 3.4 times risk of dying than whites
- Age
 - Age >40 increases risk to 30 TIMES the risk of women <20 years old
- Hypertension – chronic or hypertensive disorder of pregnancy
 - Risk of MI is 13 fold
 - Risk of heart failure is 8 fold
- Obesity
 - 60% of maternal deaths occur in overweight or obese women

Racial Disparities in Maternal Mortality



Racial Disparities in Specific Cardiovascular Outcomes

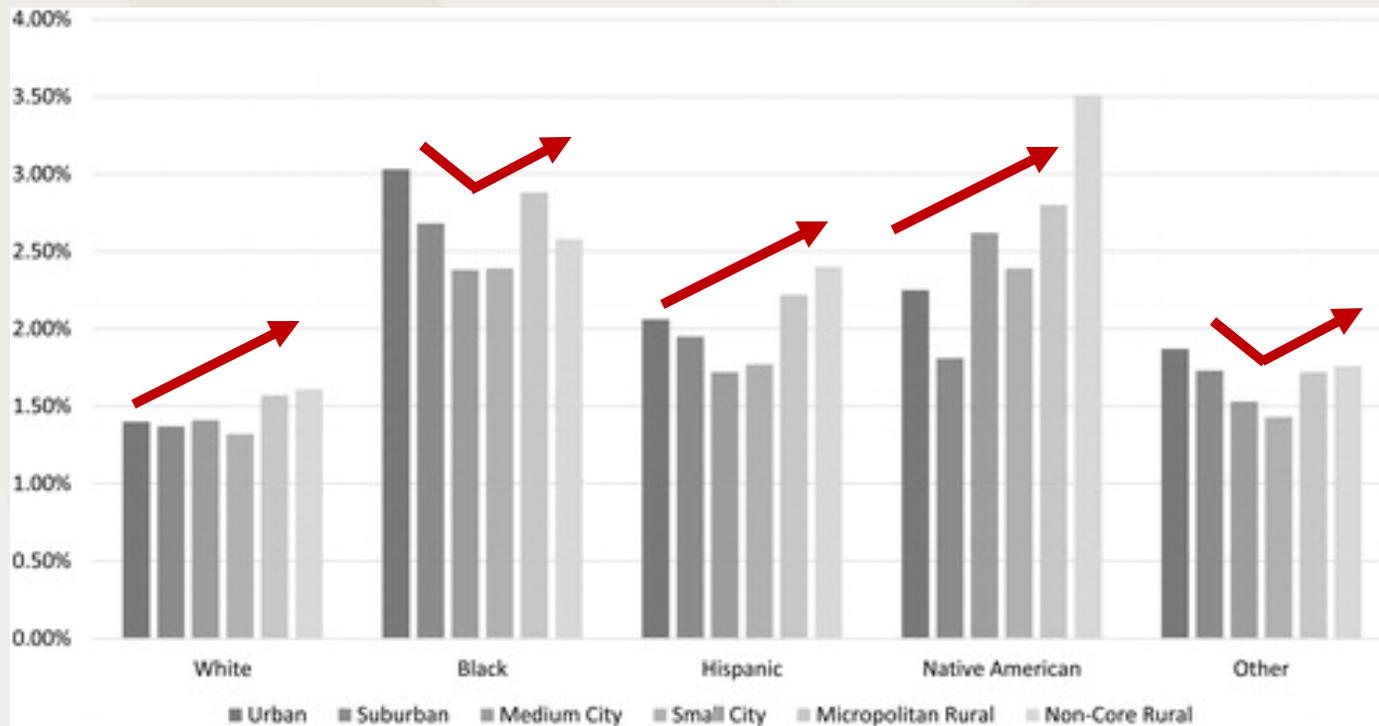
Table 1: Unadjusted Rates and Adjusted Hazard Ratios of Individual Causes of Cardiovascular Hospitalizations in Black and Hispanic Women Compared to White Women

	White	Black			Hispanic		
	Unadjusted rate (%)	Unadjusted rate (%)	Adjusted Hazard Ratio	95% CI	Unadjusted rate (%)	Adjusted Hazard Ratio	95% CI
<i>All Cardiovascular Hospitalizations</i>	0.33	0.72	1.60	1.53 - 1.67	0.30	0.80	0.76 - 0.84
<i>Acute Myocardial Infarction</i>	0.01	0.02	1.31	1.02 - 1.66	0.01	0.62	0.46 - 0.85
<i>Heart Failure</i>	0.12	0.36	1.94	1.82 - 2.08	0.11	0.75	0.68 - 0.82
<i>Stroke</i>	0.05	0.1	1.41	1.25 - 1.58	0.06	1.09	0.96 - 1.23
<i>Venous Thromboembolism</i>	0.15	0.25	1.31	1.22 - 1.40	0.13	0.74	0.68 - 0.81
<i>Arrhythmia</i>	0.02	0.03	1.68	1.37 - 2.06	0.01	0.77	0.59 - 0.99

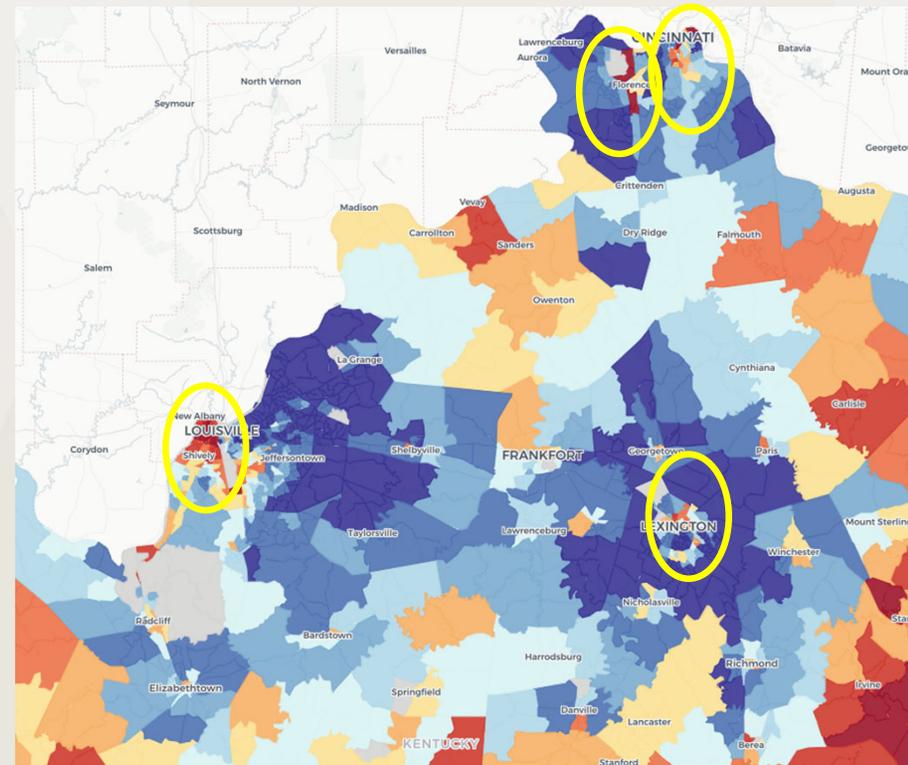
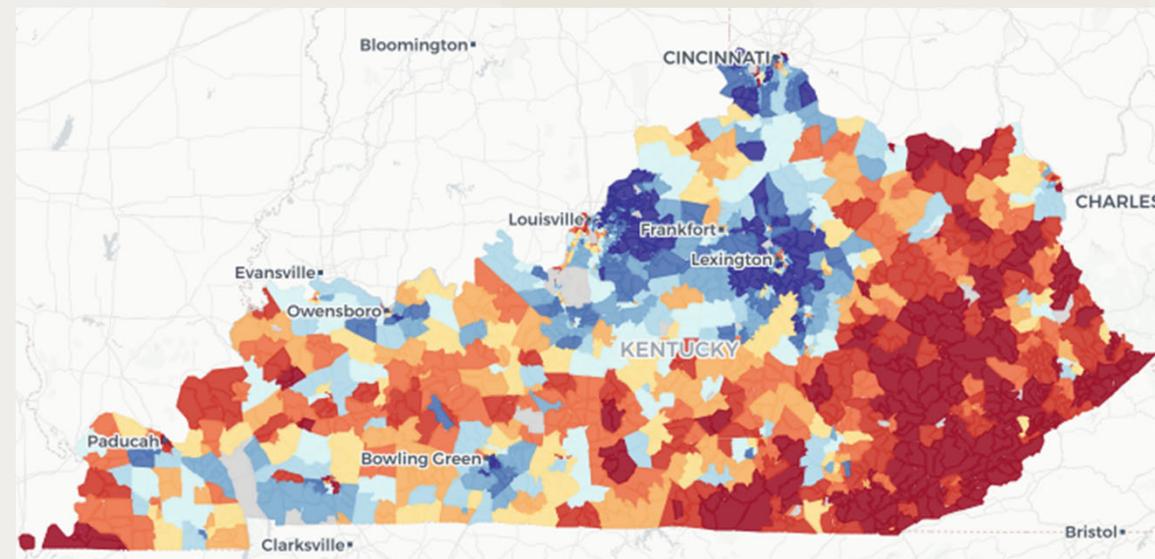
CI=confidence interval.

Adjusted Hazard ratios control for age, insurance type, zip code income quartile, state, chronic hypertension, cesarean delivery, multiple gestation and Elixhauser comorbidities specifically: chronic kidney disease, diabetes.

The Interaction of Race and Rurality



Maternal Vulnerability in Kentucky



Hypertension: A Major Cause of CV Morbidity and Mortality

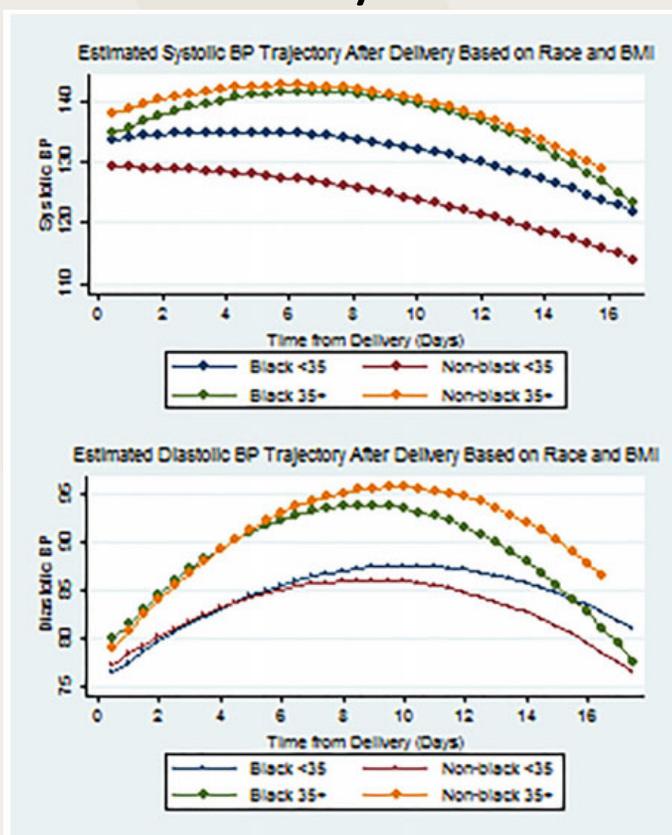
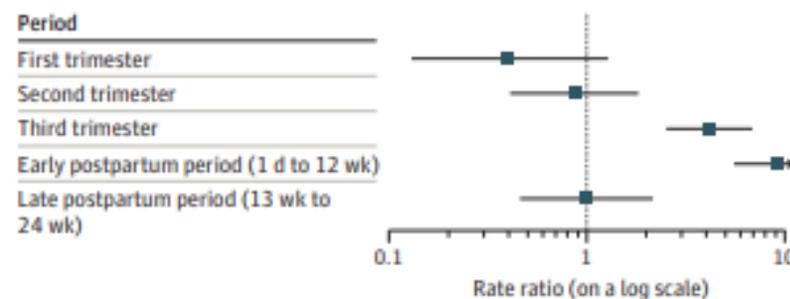
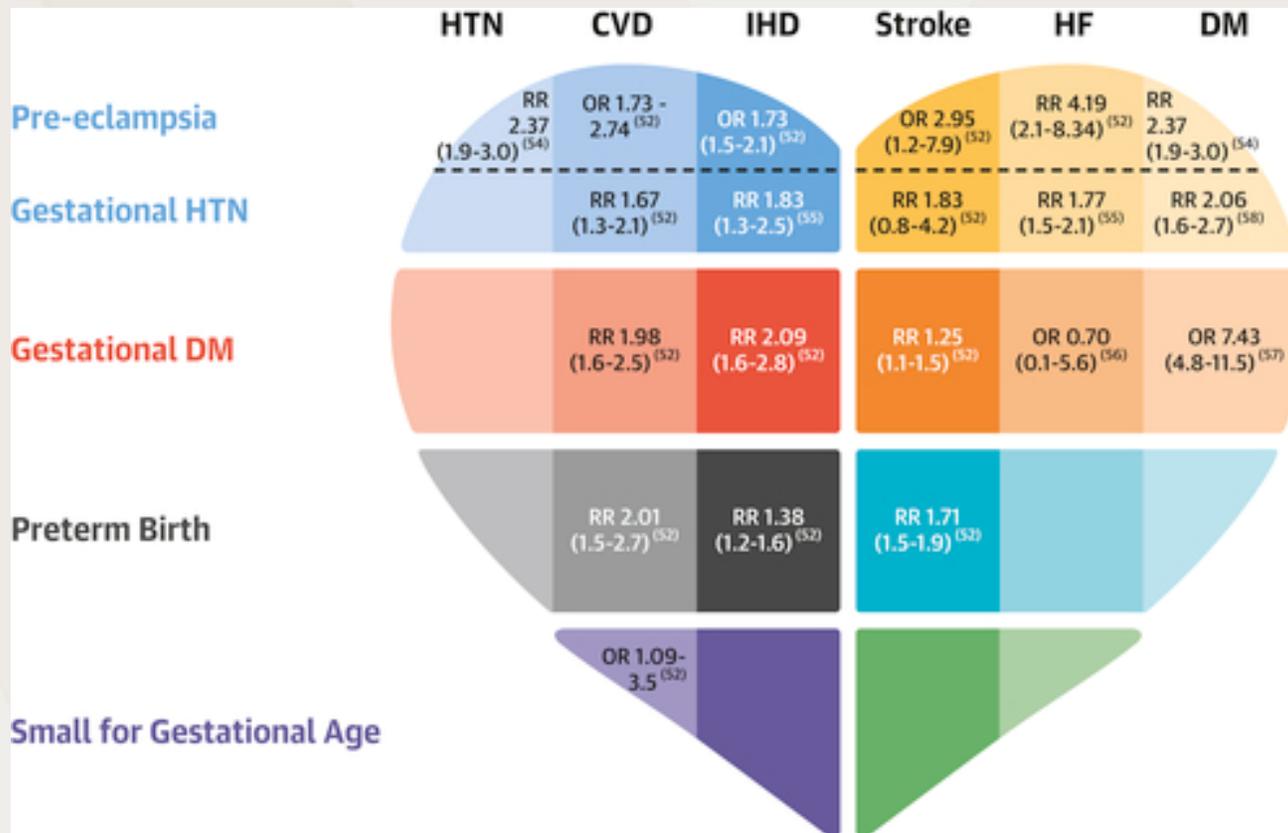


Figure 3. Rate Ratios for Intracerebral Hemorrhage During Pregnancy and Post Partum as Determined by Conditional Poisson Regression in a Matched Patient Population



The 64-week matched observation period of 2 719 443 patients is stratified into the 3 trimesters of pregnancy and 2 12-week postpartum periods. Rate ratios are indicated by squares and associated 95% confidence intervals are indicated by horizontal error bars. A dashed vertical line is present at 1 as a reference line for statistical significance.

Adverse Pregnancy Outcomes Increase Future CVD Risk



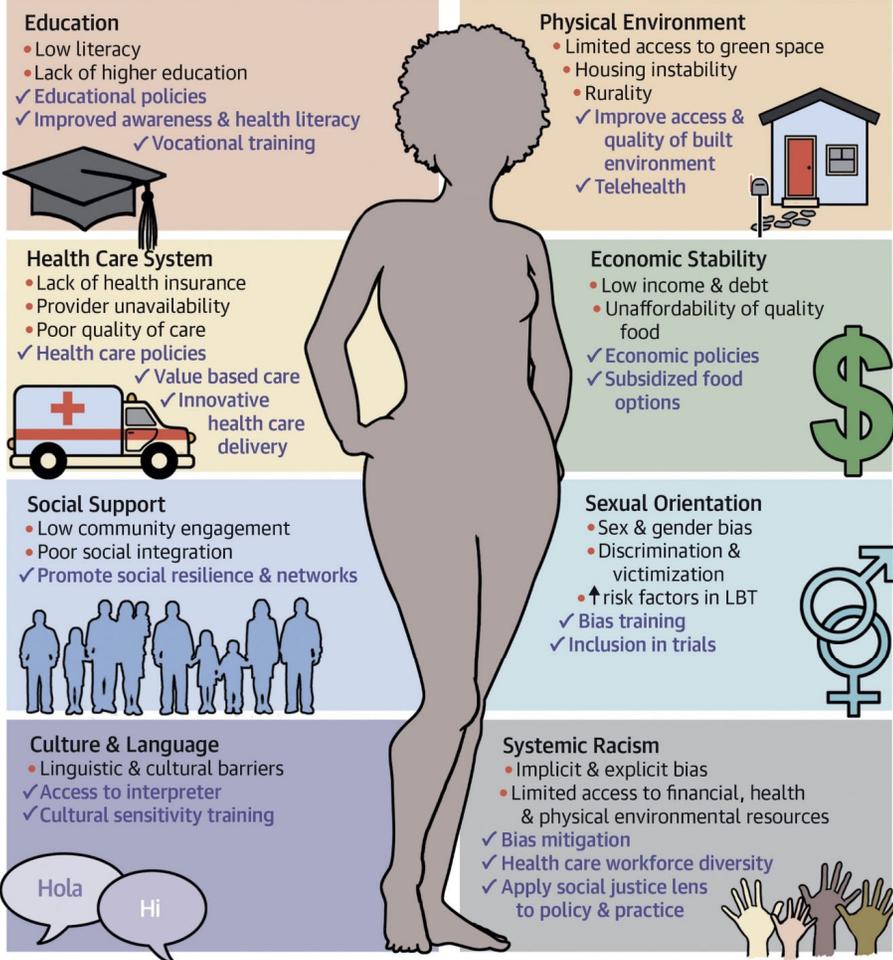
What Can We Do To Move The Needle?



1. Address Social Determinants of Health

- ✓ Education – community, healthcare team and patients
- ✓ Advocacy – improve access to equitable care
- ✓ Investment – communities and clinical-community relationships
- ✓ Bias and culture sensitivity training
- ✓ Inclusion – increase diversity in clinical trials
- ✓ Diversification – healthcare and research teams

CENTRAL ILLUSTRATION: Social Determinants of Health and Cardiovascular Disparities in Women

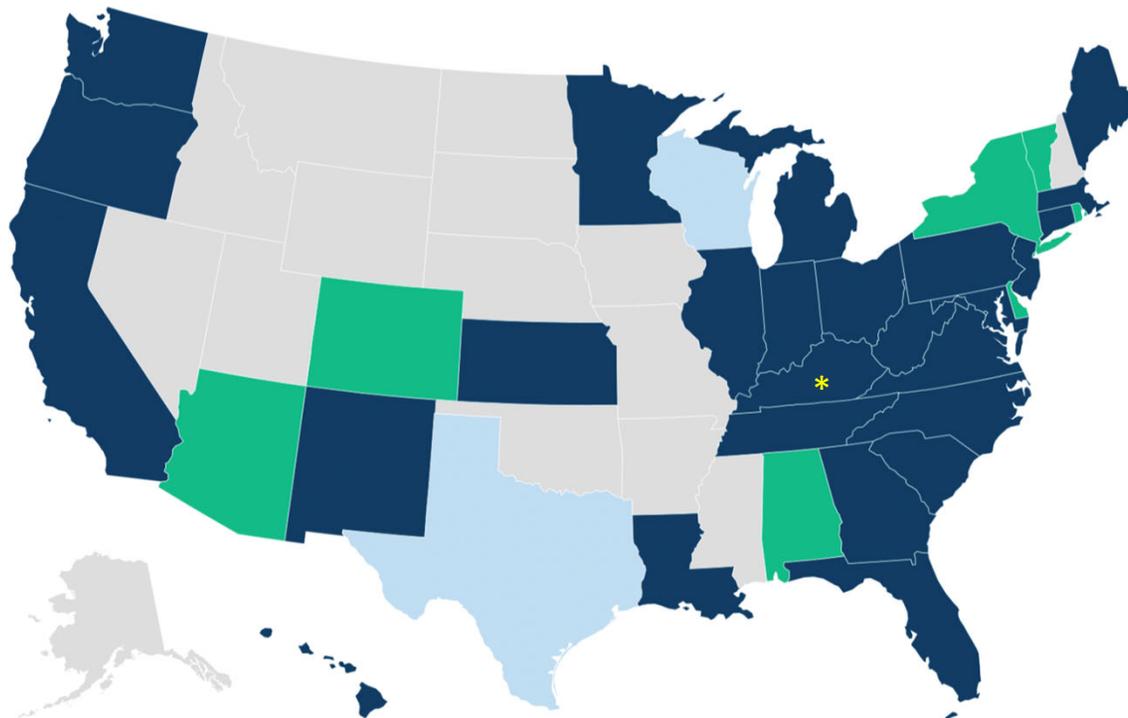


Lindley, K.J. et al. J Am Coll Cardiol. 2021;78(19):1919-1929.

2. Impro

Postpartum Coverage Tracker Map

- 12-month extension implemented (27 states including DC)
- Planning to implement a 12-month extension (7 states)
- Limited coverage extension proposed (2 states)



SOURCE: Data KFF analysis of approved and pending 1115 waivers, state plan amendments, and state legislation, as of November 10, 2022

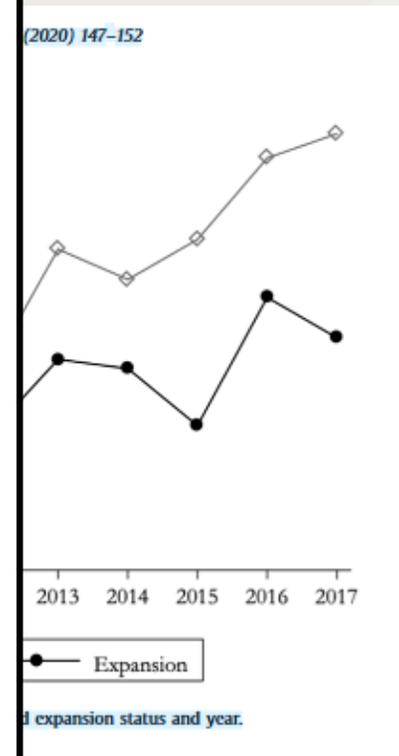
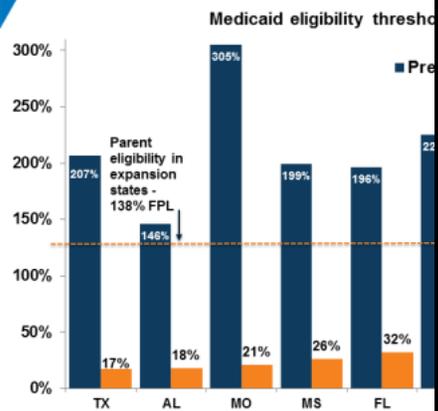


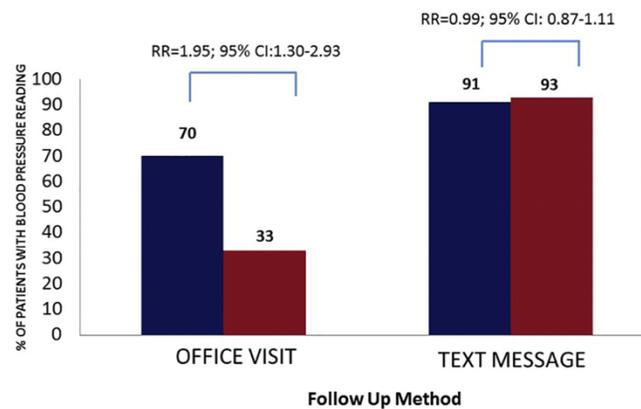
Figure 1
Medicaid Eligibility Is Much Higher for Pregnant Women, Particularly in States with Expansion



NOTE: For pregnant women, reflects highest eligibility limit for pregnant women under Medicaid. For non-pregnant women, reflects highest eligibility limit for non-pregnant women under Medicaid. Percentages are calculated based on a family of three for parents. In 2019, the FPL was 138%. SOURCE: Based on national survey conducted by KFF with the Georgetown University Center for Workforce Studies.

Identify Novel Ways To Reach High Risk Patients

FIGURE
Postpartum blood pressure ascertainment by race and follow-up method

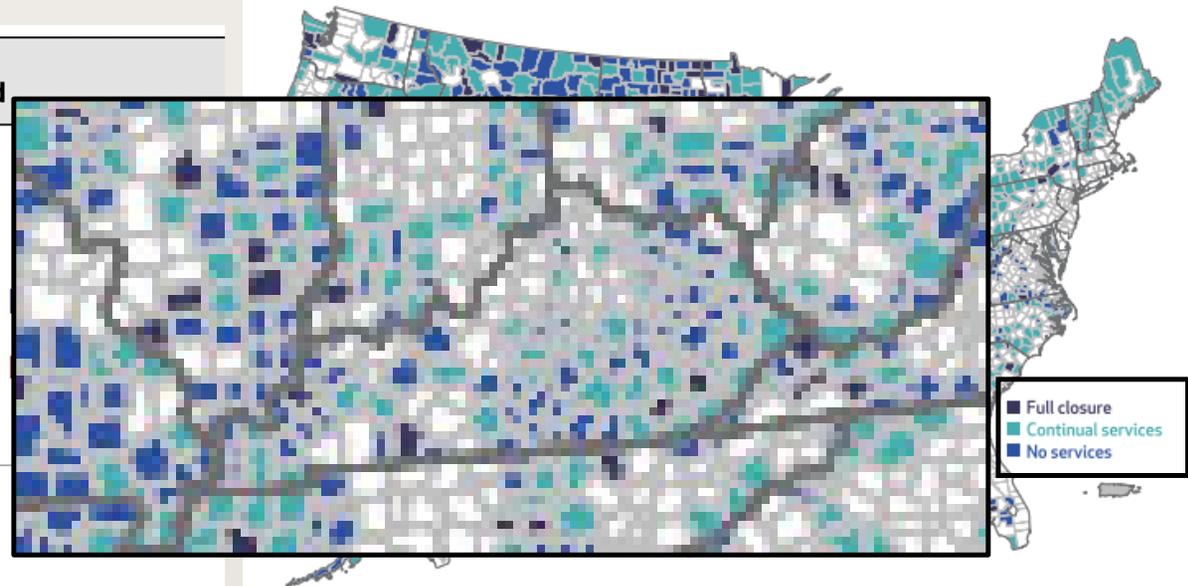


CI, confidence interval; RR, relative risk.

Hirshberg. Text messaging remote blood pressure monitoring. *Am J Obstet Gynecol* 2019.

EXHIBIT 3

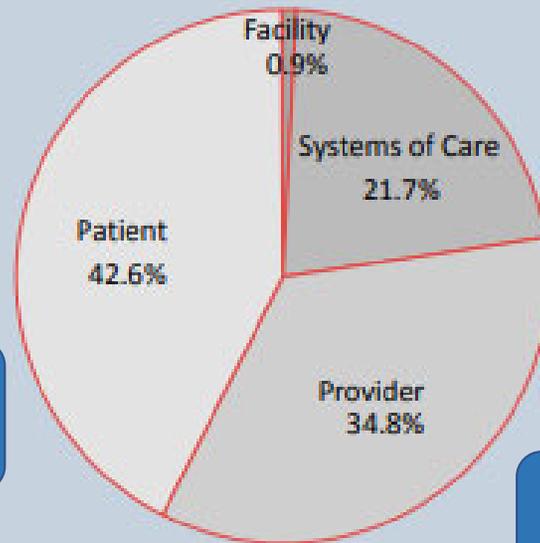
Hospital obstetric services in US counties, 2004-14



SOURCE Authors' analysis of data for 2003-14 from the American Hospital Association Annual Survey, for 2004-14 for county-level obstetric services status from the Centers for Medicare and Medicaid Services' Provider of Services files, and for 2013 for metropolitan and nonmetropolitan designation from the Office of Management and Budget. **NOTES** "Full closure," "continual services," and "no services" are defined in the Notes to Exhibit 1. Urban counties are not in the study sample.

3. Improve Delivery of Care

Figure 9. Distribution of Critical Factors among Pregnancy-Related Deaths



- Lack of Communication
- Barriers to Coordination of Care

- Failure to Recognize Disease
- Ineffective Treatment
- Failure to Refer

- Failure to Recognize Symptoms
- Chronic Conditions (esp obesity)

EXPERT, COORDINATED care is a KEY SOLUTION to reducing maternal mortality

- Multidisciplinary Approach
- Pre-conception Counseling
- Delivery Planning
- Managing Cardiac Complications
- Contraception Counseling



Cardiology



OB/GYN



Support Services



Anesthesia



Neurology



Our Amazing VUMC Cardio-OB Team!

VANDERBILT HEALTH
Women's Heart Center

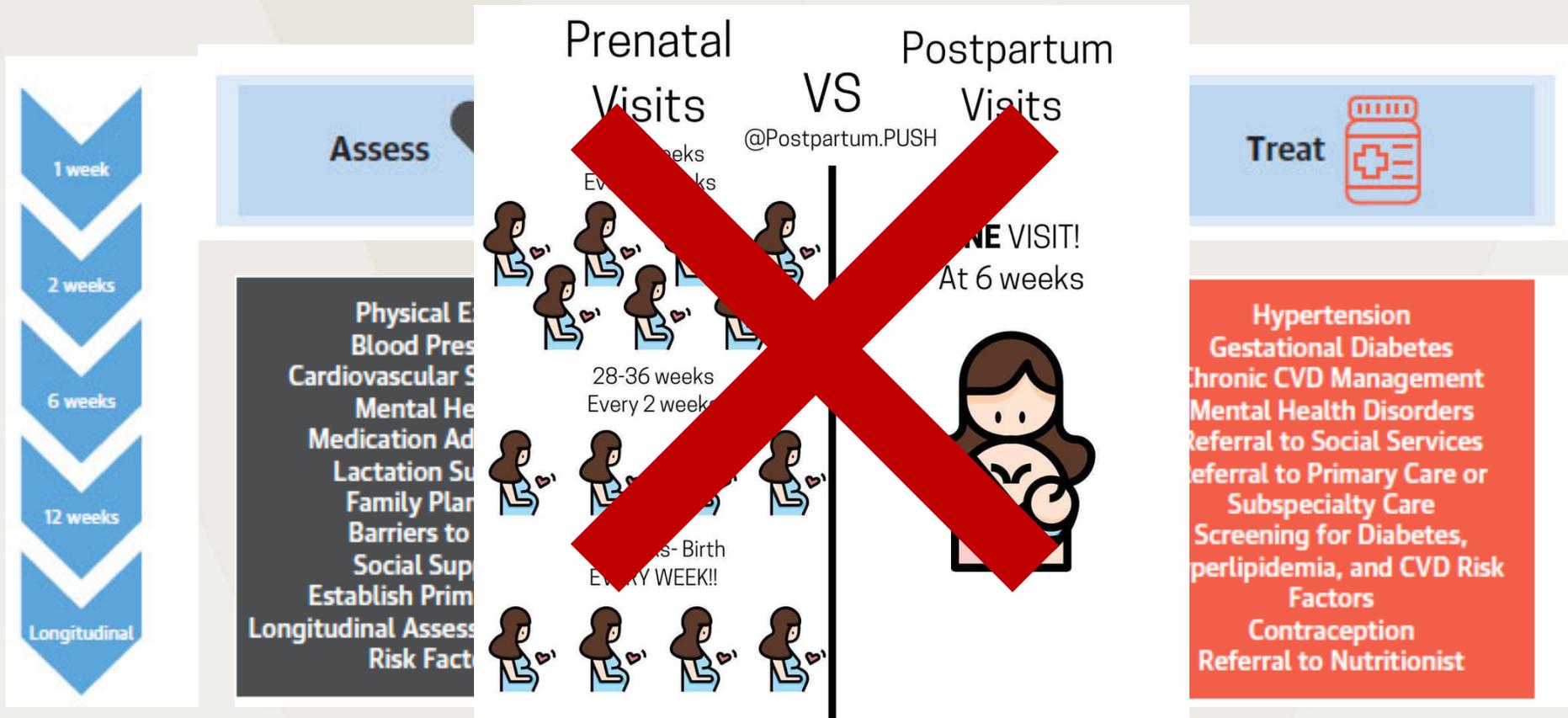
Pediatrics



Comprehensive Cardio-OB Patient Care

- ✓ Twice weekly multidisciplinary clinics
- ✓ Once monthly multidisciplinary meetings
- ✓ Dedicated inpatient cardio-ob service line
- ✓ Dedicated early postpartum follow-up cardio-ob clinic
- ✓ Post-partum hypertension management program
- ✓ Mental health counseling and social work support

Novel Models of Postpartum Care



4. Improved Training in Cardio-Obstetrics

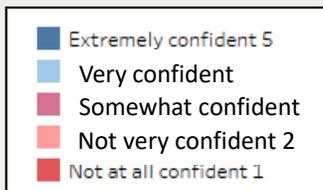
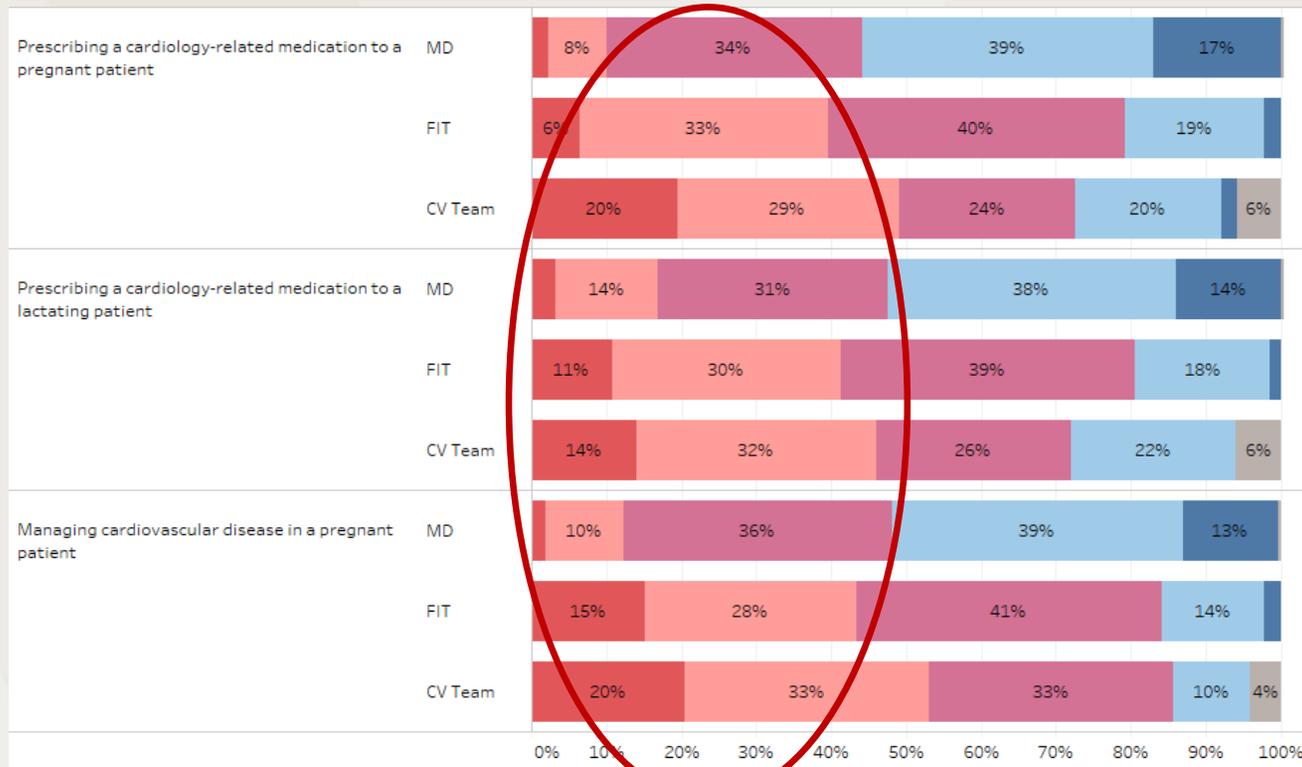


Figure 4. Gaps in Comfort Level for the treatment of CVD by topic for pregnant vs non-pregnant adults.

	MD	FIT	CV Team
Acute coronary syndromes during pregnancy	39%	67%	71%
Peripartum cardiomyopathy	18%	44%	57%
Chronic coronary artery disease during pregnancy	30%	51%	66%
Complex congenital heart disease	15%	11%	8%
Hypertension management during pregnancy	21%	38%	58%
Management of aortopathies during pregnancy and delivery	40%	55%	43%
Management of arrhythmias during pregnancy	33%	49%	58%
Management of prosthetic valves and anticoagulation in pregnancy	38%	46%	65%
Medication safety in lactation and pregnancy	42%	52%	68%
Multimodality imaging in pregnancy	30%	51%	39%
Performing a physical exam and interpreting cardiovascular physiology during pregnancy	24%	66%	53%
Recommending contraception to women with CVD	5%	21%	12%
Simple congenital heart disease	24%	31%	16%
Valvular disease in pregnancy	30%	69%	49%

Larger gap (%) indicates higher level of discomfort when treating pregnant patients. Note: just because the gap is small it doesn't imply comfort level is high, could be low for both pregnant and non-pregnant adults (component scores for pregnant and non-pregnant comfort level for the supplement)

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Medication safety in lactation and pregnancy	42%	52%	68%
Multimodality imaging in pregnancy	30%	51%	39%
Performing a physical exam and interpreting cardiovascular physiology during pregnancy	24%	66%	53%
Recommending contraception to women with CVD	5%	21%	12%
Simple congenital heart disease	24%	31%	16%
Valvular disease in pregnancy	30%	69%	49%

Larger gap (%) indicates higher level of discomfort when treating pregnant patients. Note: just because the gap is small it doesn't imply comfort level is high, could be low for both pregnant and non-pregnant adults (component scores for pregnant and non-pregnant comfort level for the supplement)

5. LARC Reduces Unintended Pregnancy

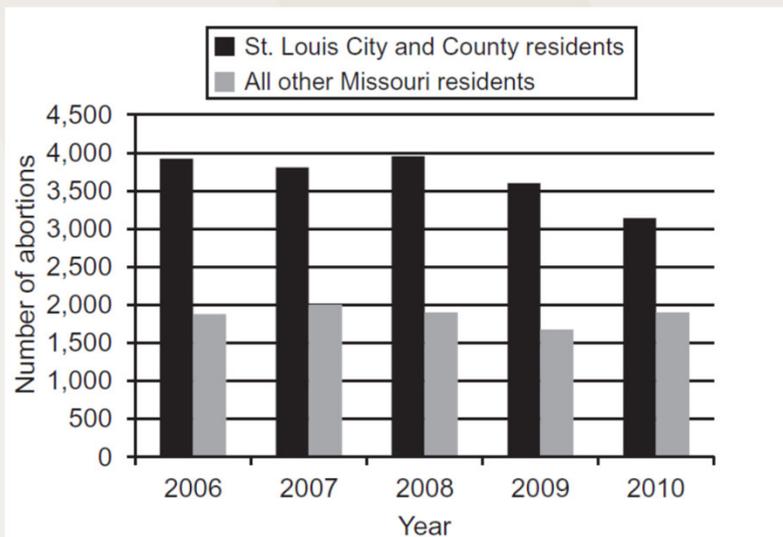
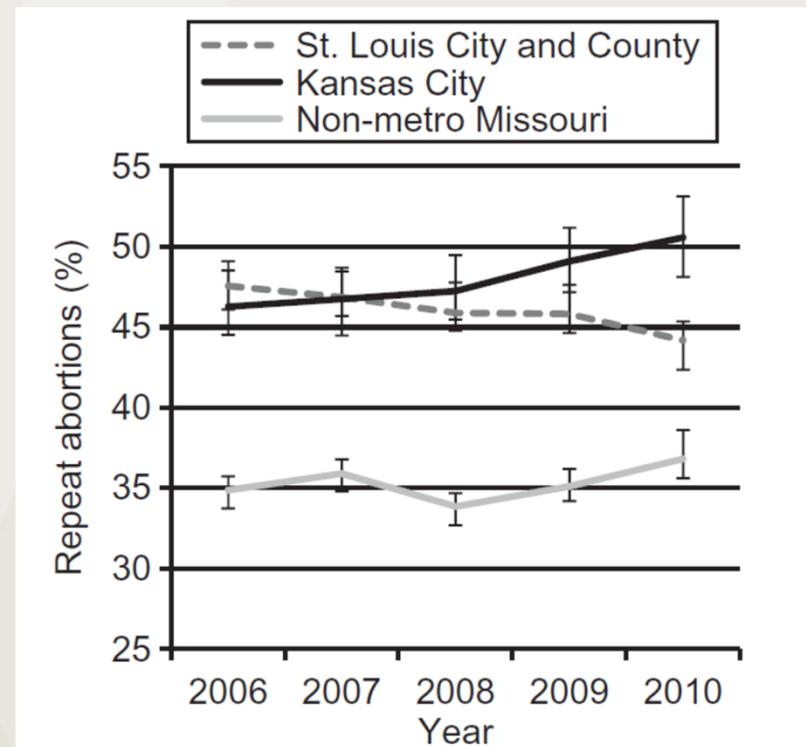


Fig. 1. Number of abortions in Missouri residents reported by Reproductive Health Services, 2006–2010. *P* for test of trend over time: St. Louis City and County, $P < .001$; all other Missouri residents, $P = .39$.

Peipert. *No-Cost Contraception and Unintended Pregnancies. Obstet Gynecol* 2012.



Tier III
(18% to 28% Failure / Year)

- Barrier Methods Alone
- Withdrawal
- Natural Family Planning

Tier II
(6% to 12% Failure / Year)

- Progestin Only Pill
- Depot Medroxyprogesterone Acetate Injection
- Combined Hormonal Contraceptives (pill, patch, ring)
- Diaphragm

Tier I
(<1% Failure / Year)

- Levonorgestrel IUD
- Copper IUD
- Etonogestrel Subdermal Implant
- Male Sterilization
- Tubal Sterilization

Caution in use of Combined Hormonal Contraceptives in the Following Conditions*

Prior
Thromboembolism
Coronary Disease
Unrepaired ASD
Fontan Palliation
Pulmonary Arterial Hypertension
Systemic Ventricular Dysfunction
Unrepaired Cyanotic Defects
Mechanical Valve
Atrial fibrillation
Hypertension

6. Increased Resources For Research



Study Pregnant Women!

- Pregnant women are scientifically complex, not vulnerable
- Excluding pregnant women from clinical trials puts many more women and fetuses at risk due to lack of data
- Obstetric data has not been rigorously collected in cardiovascular trials
- Pregnancy complications have not been rigorously studied by the cardiovascular community



Sharonne Hayes MD @SharonneHayes · Jan 27

If we'd included pregnant women in [#CovidVaccine](#) clinical trials, we'd have better answers now. "Nothing about us without us" has never been more cogent. For heart disease too! [#ACCWIC](#) [@DrKLindley](#) [@GarimaVSharmaMD](#) [@TXmommydoc](#) [@DrRachelMBond](#) [npr.org/sections/health...?](https://www.npr.org/sections/health...?)



Protect Pregnant Women 'Through Research,' Not 'From Research,' O...
As COVID-19 vaccines roll out, doctors say it's long past time to address the exclusion of pregnant women from research on drugs an...
[npr.org](https://www.npr.org)

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Thank You!

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