The Maternal Health Crisis: How Did We Get Here and How Can Technology Help Us

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Presenter Disclosures

Elizabeth Howell, MD, MPP

I have no personal financial relationships with commercial interests relevant to this presentation and am not endorsing any technology product.

Maternal Health Crisis - The Case of Maternal Mortality and Morbidity

New York Times

We finally have a new US maternal mortality estimate. It's still terrible.

Among 10 similarly wealthy countries, "the US would rank 10th."

By Julia Belluz | @juliaoftoronto | julia.belluz@voxmedia.com | Jan 30, 2020, 10:40am EST

According to a **report** out Thursday from the Centers for Disease Control and Prevention's **National Vital Statistics System**, the 2018 maternal mortality rate was 17.4 maternal deaths per 100,000 live births — meaning 658 women died in 2018. The figure includes deaths during pregnancy, at birth, or within 42 days of birth.

US rate =17.4

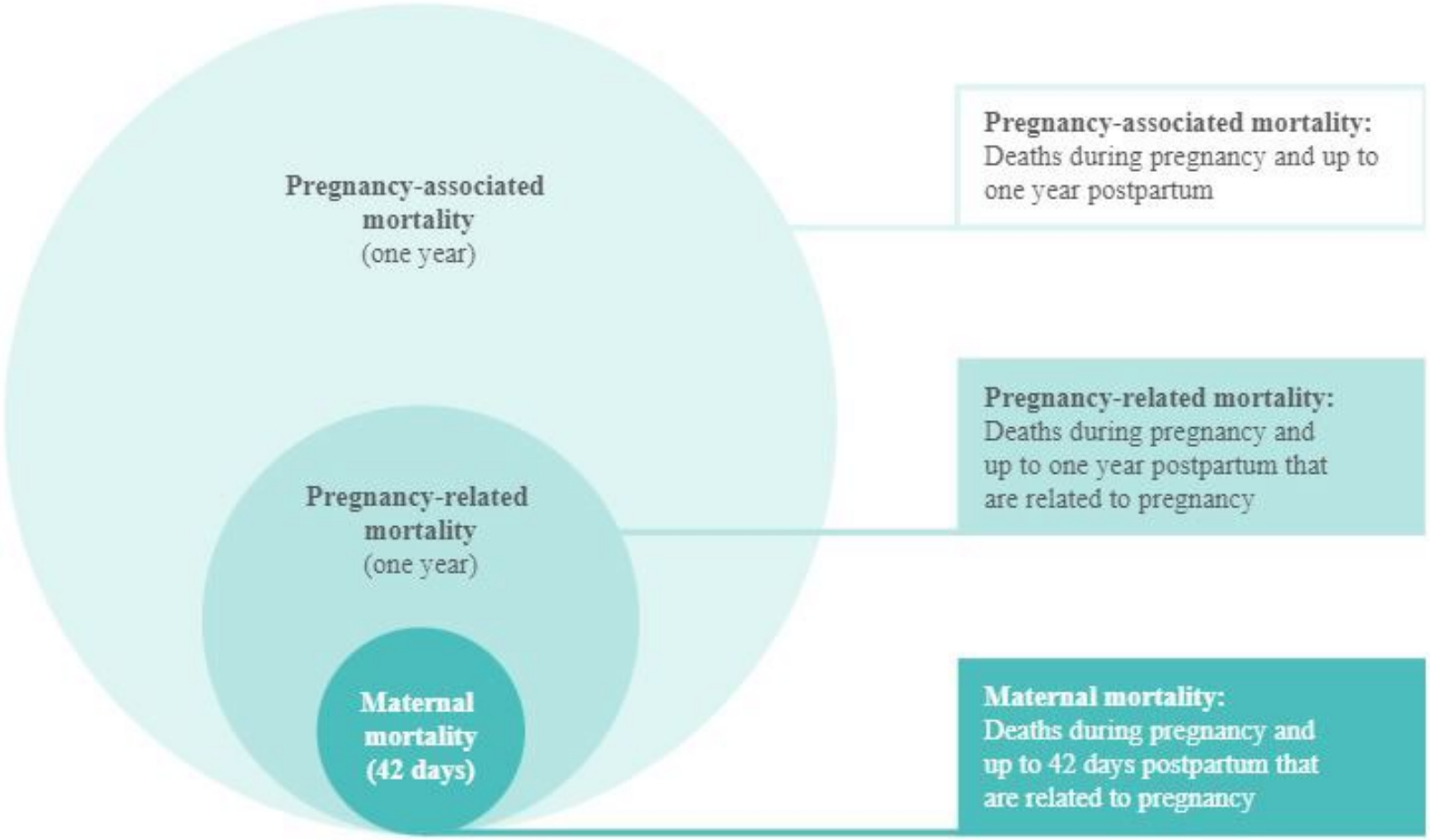
The rate once again put the US last among similarly wealthy countries, according to **Eugene Declercq**, a professor of community health sciences at Boston University School of Public Health. If you compare the CDC figure to other countries in the World Health Organization's latest maternal mortality ranking, the US would rank 55th, just behind Russia (17 per 100,000) and just ahead of Ukraine (19 per 100,000). And "If you limit the comparison to those similarly wealthy countries," such as Germany, "the US would rank 10th — out of 10 countries."

Ranked 55th

"No matter how one analyzes the data, we still lag well behind other countries," he added.

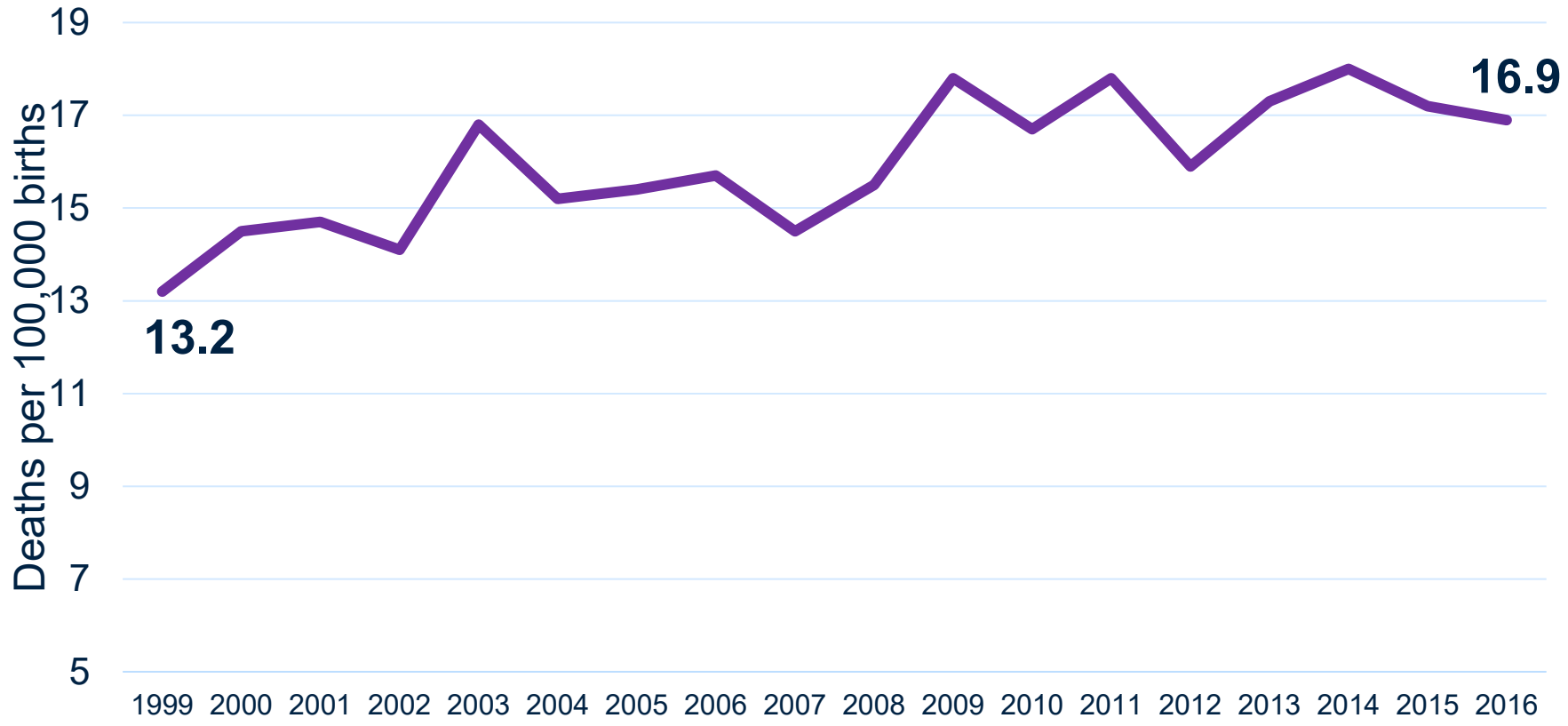
https://www.cdc.gov/nchs/maternal-mortality/index.htm https://www.vox.com/2020/1/30/21113782/pregnancy-deaths-us-maternal-mortality-rateb

What do we mean by maternal mortality?



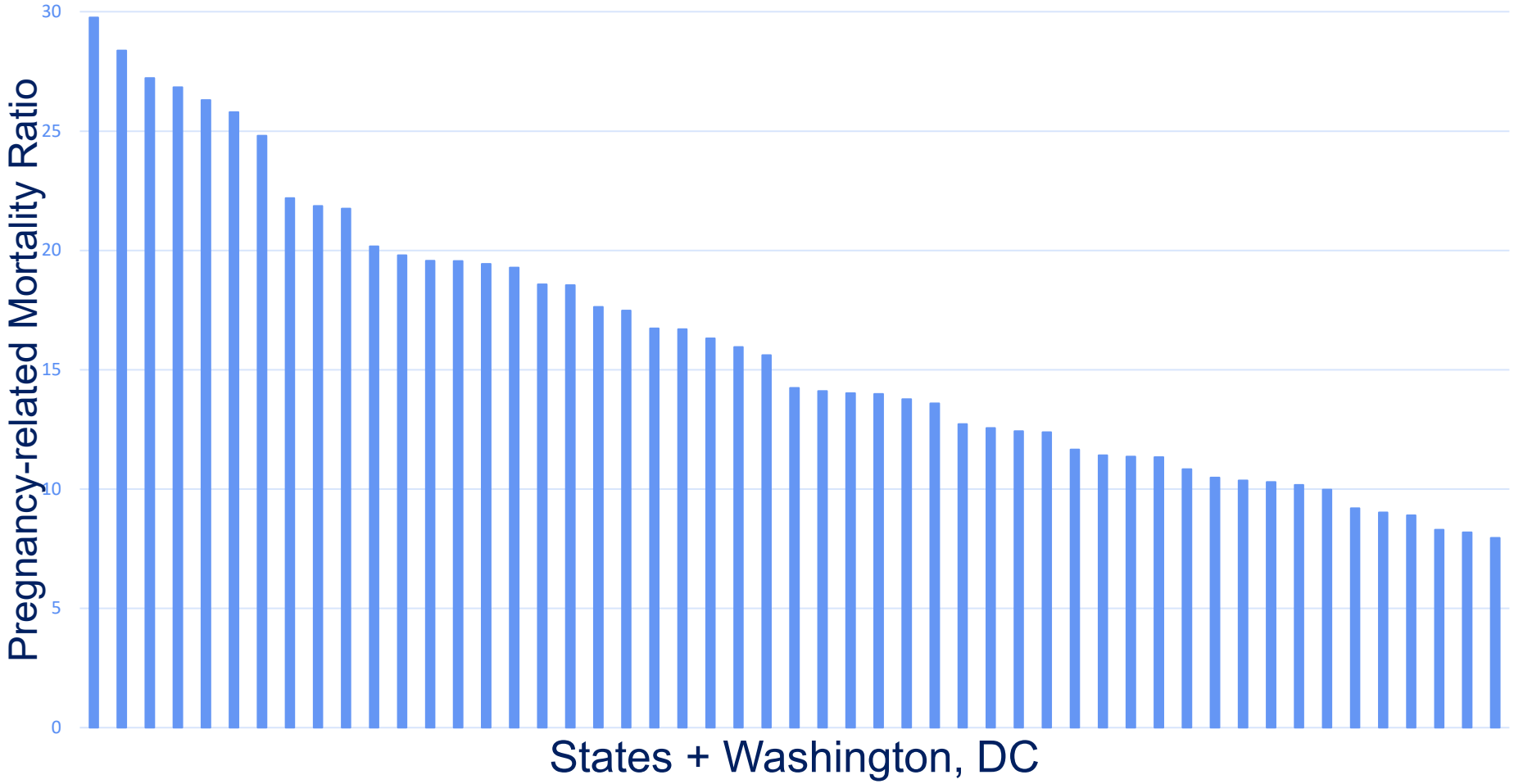
Source: Eugene Declercq and Laurie Zephyrin, *Maternal Mortality in the United States: A Primer* (Commonwealth Fund, Dec. 2020). https://doi.org/10.26099/ta1q-mw24

Pregnancy-Related Mortality, PMSS, 1999-2016



Petersen EE, Davis NL, Goodman D, et al. Racial/Ethnic Disparities in Pregnancy-Related Deaths — United States, 2007–2016. MMWR Morb Mortal Wkly Rep 2019;68:762–765, Attribution: Emily Petersen

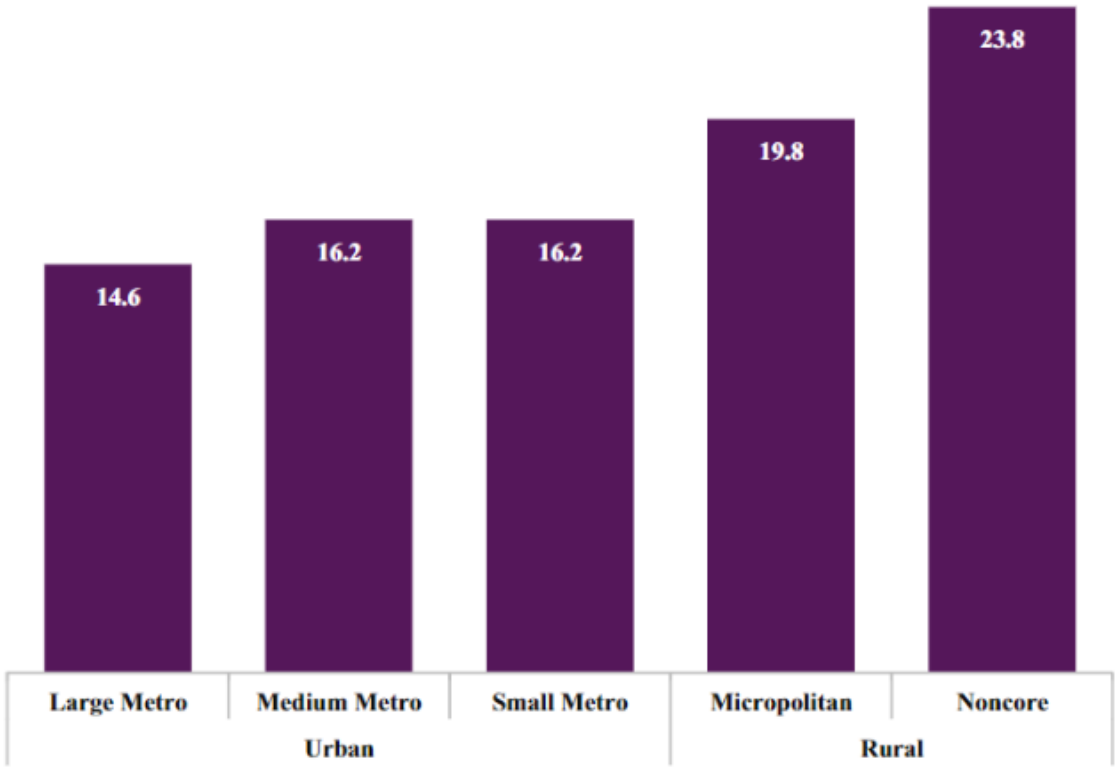
Pregnancy-related Mortality Ratio by State and Washington, DC, 2007-2016



Petersen EE, Davis NL, Goodman D, et al. Racial/Ethnic Disparities in Pregnancy-Related Deaths — United States, 2007–2016. MMWR Morb Mortal Wkly Rep 2019;68:762–765, Attribution: Emily Petersen

Striking Geographic Disparities in Pregnancy-Related Mortality Exist

FIGURE 1
Pregnancy-related mortality ratios by urban-rural category

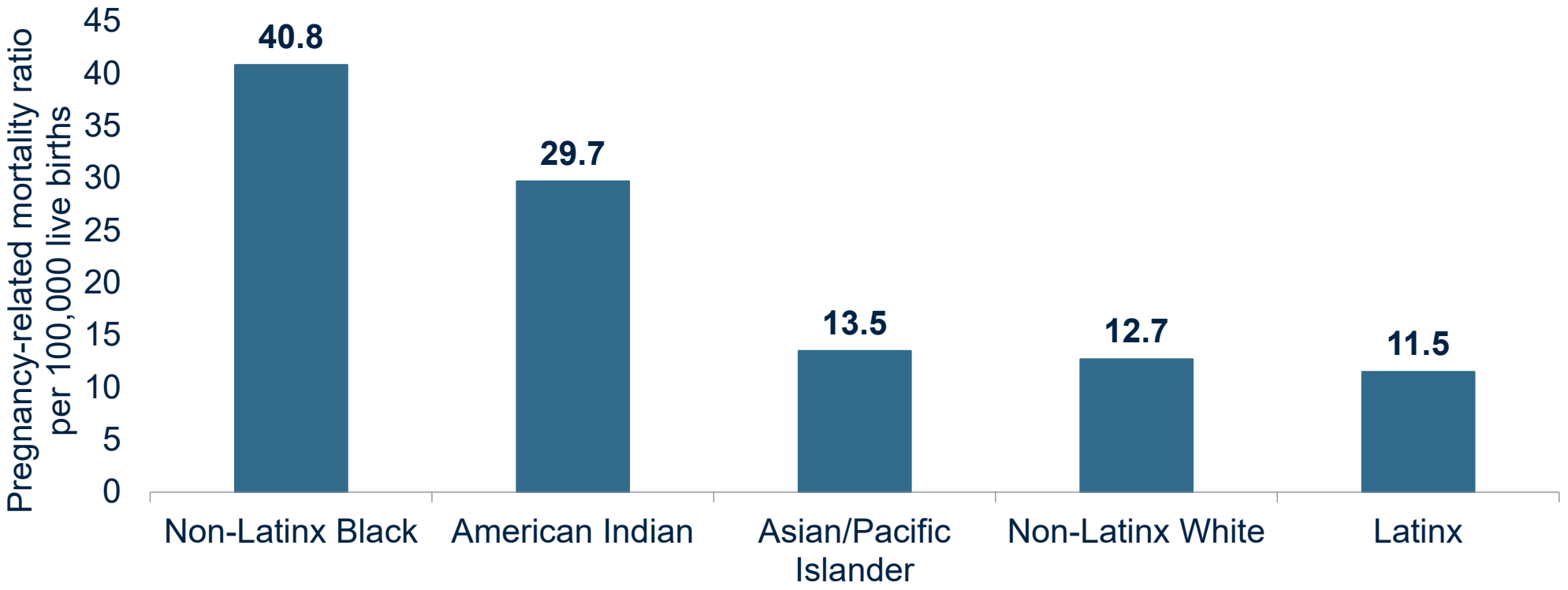


The PRMR is the number of pregnancy-related deaths per 100,000 live births. The PRMR ratio is highest in rural areas. Rural areas include micropolitan (urban cluster with a population of 10,000–49,999) and noncore (nonmetropolitan counties that did not qualify as micropolitan; most rural areas). Urban areas include large metro ("MSA," with a population of at least 1 million), medium metro (MSA with a population of 250,000–999,999), and small metro (MSA with a population of less than 250,000).

MSA, metropolitan statistical area; *PRMR*, pregnancy-related mortality ratio.

Merkt et al. Urban-rural differences in pregnancy-related deaths. Am J Obstet Gynecol 2021.

Pregnancy-Related Mortality Ratios by Race-Ethnicity, 2007-2016



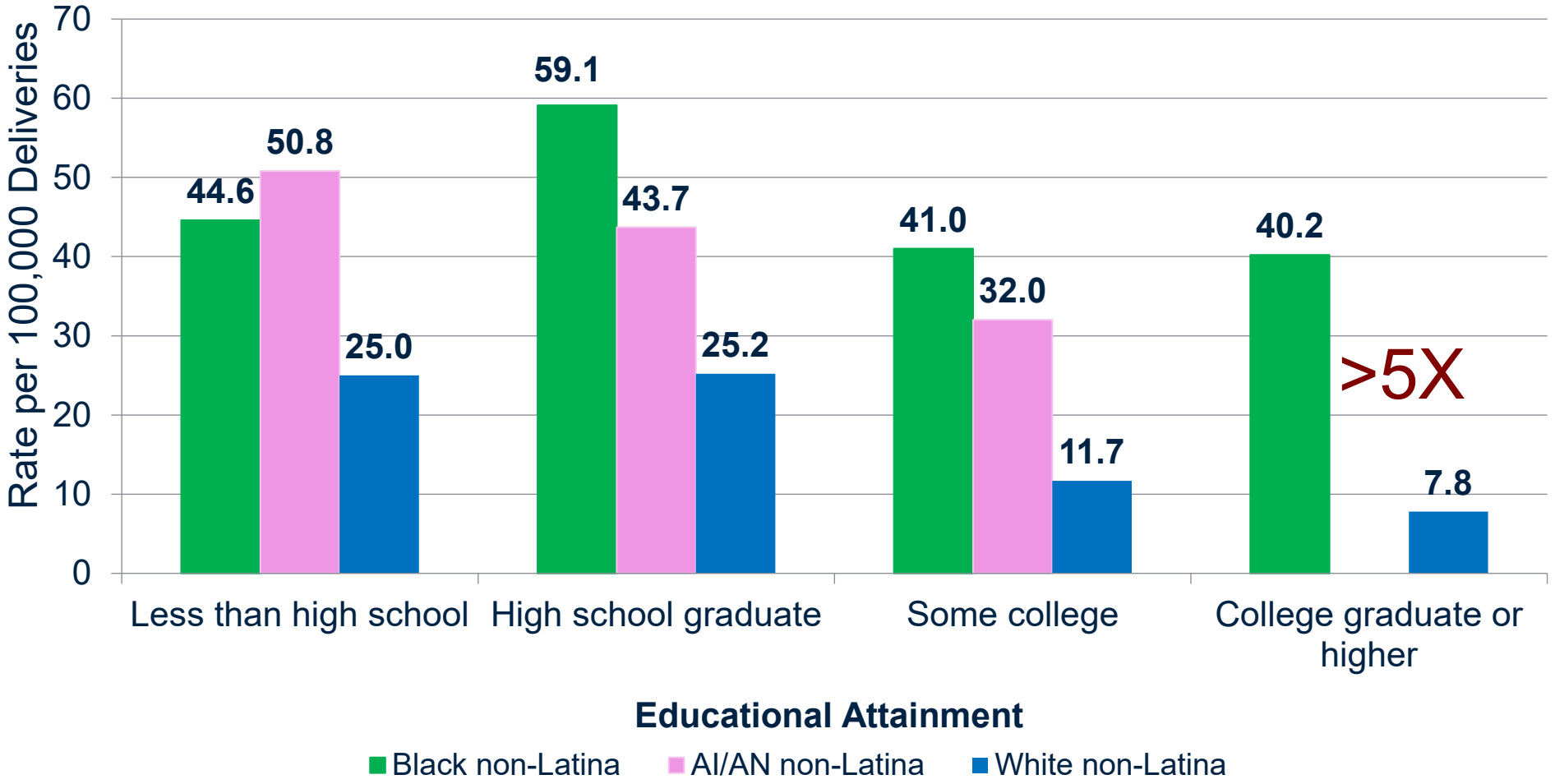
Petersen E et al. Racial/Ethnic Disparities in Pregnancy-Related Deaths – United States, 2007-2016. MMWR. Sept. 6, 2019. vol 68. no 35; New York City DOHMH. Pregnancy-Associated Mortality in NYC, 2011-2015. Long Island City, New York. Feb. 2020

Black-White Maternal Mortality Gap

Black mothers have been more likely to die than white mothers for 100 years.

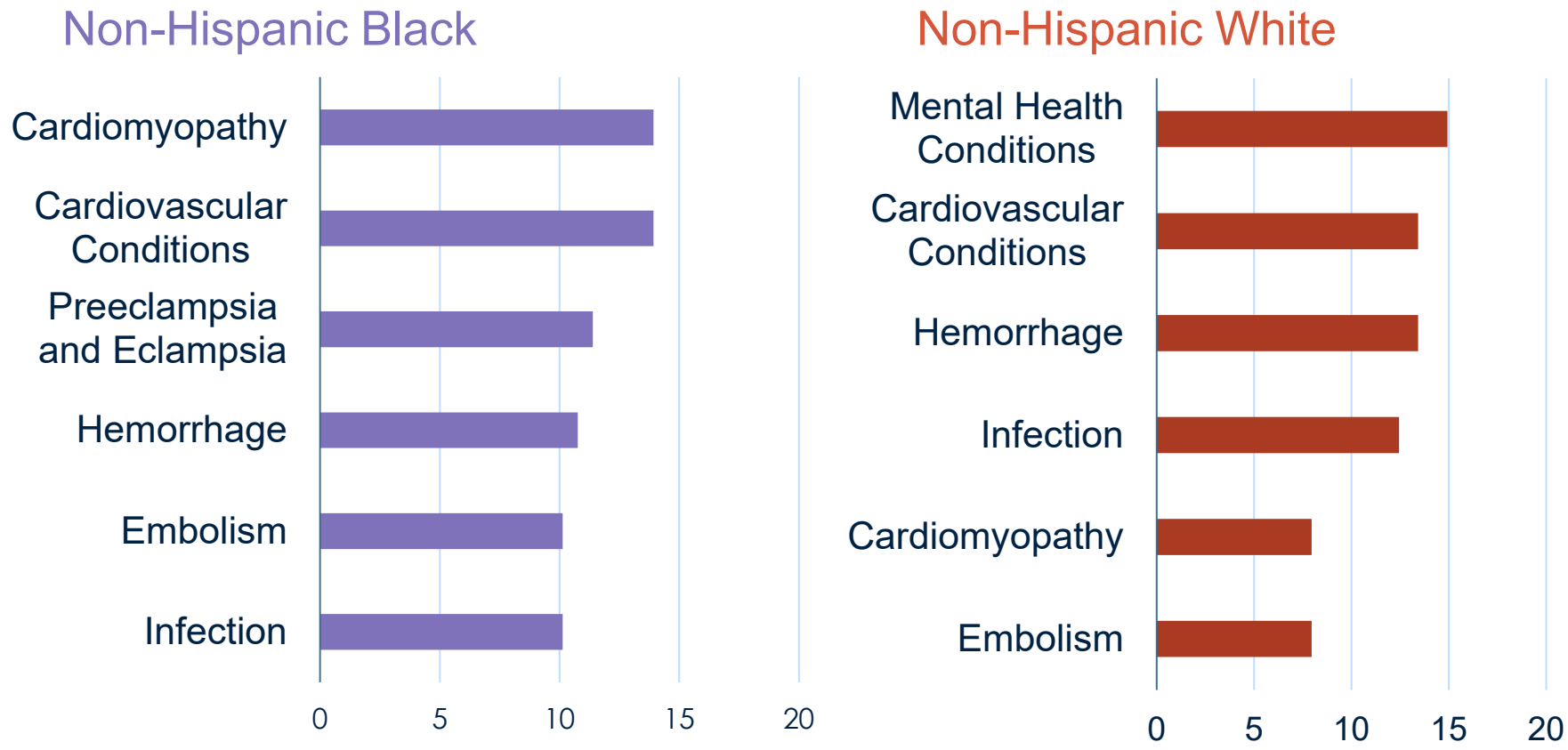
Eugene Declercq and Laurie Zephyrin, Maternal Mortality in the United States: A Primer (Commonwealth Fund, Dec. 2020). https://doi.org/10.26099/ta1q-mw24

Pregnancy-Related Mortality Ratios by Educational Attainment, 2006-2017



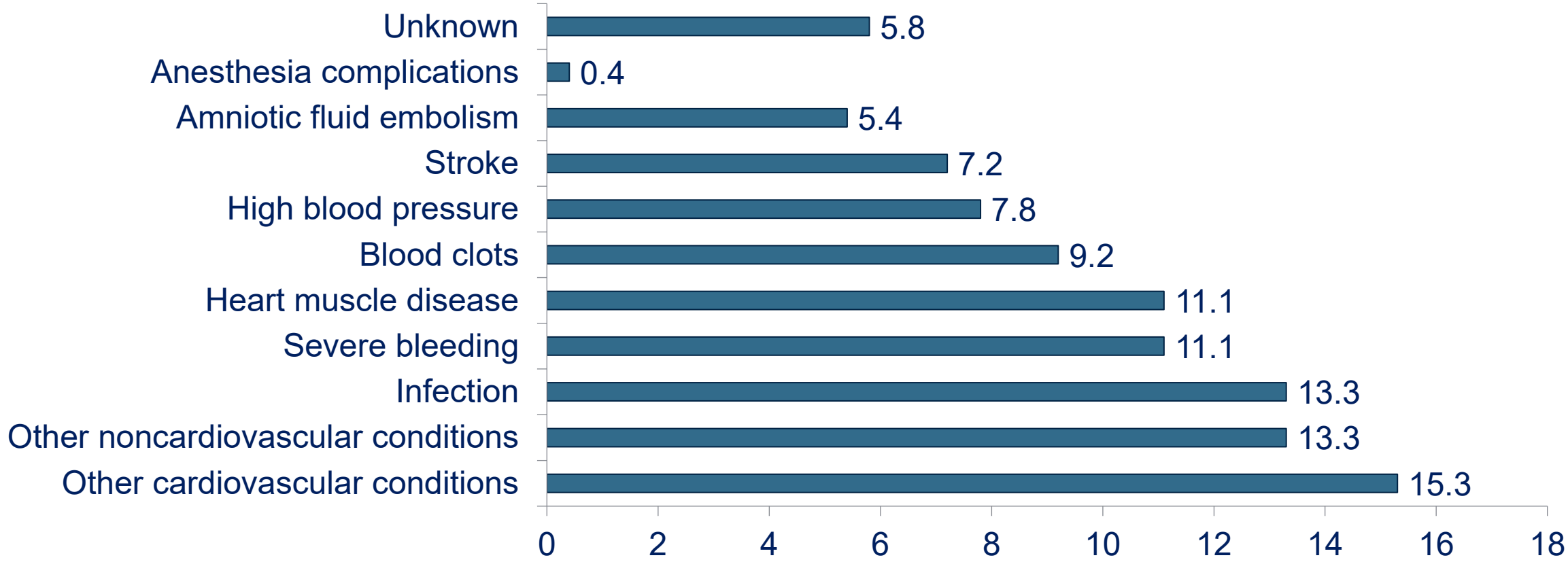
Source: Petersen E et al. Racial/Ethnic Disparities in Pregnancy-Related Deaths – United States, 2007-2016. MMWR. Sept. 6, 2019. vol 68. no 35

Leading Underlying Causes of Pregnancy-Related Deaths by Race/Ethnicity



Davis NL, Smoots AN, Goodman DA. Pregnancy-Related Deaths: Data from 14 U.S. Maternal Mortality Review Committees, 2008-2017. Atlanta, GA: Centers for Disease Control and Prevention, U.S. Department of Health and Human Services; 2019

Leading Clinical Causes of Pregnancy-related Mortality, US, 2007-2016



Data: Emily E. Petersen et al., Racial/Ethnic Disparities in Pregnancy-Related Deaths – United States, 2007-20016. *Morbidity and Mortality Weekly Report* 68, no. 35 (Sept. 6, 2019): 762–65.; Eugene Declercq and Laurie Zephyrin, Maternal Mortality in the United States: A Primer (Commonwealth Fund, Dec. 2020). https://doi.org/10.26099/ta1q-mw24

Maternal Self-Harm Deaths

EXPLORE InStyle

HOME > BEAUTY > HEALTH & FITNESS

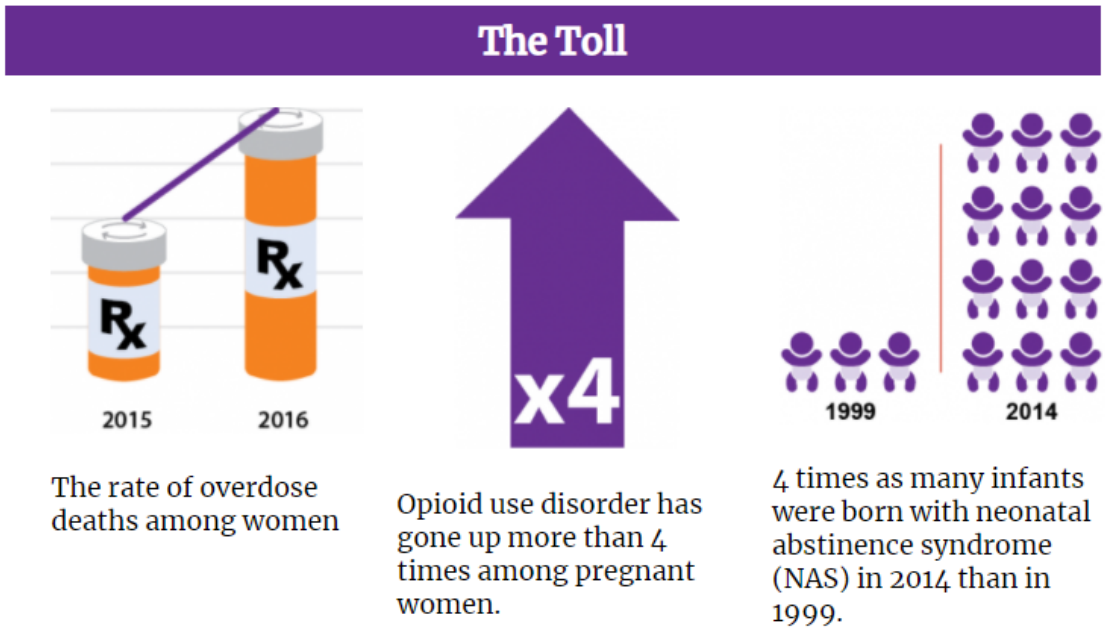
Suicide Is a Leading Cause of Death Among New Moms

Maternal deaths by suicide are an unrecognized — and preventable — public health issue. Why isn't anyone talking about it?

By **Cassie Shortsleeve** | Updated May 01, 2020 @ 10:00 am

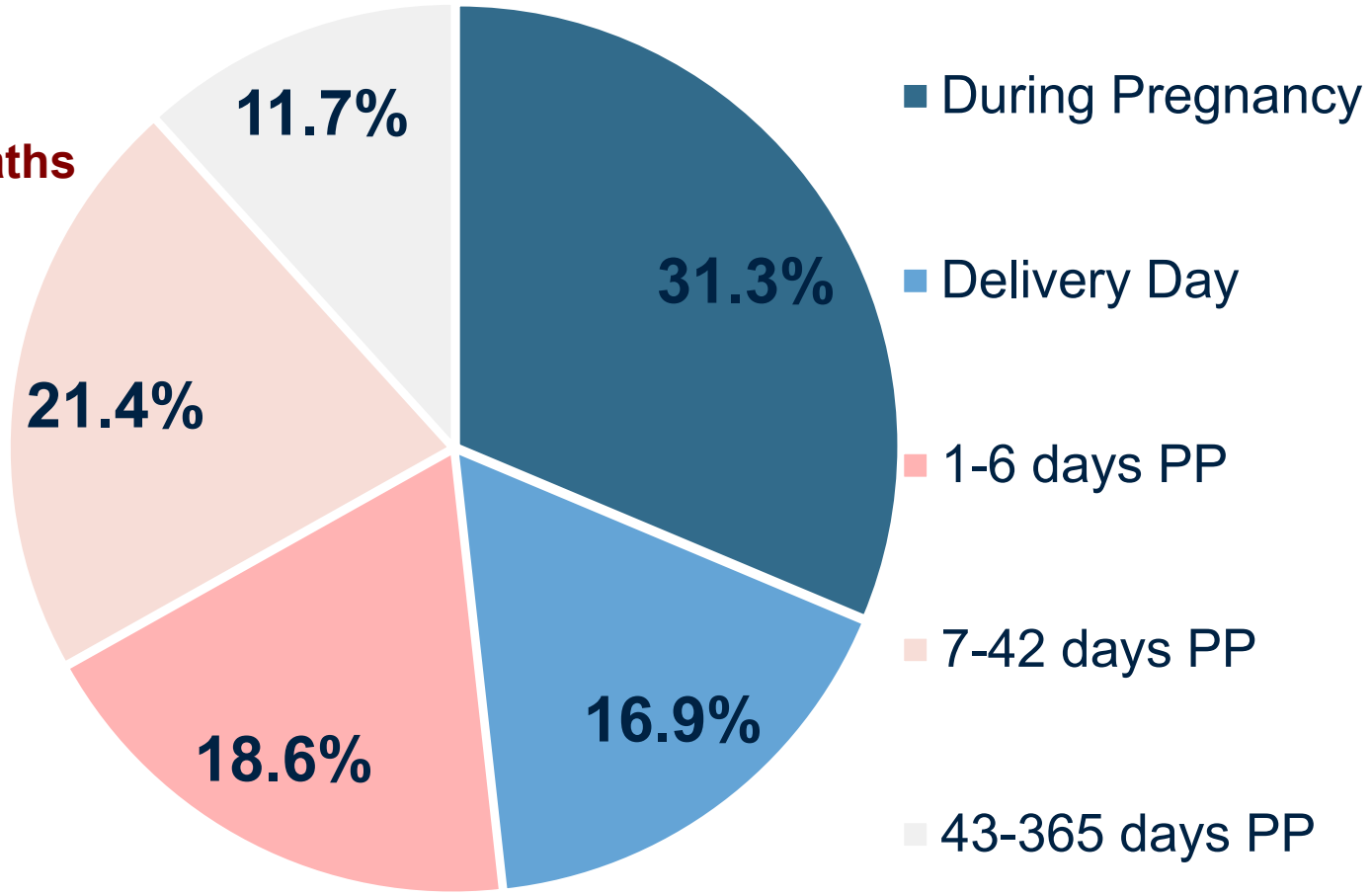
The US Opioid Crisis: Addressing Maternal and Infant Health

CDC



Timing of Pregnancy-Related Death

>50% Maternal Deaths occur Postpartum



Vital Signs: Pregnancy-Related Deaths, United States, 2011–2015, and Strategies for Prevention, 13 States, 2013–2017. MMWR Morb Mortal Wkly Rep 2019;68:423–429

Maternal Death is the Tip of the Iceberg

- For every maternal death, 100 women experience severe maternal morbidity (SMM)
- Life-threatening diagnosis or life-saving procedure
  - organ failure (e.g. renal, liver), shock, amniotic embolism, eclampsia
  - ventilation, transfusion, hysterectomy
- Adverse consequences for women and babies (e.g. PTSD, depression, interruption with breastfeeding/ infant bonding, hospital readmission)
- Significant racial and ethnic disparities exist

Callaghan. Obstet Gynecol 2012;120:1029-36; Severe Maternal Morbidity in the United States
https://www.cdc.gov/reproductivehealth/maternalinfanthealth/severematernalmorbidity.html

Racial / Ethnic Disparities in Severe Maternal Morbidity

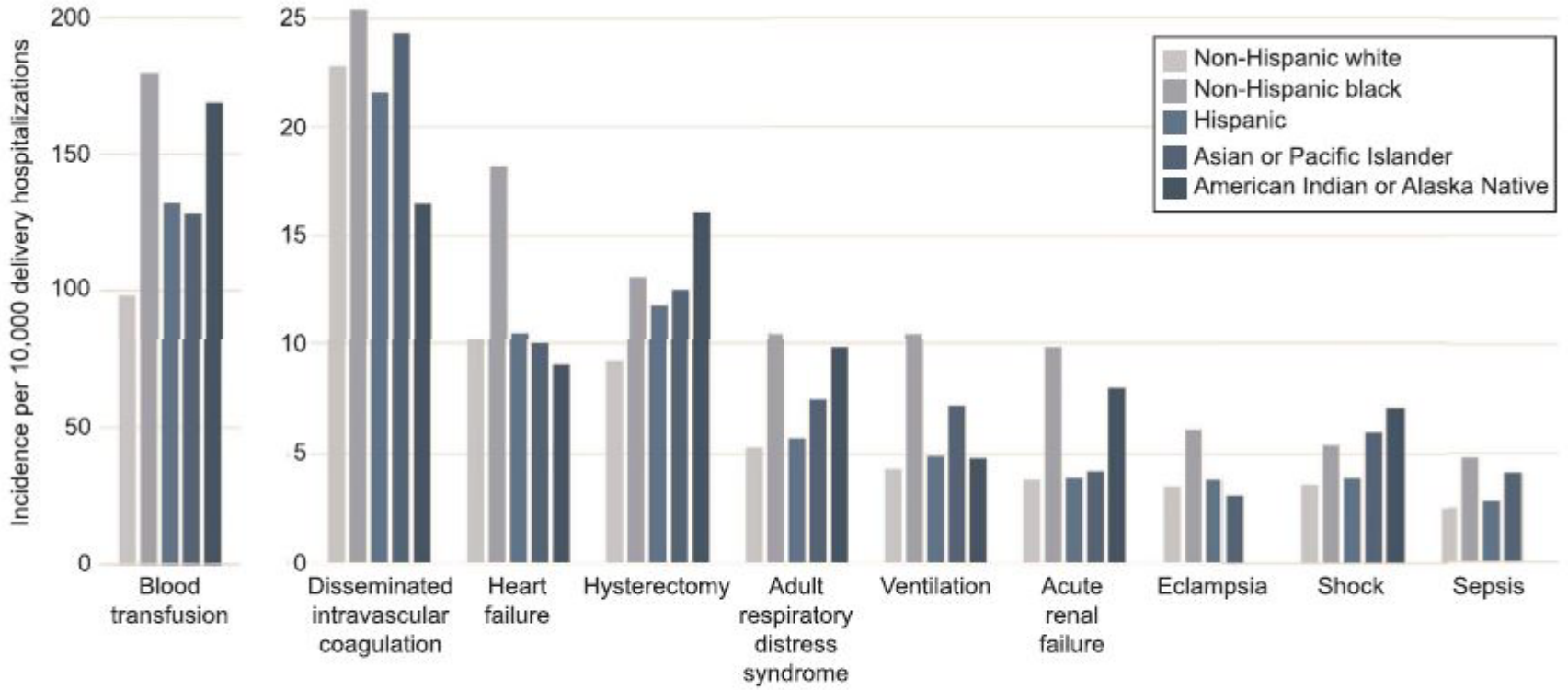
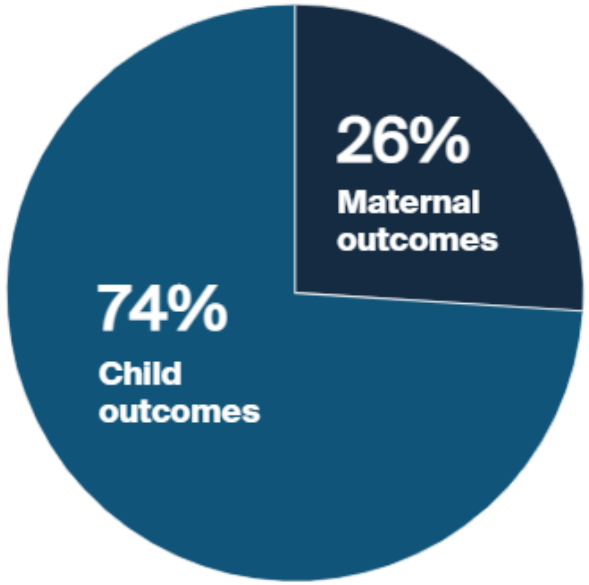


Fig. 2. Incidence of the 10 most frequent severe maternal morbidities per 10,000 delivery hospitalizations by race and ethnicity, United States, 2012–2015 (N=2,523,528). All data are survey-weighted and represented as rate per 10,000 delivery hospitalizations (95% CI). Adjusted for age, income, payer, rural vs urban residence, and hospital region.

Admon. Racial and Ethnic Disparities in Maternal Morbidity. Obstet Gynecol 2018.

Admon. Racial and Ethnic Disparities in the Incidence of Severe Maternal Morbidity in the United States, 2012-2015 Obstet Gynecol. 2018 Oct 5.

Maternal and Child Costs Due to Maternal Morbidity for U.S. Births in 2019



$21.9 billion from conception to age 1

- **$3.8 billion** from maternal outcomes
- **$18.1 billion** from child outcomes

$32.3 billion from conception to age 5

- **$8.3 billion** from maternal outcomes
- **$24.0 billion** from child outcomes

Source: So O'Neil et al., *The High Costs of Maternal Morbidity Show Why We Need Greater Investment in Maternal Health* (Commonwealth Fund, Nov. 2021). https://doi.org/10.26099/nz8s-4708

How Did We Get Here?

Racism & Discrimination

Patient Factors
- Socio-demographics: age, education, poverty, insurance, marital status, employment, language, literacy, disability
- Knowledge, beliefs, health behaviors
- Psychosocial: stress, weathering, social support

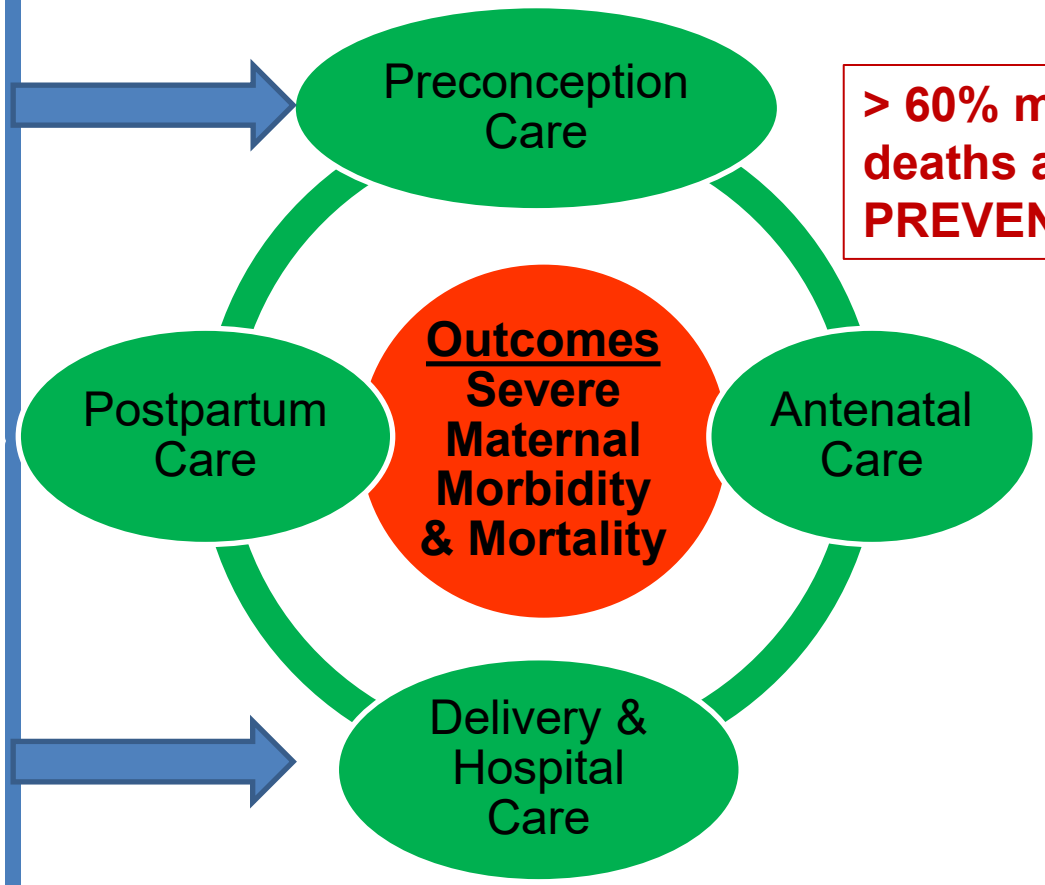
Community/ Neighborhood
- Community, social network
- Neighborhood: crime, poverty, built environment, housing

Clinician Factors
- Knowledge, experience, implicit bias, cultural humility, communication

System Factors
- Access to high quality care, transportation, structural racism, policy

Health status: comorbidities (e.g. HTN, DM, obesity, depression); Pregnancy complications

Figure 1: Pathways to Adverse Maternal Outcomes

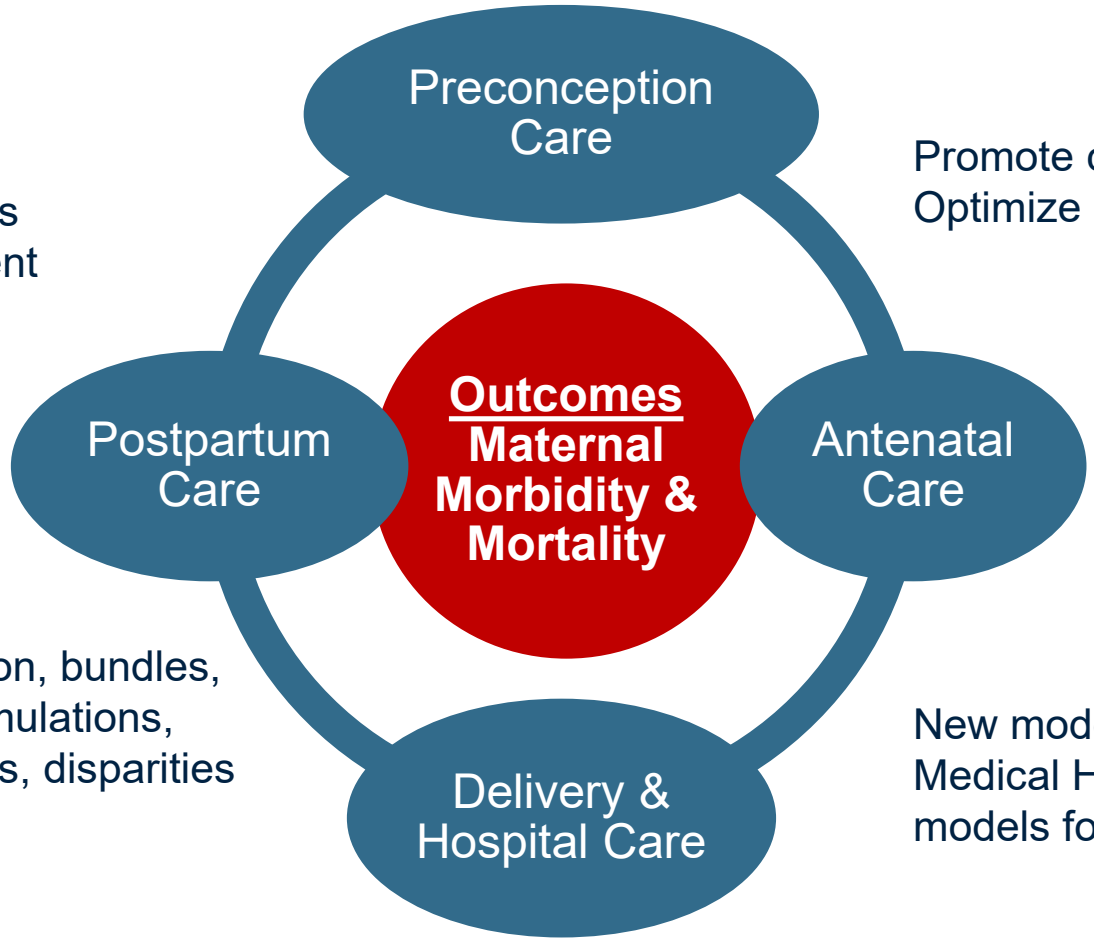


> 60% maternal deaths are PREVENTABLE

Adapted from Howell EA. Clin Obstet Gynecol. 2018 Jun;61(2):387-399

Levers to Improve Maternal Health and Reduce Disparities – Quality of Care Perspective

Lifecourse



New models –
Patient navigators
Case management

Promote contraception
Optimize preconception health

QI, standardization, bundles, team training, simulations, reviews, protocols, disparities dashboard

New models – Centering, Medical Homes, enhanced models for high risk women

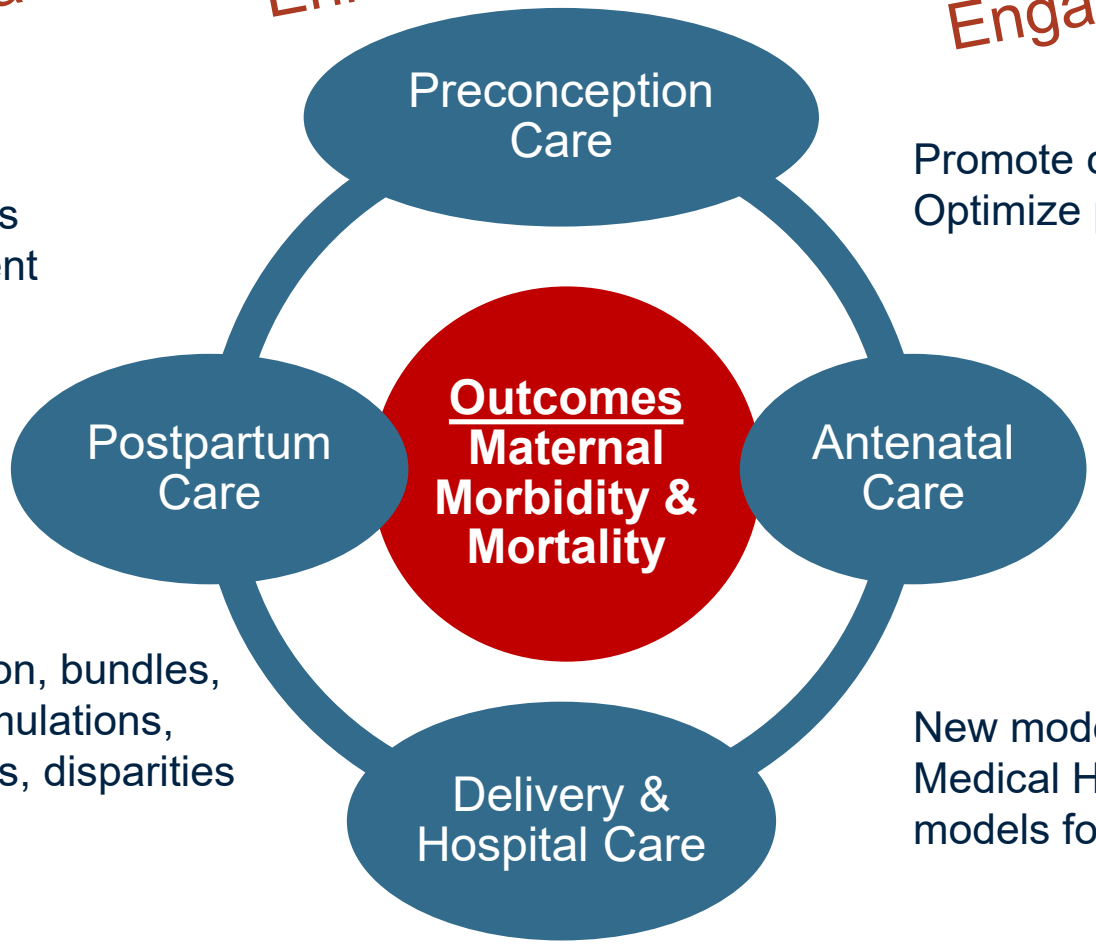
Levers to Improve Maternal Health and Reduce Disparities – Quality of Care Perspective

Eliminate Bias

Enhance Communication

Engage Community

New models –
Patient navigators
Case management



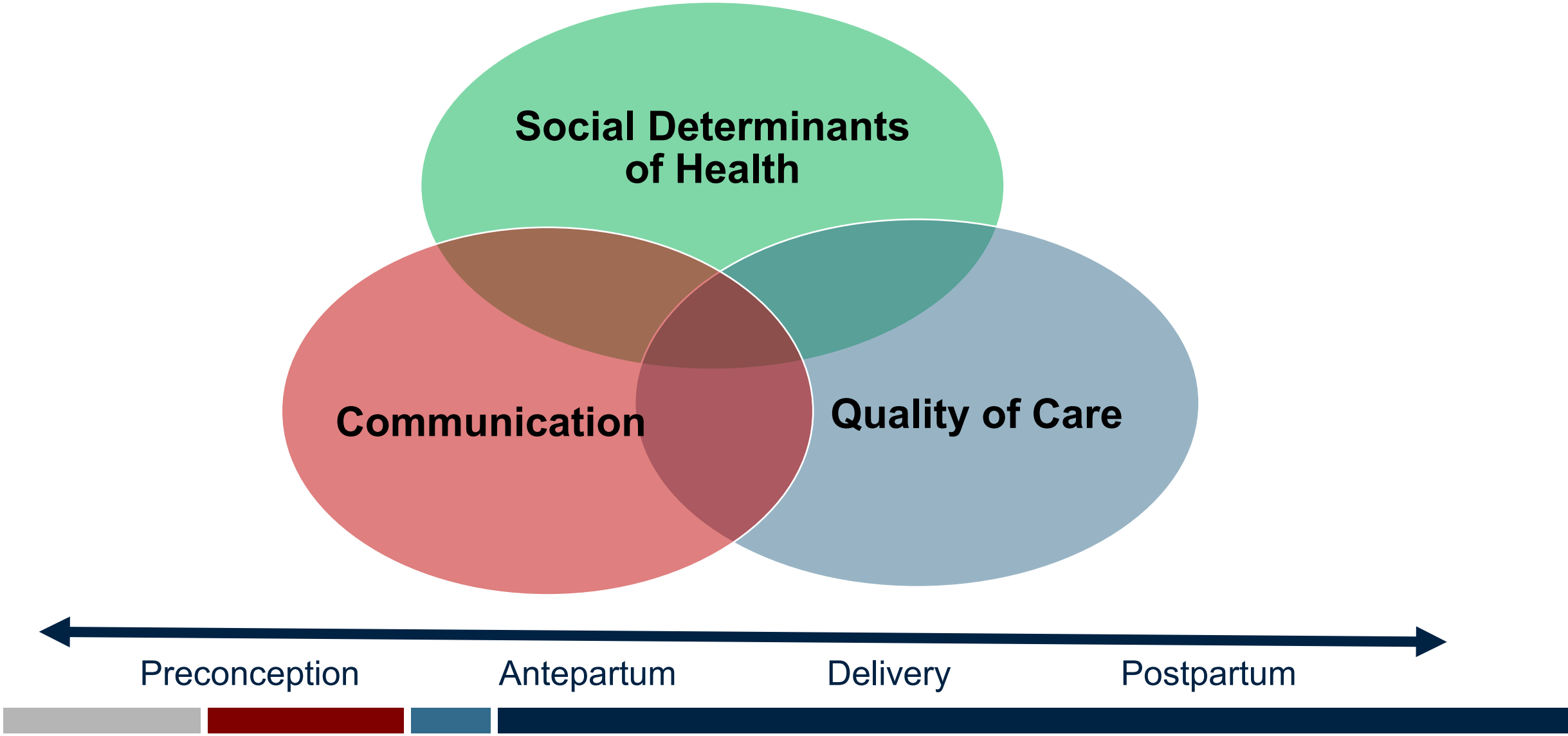
Promote contraception
Optimize preconception health

QI, standardization, bundles, team training, simulations, reviews, protocols, disparities dashboard

New models – Centering, Medical Homes, enhanced models for high risk women

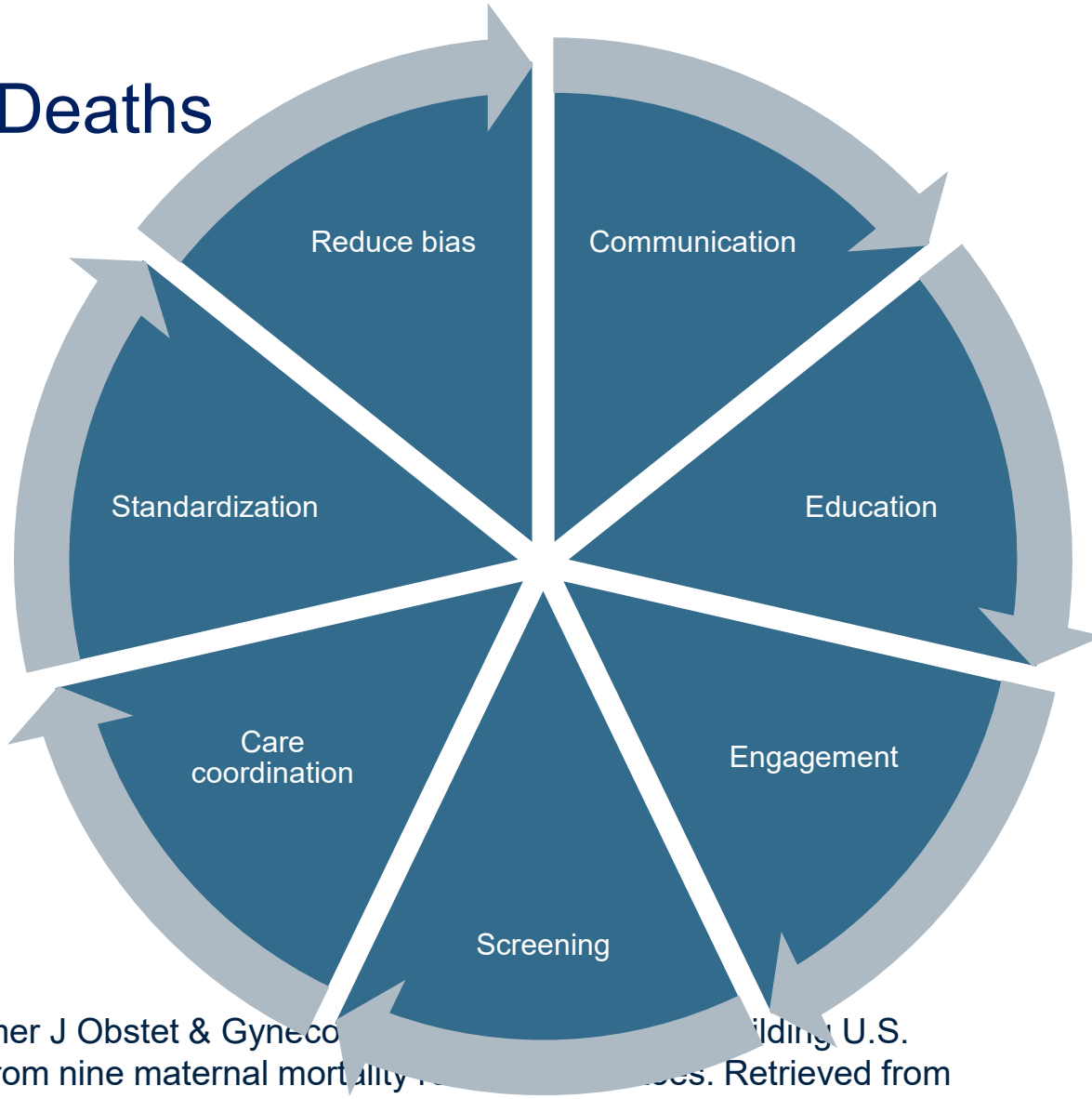
How Can Technology Help Us?

Opportunities for Technology to Address Maternal Health Across the Care Continuum



Factors Associated with Maternal Deaths

- Inadequate assessment of risk
- Failure of communication
- Failure to screen
- Ineffective treatment
- Delay in diagnosis, treatment, follow up
- Lack of coordinated care



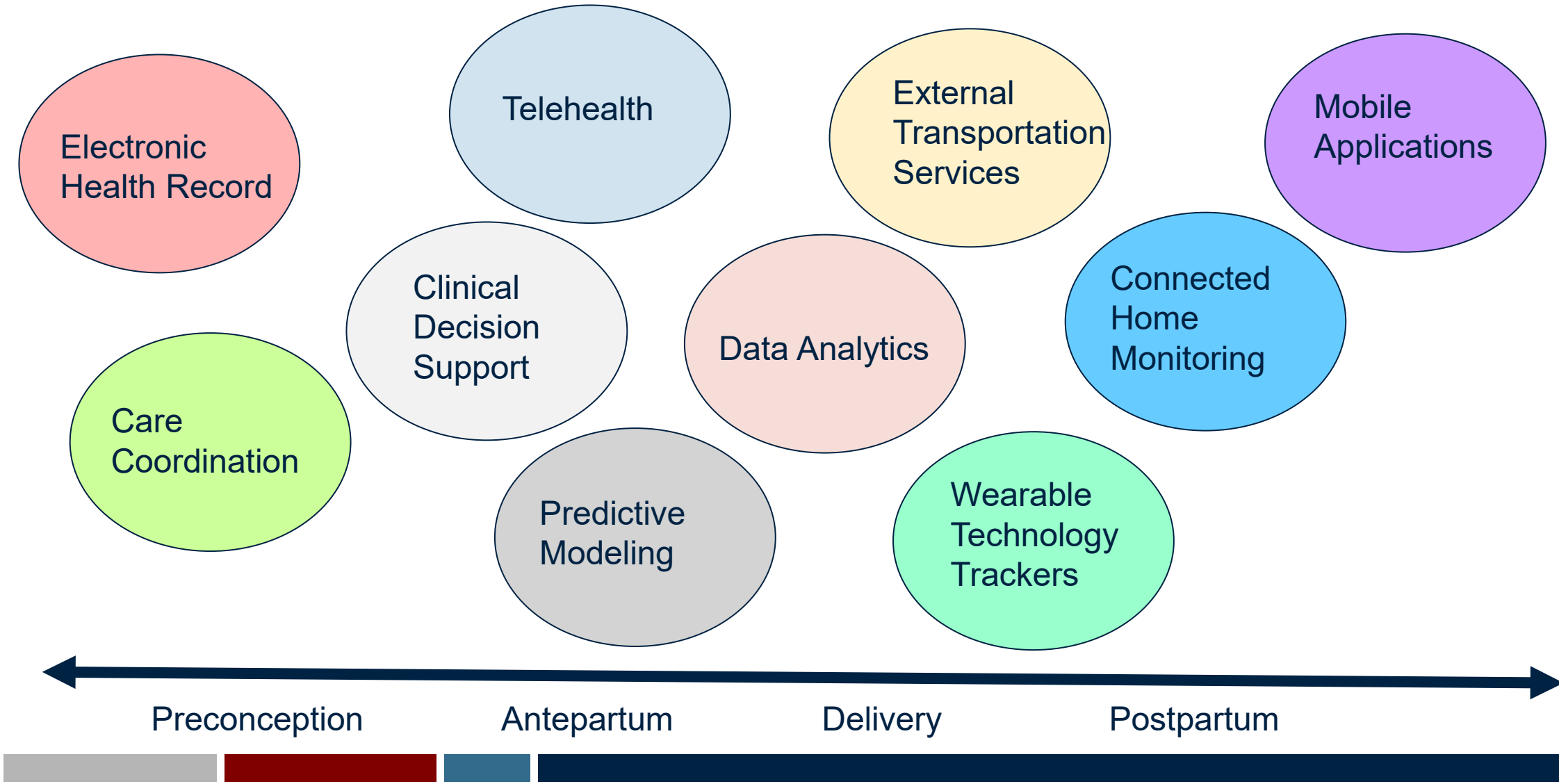
Grigoriadis S. Can Med Assoc J 2017;189:E1085-92; Mangla K. Amer J Obstet & Gyneco ilding U.S. Capacity to Review and Prevent Maternal Deaths. (2018). Report from nine maternal mort ality r ces. Retrieved from http://reviewtoaction.org/Report_from_Nine_MMRCs

Challenges to Use of Technology

- Lower SES and individuals of color less likely to engage in internet health-seeking behaviors
- Despite high access to mobile phones (>80-90%), many change phone numbers within a year
- Use of digital health management practices (e.g. email, health tracking apps, etc.) is low
- Use of patient portal associated with age, race, education, health literacy, English language proficiency
- Interventions that don't focus on equity, usability, and user preferences can inadvertently widen racial and SES disparities
- *"Digital inclusion" – framework for implementing and evaluating electronic health tools, connects technology, access, equity, and justice*

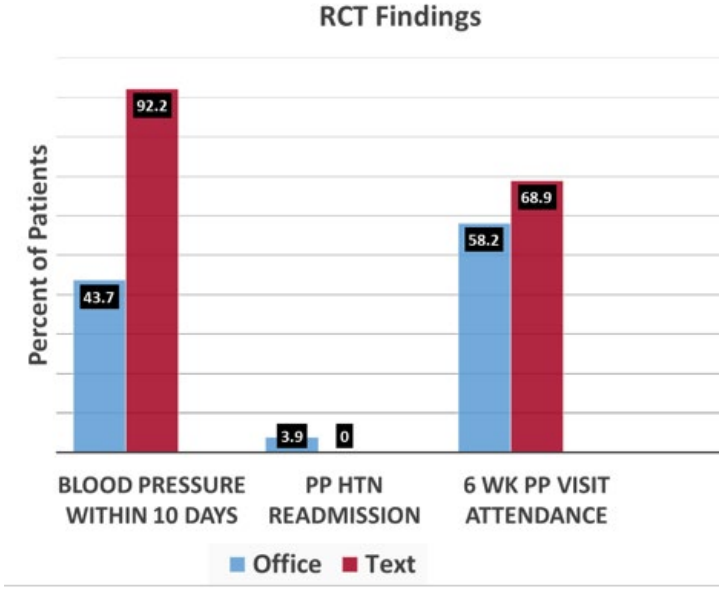
Guendelman et al. J of Med Internet Res 2017. vol. 119. iss 7 pp 1-11; Steinberg. J Diabetes Sci Tech 2021. Aug 22 epub

Technology Tools to Address Maternal Health Across the Care Continuum



Heart Safe Motherhood

- At home postpartum blood pressure monitoring program that leverages technology



Results

- Increased BP measurement in 1st 10 days PP
- Reduced ED visits and readmissions
- Decreased disparities
- Increased postpartum visits

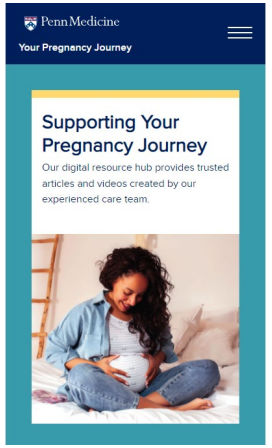
Implementation

- Penn Medicine (all 5 delivery hospitals)
- Philadelphia downtown delivery hospitals

Hirshberg BMJ Qual Saf. 2018 Nov;27(11):871-877
Hirshberg et al. AJOG 2019 Sep;221(3):283-285

Developed by Penn Medicine Faculty – Drs. Adi Hirshberg and Sindhu Srinivas

THEA



- Text message-based antenatal educational and blood pressure monitoring

Design

- Weekly educational text messages beginning before the first prenatal visit
- In-depth text articles and videos hosted on educational website
- Weekly blood pressure monitoring beginning in the second trimester, with algorithmic triage of abnormal values

Results

- 80% of patients submitted at least one blood pressure during pregnancy
- High-risk population, with 41% of patients diagnosed with gestational hypertension or pre-eclampsia
- Facilitated reduced visit prenatal care schedules and incorporation of telemedicine visits
- 60% of elevated blood pressures in pregnancy were first diagnosed using the home cuff

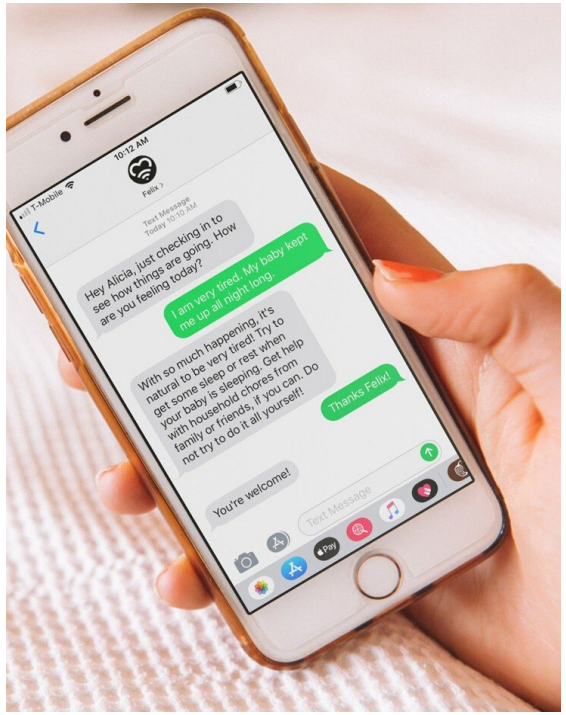
Implementation

- Penn Medicine (HUP)

Developed by Penn Medicine Faculty – Dr. Anna Graseck

Healing at Home

bridging the gap in **fourth-trimester care** by providing parents with around-the-clock access to clinical guidance



Design

- Combination of anticipatory guidance, 2-way texting and support for lactation and postpartum depression screening
- Texting or chatbot uses natural language processing and augmented intelligence to coordinate care, provide resources and address issues
- Answers questions, connects women to their providers when necessary

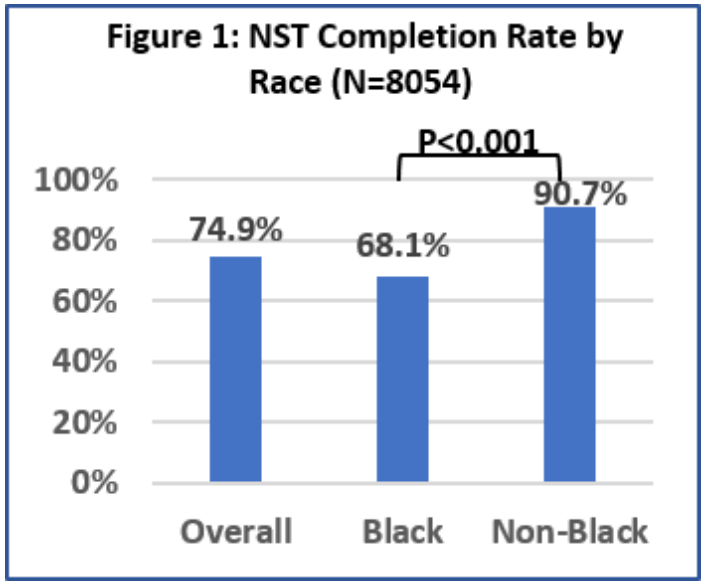
Outcomes

- Allowed for 24 hour hospital discharge following delivery during Covid
- 93% patients completed at least one survey (EPDS, Feeding, Metrics)
- 66% patients completed EPDS
- 52% patients asked at least one question – most often regarding breastfeeding

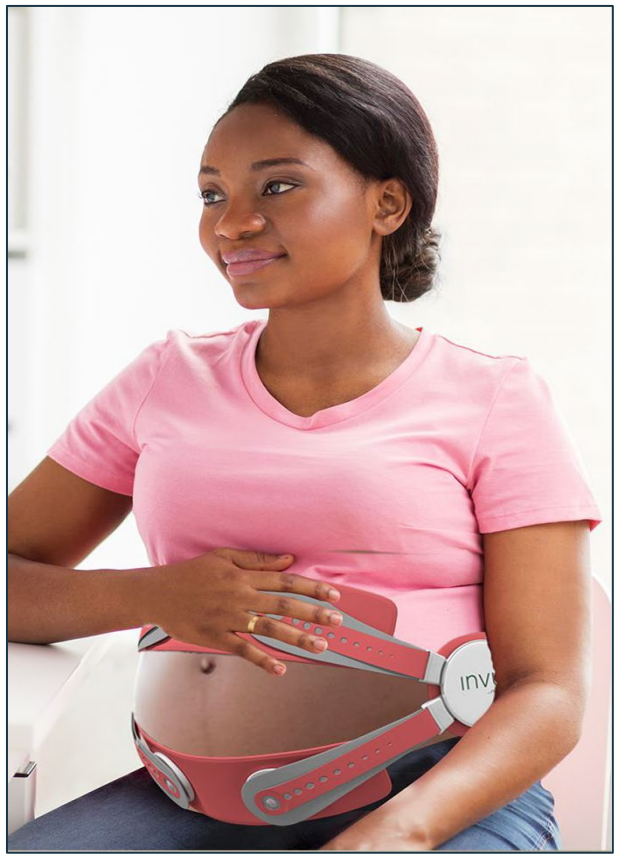
Developed by Penn Medicine Faculty – Drs. Kirstin Leitner and Lori Christ

Remote fetal monitoring for high risk pregnancies

- ~26,000 stillbirths per year in US
- Social determinants raise barriers to accessing in-office fetal monitoring
  - Child care, time off work, transportation, COVID-19, etc
  - Black women are >2x risk of stillbirth and have more difficulty accessing care



Unpublished Penn data



Invu™ (Nuvo Group Ltd)

- A self-administered sensor belt
- Cloud-based algorithms supply maternal/fetal heart rate and uterine activity for NSTs

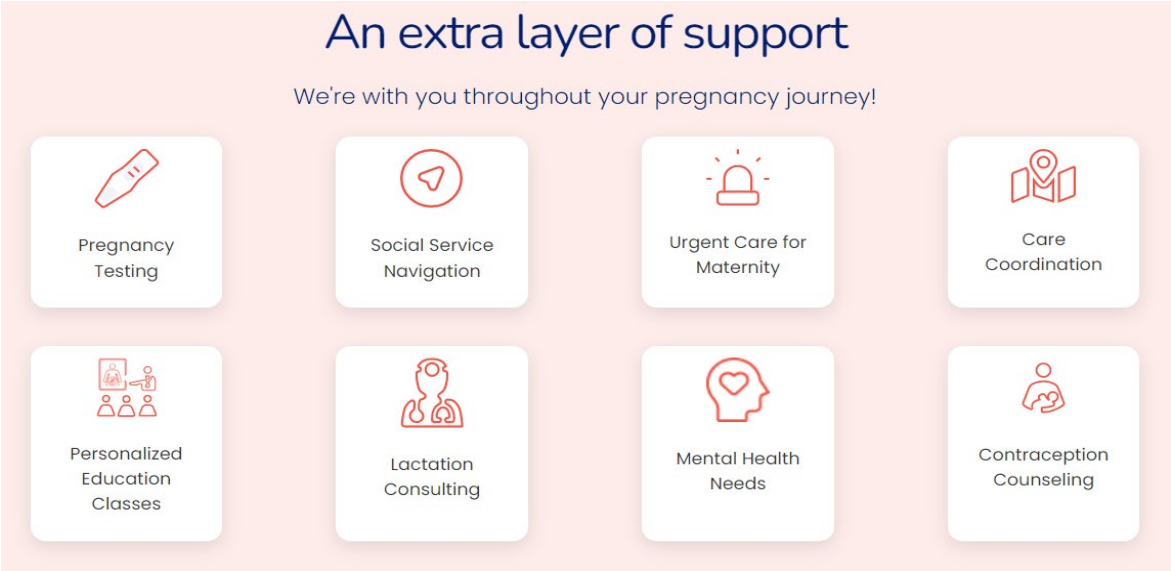
- Penn has led 2 Nuvo-sponsored, multi-center clinical trials validating the technology (PI: Nadav Schwartz)
  - Mhajna et al AJOG-MFM 2020
  - Schwartz et al. AJOG 2021
- Ongoing work:
  - Workflow optimization using innovation methodology and community-engagement
  - Plan for Type I hybrid implementation effectiveness trial

Funding acknowledgement:
- Nuvo Group
- UPENN CTSA UL1TR001878
- NIH RO1HD105446

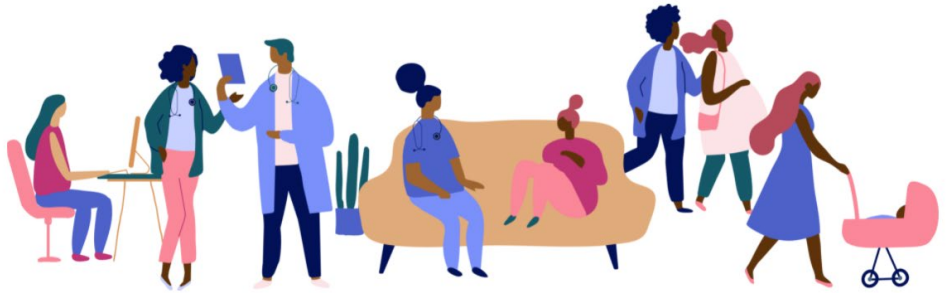
Cayaba Care

Design

- Multidisciplinary care team
- Maternity navigator
- In-home and virtual visits to meet patients where they are
- Community partnerships
- Leverages Cayaba Brain -EMR, claims, questionnaires – used to risk stratify and personalize care and to support multidisciplinary care team



The Cayaba Care Model



Cayaba Care is tackling a critical life event for underserved populations. The pregnancy experience can change the long-term trajectory of health, success, and well-being for moms, babies, and their communities.

Results

- 80% of patients submitted at least one blood pressure during pregnancy
- 35% reduction in emergency room visits.
- 3 times more likely to attend their scheduled OB appointments.
- 90% members would recommend service to a friend

Implementation

- Philadelphia

www.cayabacare.com

Data-driven Modeling of Pregnancy-Related Complications

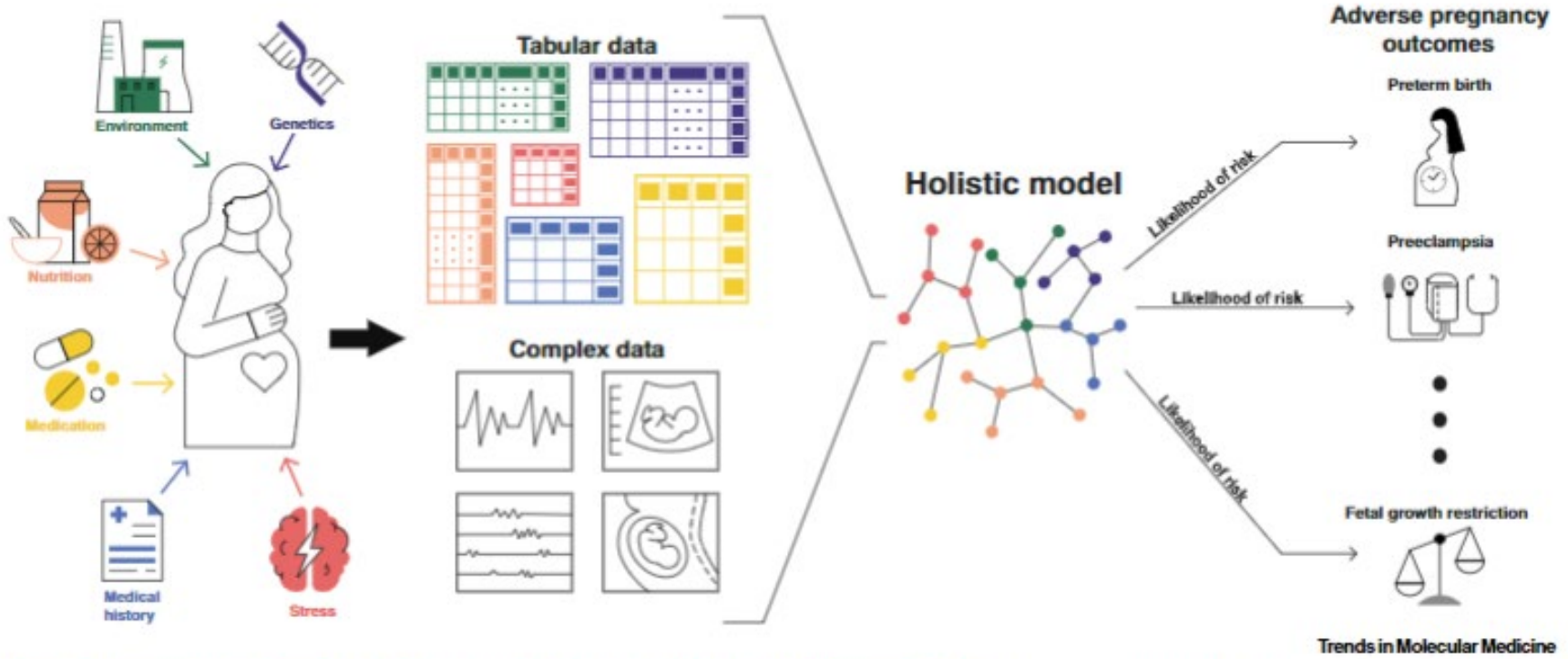


Figure 1. Incorporating Diverse Data Modalities to Build Holistic Models of Pregnancy Biology. The various factors that influence maternal and fetal health during gestation are measured to generate diverse, intercorrelated types of data. Machine-learning methods can be used to develop holistic models of maternal and fetal biology that capture the complex interactions between these modalities, reveal mechanistic insight into various adverse outcomes, and assist in diagnostics, therapeutics, and the generation of predictive analytics.

Espinosa et al. Trends in Molecular Medicine. 2021 Aug;27(8):762-776

"MOST HEALTH DISPARITIES ARE AVOIDABLE. THEY RESULT FROM DECISIONS WE MAKE AS A SOCIETY REGARDING HOW WE ALLOCATE OUR RESOURCES AND HOW MUCH INJUSTICE WE ARE WILLING TO ACCEPT AS A FACT OF LIFE."

—Lisa Cooper

Johns Hopkins health equity expert

Digital Inclusion

THANK YOU

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Elizabeth.howell1@pennmedicine.upenn.edu