Maternal Deaths: An Overview

(Forensic Pathology edition)

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Outline

- Definitions/Terminology
- Incidence
  - Factors affecting pregnancy-related and pregnancy-associated mortality
  - 42 days ??
  - Utah Criteria
- Issues with measuring maternal mortality
  - The Death Certificate
- Impact & Significance
- Role of the ME/C
- References

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Definitions (1/4)

- Maternal death (WHO) - The death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, *but not from accidental or incidental causes*
- Late maternal death – As above, but death occurs 43 days through 1 year following the termination of pregnancy
  - *Late maternal deaths are not included in the calculation of maternal mortality ratios*
  - Some nations do not gather data on late maternal deaths
- Maternal mortality ratio (MMR) - the number of maternal deaths per 100,000 live births
  - Sometimes used interchangeably with maternal mortality rate

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Definitions (2/4)

- Trimester – a period of ~3 months, most commonly used to divide human gestation (40 weeks from 1st day of LMP) into three phases:
  - **1st** - Week 1 through Week 13/14
  - **2nd** - Week 13/14 through Week 27
  - **3rd** – Week 28 through Birth/40(+) weeks
- Gestational age – the common term used during pregnancy to describe how far along the pregnancy is. It is measured in weeks, from the first day of the woman's last menstrual period to the current date
- Fetus – the unborn offspring of a viviparous animal that develops from an embryo. In humans, the fetal stage begins at 10 weeks gestational age (8 weeks from fertilization)
- Neonate – a.k.a. newborn, a child 4 weeks of age or less

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Definitions (3/4)

- Abortion - the process of delivering a conceptus prior to the fetus's viability, which is defined as 20 weeks of pregnancy or a fetus weighing 500 grams or more. In several states, the weight requirement for viability has recently been reduced to 300 grams
  - The general population typically refers to an abortion as a "miscarriage" when they mean an abortion that occurred naturally, reserving the term "abortion" for an induced pregnancy termination
- Stillbirth - the death of a fetus at or after 20 (US) to 28 (WHO) weeks of pregnancy. Occurs before or during labor and delivery

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Definitions (4/4)

- Pregnancy-related death – a death during pregnancy or within **1 year** of the end of pregnancy from a pregnancy complication, a chain of events initiated by pregnancy, or the aggravation of an unrelated condition by the physiologic effects of pregnancy
- Pregnancy-associated death – pregnancy-associated deaths include all pregnancy-related deaths, **plus** the deaths of pregnant or PP persons from causes unrelated to pregnancy (up to 1 year)
  - Not pregnancy-related
    - For the most part, excluded from official MMR calculations
  - Cannot be determined if pregnancy-related
    - For the most part, excluded from official MMR calculations

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Incidence and Influencing Factors

- Current overall **US** maternal mortality ratio (CDC, 2023): 18.6 per 100,000 live births (669 deaths)
- Significant racial disparities
  - Black – **50.3**
  - White – 14.5
  - Hispanic – 12.4
  - Asian – 10.7
- Epidemics and pandemics
  - Recent peak in 2021 (COVID-19): **32.9** (1,205 deaths)
    - Racial disparities persisted or worsened
  - Opioid epidemic (increased pregnancy-*associated* deaths)

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Factors, cont.

- United States fares significantly worse than other "wealthy" nations
  - Canada – 11
  - Germany – 4
  - UK – 10
- Maternal age
  - The birth rate for women>40 has recently eclipsed that of teenagers
- U.S. Geography
  - Urban v. rural
  - Access to facilities and providers
    - Transportation
- ? Legislation

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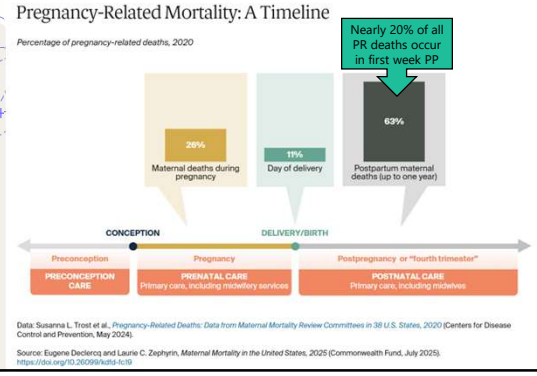
Pregnancy-Related Mortality: A Timeline

Percentage of pregnancy-related deaths, 2020



Data: Susanna L. Trost et al., *Pregnancy-Related Deaths: Data from Maternal Mortality Review Committees in 38 U.S. States, 2020* (Centers for Disease Control and Prevention, May 2024).

Source: Eugene Declercq and Laurie C. Zephyrin, *Maternal Mortality in the United States, 2025* (Commonwealth Fund, July 2025).
https://doi.org/10.26099/kdfd-fc19

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The 'Magical' 6 Week Mark (42 days)

- The traditional "6-week postpartum checkup" arose from *early 20th-century* obstetric guidelines that focused on the time required for the uterus to return to its pre-pregnancy size and for the risk of infection to decrease
  - Medical tradition
  - Cultural – "Lying in"
- It is not a strict recovery deadline, but rather an archaic "clearance" point for resuming exercise and sexual activity, often considered a neglectful by modern care standards
- Reality: research has indicated that recovery often takes 6–18 months
  - The ACOG now recommends that postpartum care be an ongoing process rather than a single visit, favoring individualized check-ins tailored to the patient

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The Two Most Widely Used Maternal Mortality Metrics

Measure	Definition	Source	Difference in using 42-day period or a one-year period: Tennessee (2020-2022)
Maternal mortality (ratio per 100,000 live births)	The death of a woman ***while pregnant or within 42 days of termination of pregnancy***, irrespective of the duration and site of the pregnancy, from any cause ***related to or aggravated by the pregnancy*** or its management but not from accidental or incidental causes.	CDC National Vital Statistics System (NVSS)	39.6
Pregnancy-related mortality (ratio per 100,000 live births)	The death of a woman ***during pregnancy or within one year*** of the end of pregnancy ***from a pregnancy complication, a chain of events initiated by pregnancy***, or the aggravation of an unrelated condition by the physiologic effects of pregnancy.	CDC Pregnancy Mortality Surveillance System (PMSS)	59.3

Download data

Data: Tennessee Department of Health, Division of Family Health and Wellness, *Maternal Mortality in Tennessee. Annual Report, 2024* (State of Tennessee, 2024).

Source: Eugene Declercq and Laurie C. Zephyrin, *Maternal Mortality in the United States, 2025* (Commonwealth Fund, July 2025). https://doi.org/10.26099/kdfd-fc19

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The Utah Criteria/Consensus on Unintentional Overdose & Suicide

- Identified consensus supporting the application of 8 (out of 10) standardized criteria in MMRC determinations of pregnancy-relatedness among suicide and unintentional overdose deaths
  - Consensus in favor of a criterion was met when ≥75% of participants identified a case as pregnancy-related in at least 1 scenario. 58 participants (representing 48 MMRCs) reviewed scenarios
- "The results of the (modified Delphi) process also suggested the need for continuing iterative adaptation to help expand consensus criteria beyond those currently identified, especially in the late postpartum period."

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Utah Criteria, con't.

		Summary of Expert Consensus Criteria	Pregnancy* Base	Pregnancy* Additional	Early postpartum* Base	Early postpartum* Additional	Late postpartum* Base	Late postpartum* Additional
Pregnancy complication	1a	Increased pain directly attributable to pregnancy or postpartum events leading to self-harm or drug use						
	1b	Traumatic event in pregnancy or postpartum with a temporal relationship between the event leading to self-harm or increased drug use						
	1c	Pregnancy-related complication likely exacerbated by drug use (peripartum, round 1)			Not applicable			
		Criteria						
Chain of events initiated by pregnancy	2a.1	Cessation or attempted taper of medications for pregnancy-related concerns of neonatal or fetal risk, leading to maternal destabilization or drug use						
	2a.2	Cessation or attempted taper of medications during pregnancy due to fear of Child Protective Service involvement, leading to maternal destabilization or drug use						
	2b	Inability to access inpatient or outpatient drug or mental health treatment due to pregnancy						
	2c	Perinatal depression, anxiety, or psychosis resulting in maternal destabilization or drug use						
		Criteria						
Aggravation of underlying condition	3a	Worsening of underlying depression, anxiety, or other psychiatric condition in pregnancy or the postpartum period with documentation that mental illness led to drug use or self-harm						
	3b	Exacerbation, undertreatment, or delayed treatment of pre-existing condition in pregnancy or postpartum leading to use of prescribed or illicit drugs						

* Cases were modified for each time point (prenatal, early postpartum defined as within 8 weeks postpartum, and late postpartum defined as within 6-12 months postpartum) and details were changed as appropriate.

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Challenges with measuring pregnancy-associated mortality

- Non-uniform reporting requirements
  - Sows confusion, impairs the accuracy of certification
- Inaccurate death investigation and/or certification
  - Based on death certificate data, postmortem examinations are only performed in 40% of maternal deaths (Commonwealth Fund)
- Erroneous or inappropriate use of the pregnancy checkbox
- Non-uniformity of terminology/lack of generalizability of data
  - 42 days versus 1 year postpartum
  - Changing attitudes/practices with respect to the pregnancy-relatedness of non-natural deaths
- Defunding/decommissioning of MMRCs

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The Death Certificate

- The Standard Pregnancy Checkbox
- Part of a revision to the U.S. Standard Certificate of Death (2003)
  - Not fully implemented in all states until 2017!

36. IF FEMALE:
- ☐ Not pregnant within past year
- ☐ Pregnant at time of death
- ☐ Not pregnant, but pregnant within 42 days of death
- ☐ Not pregnant, but pregnant 43 days to 1 year before death
- ☐ Unknown if pregnant within the past year

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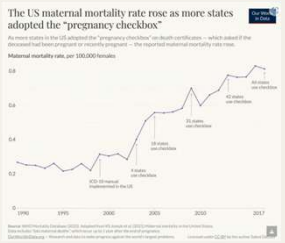

+ Caveat: improved detection comes with a greater potential for errors, including mistakenly checked boxes on the death certificates of women of reproductive age who weren't pregnant or postpartum
  + More 'false positives' with women >40 yo

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Impact and Significance

+ Personal
+ Community
+ Wider society
  + Maternal mortality is widely accepted as a key indicator of health and socioeconomic development
  + It is a reflection of the whole national health care system and represents the outcome of its pros and cons, along with its other characteristics such as intersectoral collaboration, transparency and disparities
+ 84% of maternal deaths are deemed *preventable* after thorough review

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Role of the ME/C

+ Public health physicians
  + Identification of natural and non-natural maternal deaths
  + Proper investigation and certification
+ Not overly burdensome
  + Maternal deaths are relatively uncommon
  + In 2018, there were 658 reported maternal deaths and 890 estimated autopsy pathologists working in ME/C offices
+ Maternal Mortality Review Committees (MMRCs)
  + FPs are crucial members with invaluable insight

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Investigation of Maternal Deaths: Jurisdictional Considerations

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Recommendations for the Investigation of Maternal Deaths

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OUTLINE: Maternal Death Investigation: Jurisdictional Considerations

- Maternal Mortality and Maternal Death Investigation
- Jurisdiction for Maternal Deaths--General and Specific
- What Possible Pregnancy-Related Deaths are being Missed—that is, not being evaluated by ME/Cs?
- Current US systems to Improve the identification, Investigation, and Evaluation of Maternal Deaths
  - Washington State, New York City, and Alabama
- Summary of Positions Related to Jurisdiction—NAME Position Paper: Recommendations for the Investigation of Maternal Deaths

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Maternal Mortality and Maternal Death Investigation

- Maternal mortality is an important public health issue in the United States, which has one of the highest maternal mortality rates among high-income countries.
- Efforts to reduce maternal mortality have been led by CDC-supported state and local multidisciplinary Maternal Mortality Review Committees (MMRCs). Deaths are reviewed and analyzed in order to identify causes, contributory factors, and possible preventive efforts. Most (42/50) MMRCs include a forensic or anatomic pathologist on their roster [9].
- An accurate cause of death is a fundamental component of both maternal mortality data and maternal mortality review.
  - Forensic Pathologists have expertise in integrating investigative, clinical, autopsy and other relevant information to accurately determine the cause and manner of death, and have contributed their expertise to identify and address many public health issues.
  - ME/C offices and forensic pathologists have a central role in the investigation and evaluation of maternal deaths, which often includes autopsy.
- Despite variations in state and local death investigation laws, most ME/C statues include language which allows the ME/C to both require reporting of maternal deaths and accept jurisdiction for investigation / evaluation / autopsy of those deaths.

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Do Maternal Deaths fall under the jurisdiction of the ME/C office? Yes!

ME/C offices focus on the investigation of deaths which are sudden, unexpected, or unexplained and deaths due to injury / violence of any type. These are deaths which are of interest to the public health and welfare.

- Pregnancy-Associated (PA) deaths from apparent or suspected physical injury or drug use generally fall under the jurisdiction of the ME/C, and are evaluated using routine procedures to determine cause and manner of death, without specific consideration of pregnancy status.
- Pregnancy-Related (PR) deaths often present as sudden, unexpected or unexplained deaths without clear or identifiable etiology. They therefore fall under the ME/C jurisdiction, and warrant evaluation.
- When a possible PR death occurs outside a medical facility (no medical attendance), ME/C evaluation is indicated, which often includes autopsy. The possibility of a PR or PA cause of death should be considered in the evaluation of any unexpected death of a woman of reproductive age (~10-50 years).
- A possible PR death may also occur during a hospitalization before a clear cause can be determined to reasonable certainty. ME/C investigation is also indicated to determine the extent of evaluation indicated, which may include autopsy.
- A possible PR death occurring in the setting of a well-documented hospital course with a clear connection between the pregnancy and cause of death will not likely require further ME/C evaluation after reporting.

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Do ME/Cs have the authority to require reporting of and to investigate and evaluate maternal deaths? Yes!

In a 1994 review of death investigation statute terminology for 50 US states, Hanzlick, Parrish, and Combs [1] found that nearly all (48-49) contained language referencing investigation of a sudden, unexpected, and/or unexplained death in an apparently healthy person, or under suspicious circumstances, or unusual or unnatural manner of death.

- Such language allows ME/C offices to require that maternal deaths (pregnancy-related and pregnancy-associated) be reported and to accept jurisdiction for these deaths, which are generally unusual in the US, and are often unexpected and/or sudden, regardless of occurrence in a hospital or not.
- Likewise, NAME Forensic Autopsy Standard A2.3 states that "The forensic pathologist or representative shall investigate all unexpected or unexplained deaths of those in apparent good health," while Standard B1.12 states that autopsies shall be performed when "the forensic pathologist deems a forensic autopsy is necessary to determine cause or manner of death, document injuries/disease, collect evidence, or adequately document findings and issues of concern"[2].
- Thus, specific designation in an office's statutory or reporting requirements is not necessary for pregnancy-related (PR) and pregnancy-associated (PA) deaths to be reported to and/or investigated and evaluated by the ME/C.

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But—ME/C Offices Could Consider Adding Maternal Deaths to their Published Reporting Requirements!

- In jurisdictions which do not have specific requirements for the reporting and investigation of maternal deaths without a clear etiology or cause, reporting individuals and institutions may not recognize that these deaths are reportable, and the decision to investigate a death may be based solely on subjective interpretations by the ME/C as to its sudden and unexpected nature or the degree of clinical certainty about the cause of death.
- More specific requirements for reporting of these maternal deaths would be helpful in clarifying that these deaths are to be reported—for practicing physicians and other healthcare providers, their institutions, the public, and ME/Cs. This could enhance the scientific, legal and public health value of these death investigations.
- Hanzlick et al also note that more specific requirements for the reporting of maternal deaths does not encroach on ME/C discretion with respect to the extent of the investigation and evaluation necessary for the accurate certification of cause and manner of death [1].

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Which possible PR Deaths are commonly "missed"--not evaluated by ME/Cs?

An important group of potential PR deaths which may not be routinely reported to and/or investigated by the ME/C office as an accepted and standard practice are deaths occurring in a health care setting (hospital or birthing center), especially during pregnancy, labor, delivery, or the postpartum period (42 days of the end of a pregnancy), and which are unexpected, sudden, unusual, or the underlying cause of death is uncertain or not clearly determined [3].

- When these deaths are not reported to the ME/C, or if they are reported and jurisdiction is declined because of medical attendance and/or "willingness" of a clinician to certify the death, ME/C investigation with autopsy as appropriate will not likely occur. This may impact the accuracy of the cause of death [3].
  - Clinical certification of maternal deaths may use non-specific mechanisms or default diagnoses (for example, pulmonary thromboembolism), as the involved clinicians are often not trained or experienced in accurate death certification. In deaths with clinically unclear or uncertain cause, autopsy may provide a more accurate cause of death (and is generally considered the gold standard for cause of death determination).
  - The medical literature contains numerous examples of continuing significant discrepancies (up to 50% or more) between clinical and autopsy diagnoses in many hospital settings.
  - Specific to maternal deaths: Discrepancies between autopsy and clinical causes of death differed in up to 36% of maternal deaths. In up to 38% of maternal deaths without autopsy, the underlying cause of death could not be determined based on the clinical record [4].

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What systems have been implemented in the US to improve reporting, investigation, and evaluation of possible Pregnancy-Related deaths?

2019 Washington state Maternal Mortality Law [5,6].

RCW 70.54.450, 2016; [amended 2019 c 317 s 1; 2016 c 238 s 1.]

- Requires hospitals and licensed birth centers to make a reasonable and good faith effort to report all deaths that occur during pregnancy or within 42 days of the end of pregnancy to the local ME/C within 36 hours. The local ME/C is to "conduct a death investigation [not further specified], with autopsy strongly recommended." Autopsy services are reimbursed to the county for 100% of charges.
  - Resulted from 2017 recommendations from the first Washington MMRP review of maternal deaths in 2014 & 2015 [7].
  - There were 16 PR deaths, but only 44% (7/16) of the PR deaths were autopsied, and in 43% (3/7) of the autopsied deaths, the cause of death would not have been determined without an autopsy.
  - In addition, not all deaths were reported to the local ME/C and the quality of autopsies was variable and sometimes suboptimal (based on the report).
  - Law implemented in 7/2019: Limited data--reduction in non-autopsied deaths.

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What systems have been implemented in the US to improve reporting, investigation and evaluation of possible Pregnancy-Related deaths?

New York City (NYC) Office of the Chief Medical Examiner (NYC OCME)

Functions under the authority of the NYC Charter Section 557: Chief Medical Examiner: which allows investigation of deaths including "persons dying suddenly when in apparent health…"

NYC OCME Reportable Death Criteria [8] specifically include: Deaths that occur during pregnancy, during childbirth, or within twelve months from the end of pregnancy (added in 2021)

- It is expected that these in-hospital maternal deaths will be reported. The Reporting Procedure indicates that "when death has occurred in a hospital, a field investigation is not generally conducted; instead, the investigation routinely consists of a review of hospital records and a telephone discussion with the reporting medical certifier. "
- If jurisdiction is assumed, the autopsy is is performed at OCME. The OCME tracks the numbers of maternal autopsies being performed in their facilities.
- The NYC OCME is a single death investigation entity for NYC, with reporting and review of a high percentage of NYC deaths, including hospitalized persons, and close communication with and referral of cases from DOH Vital Statistics to achieve accurate certification.

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What systems have been implemented in the US to improve reporting, investigation and evaluation of possible Pregnancy-Related deaths?

Alabama Public Health Maternal Autopsy Program (MAP): To increase access to autopsies for maternal deaths—during or for up to one year after pregnancy.

- A complete autopsy with toxicology (including transport) is provided at no charge to the next-of-kin, if they are not getting an autopsy from another source. Autopsies are performed at the University of Alabama (UAB) at Birmingham or at the University of South Alabama in Mobile.
- The program was implemented in 2023 by the Alabama Dept of Public Health (ADPH), and is directed by Dr. Paul Benson, forensic pathologist and UAB Autopsy Section Head. A recent publication in Obstetrics and Gynecology describes the program [9].
- Requests for autopsies are directed through the ADPH. Reports are screened for C/ME exclusion criteria. Informed autopsy consent from the appropriate next of kin is is obtained by the autopsy pathologist.
- There are no ADPH reporting requirement for hospitals, first responders, or coroner offices and families may not always be informed about the program.
- This program was the result of numerous recommendations from the Alabama MMRC regarding the necessity of an autopsy in determining causes of and contributors to maternal mortality. The 2020-2021 MMRC report indicated that approximately 50% of maternal deaths did not have an autopsy performed [10].

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Summary: Three US Systems with Enhancements Focused on Improving Maternal Death Investigation

Washington state: Reporting and Funding for Autopsies: Mixed ME/C state with legislative mandate for timely reporting to ME/C of deaths within 42 days of pregnancy termination AND Full funding for those autopsies provided to the county ME/C office.

NYC OCME: Non-Legislative Reporting Requirement for Maternal Deaths: Single ME office with high rate of reporting and timely interagency coordination.

Alabama MAP: Provides funding for autopsies for up to one year after pregnancy termination if not available from another source. Mixed ME/C state (only 1 ME county); Only voluntary reporting of maternal deaths by providers, hospitals, and Coroner offices.

Death Investigation Systems vary in the US

- States (and individual jurisdictions) will will likely have different issues with respect to maternal death investigation and the current quality of maternal morality data.
- The relevant MMRC can be a valuable source for data and collaboration to identify systemic gaps and potential solutions and achieve change. Washington and Alabama provide good examples of this type of collaborative work.
- MMRCs may not routinely collect data on whether a death was reported to the ME/C, but do collect information about whether an autopsy was performed, and whether a cause of death could be determined from the available data.

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Considerations for Systems to Enhance Identification and Evaluation of Pregnancy Related Deaths

- More Specific Reporting Requirements: Timely Reporting (voluntary / mandated) of all maternal deaths to ME/Cs by hospitals / birthing centers.
- Timely ME/C Investigation of all reported maternal deaths to determine jurisdiction.
  - What is needed to accurately certify cause/manner of death? Autopsy strongly encouraged.
- Resources to support autopsy performance.
  - Funding for autopsy and any related body transport is critical.
  - Limited forensic pathologist resources must be considered.
  - Consider contractual arrangements: Regional ME offices, well-run academic autopsy services with expertise in maternal autopsy (many now directed and staffed by FPs).
- Regular assessment and communication to identify and minimize systemic gaps.
  - Include MMRCs, FPs involved in MMRCs, ME/C offices, hospital autopsy services.
  - Track metrics: Hospital reporting to ME/Cs, MMRC data on non-autopsied deaths in which cause of death could not be determined, etc.
  - Regular communication reminders about reporting guidelines to hospitals, hospital associations, and ME/C offices (in Washington--DOH on behalf of the MMRC).
- Encourage professional connections among FPs participating in MMRCs (perhaps supported by NAME). This could facilitate communication among these FPs, and provide a resource for interdisciplinary communication between forensic pathologists and other specialists involved in MMRCs.

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Recommendations for the Investigation of Maternal Deaths [3]
Positions Summarized, *with Elaboration*: **Jurisdiction--1**

Positions: Jurisdiction

- **Jurisdiction is dictated by legal statute. However, pregnancy-related and pregnancy-associated deaths during or within one year of pregnancy are unusual and unexpected, and therefore already fall within the realm of reportable deaths to the ME/C in nearly all states [1].**
  - *This includes those deaths which occur in a healthcare facility, even when due to apparent "natural causes."*
- **It is recommended that ME/C offices consider adding maternal deaths to their published lists of reportable deaths.**
  - *This could provide clarity for physicians, institutions (hospitals), families, and death investigators.*

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Recommendations for the Investigation of Maternal Deaths [3]
Positions Summarized with *Elaboration*: **Jurisdiction--2**

Position: Reporting and Case Disposition

- **Ideally, all pregnancy-related and pregnancy-associated deaths would be reported to the ME/C with a low threshold for accepting jurisdiction and performing an autopsy.**
  - **This aligns with the NAME Autopsy Standard A2.3: "The forensic pathologist or representative shall investigate all unexpected or unexplained deaths of those in apparent good health" [2].**
- *An important group of potential pregnancy-related deaths which occur in a health care setting may not be regularly reported to and/or investigated by ME/C offices as an accepted and standard practice, limiting the optimal evaluation of these important deaths.*
- *Instituting systems to facilitate timely reporting to ME/C offices by hospitals and licensed birthing centers of all deaths occurring during pregnancy, labor, delivery, and postpartum could allow appropriate evaluation of these potentially pregnancy-related and/or pregnancy-associated deaths.*

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Recommendations for the Investigation of Maternal Deaths [3]
Positions Summarized, with *Elaboration*: **Jurisdiction--3**

Examination: Maternal deaths are often unexpected, unusual, and concerning, and therefore deserve thorough review, which may include a full autopsy.

- **This aligns with NAME Autopsy Standard B1.12: Autopsies shall be performed when "the forensic pathologist deems a forensic autopsy is necessary to determine cause or manner of death, document injuries/disease, collect evidence, or adequately document findings and issues of concern"[2].**
- *Funding for these autopsies and associated resources (transport, etc) is a critical component of maternal death investigation.*
- *Other important systems requirements include routine assessment and mitigation of programmatic gaps which may prevent optimal maternal death investigation, and regular communication among involved stakeholders, including health care providers, hospitals, ME/C offices, and public health agencies, including MMRCs.*

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Acknowledgements

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The Checkbox Isn't Enough: Why the Medicolegal Death Investigator Matters

From Scene to Certification: Strengthening Maternal Death Investigation

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1

Learning Objectives

- Define maternal mortality classifications
- Understand investigator role
- Recognize misclassification
- Apply best practices

2

Key Definitions

- Maternal death
- Pregnancy-related death
- Pregnancy-associated death

3

Why This Matters

- Maternal mortality is rising in the U.S.
- Pregnancy-associated deaths often missed
- Non-obstetric causes are leading contributors

4

Why It Matters

- Accurate data drives prevention
- Improves maternal mortality review
- Guides policy and intervention
- Saves lives

5

Background

- Maternal mortality misclassification
- Checkbox limitations
- Investigator role critical

6

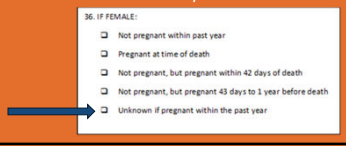
The Pregnancy Checkbox

- Identifies maternal & pregnancy-associated deaths
- Captures deaths beyond obstetric causes
- Essential for surveillance and prevention

7

Forensic Reality Check

- If you don't check the box...
- The death may not count.
- And if it doesn't count, it doesn't change.



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Misclassification Issues

- False positives from checkbox
- Missed pregnancies
- Incomplete histories
- Data entry errors

9

Data Consequences

- Misclassification skews mortality rates
- Impacts funding and prevention strategies
- Affects national statistics

10

Role of the Medicolegal Death Investigator

- Scene investigation
- History gathering
- Family/witness interviews
- Medical record acquisition
- Collaboration with pathologist

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Scene Investigation Matters

- Identification of pregnancy clues
- Medications, prenatal care evidence
- Infant-related items
- Substance use indicators

12

13

Best Practices

- Thorough scene documentation
- Ask about pregnancy status
- Cross-check medical records
- Clear communication with certifiers

14

Communication is Key

- Relay findings to pathologist
- Document clearly
- Ensure checkbox accuracy

15

Prevention Starts Here

- Most deaths are preventable
- Accurate data drives change
- Your work matters

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Take-Home Points

- The checkbox is a tool—not the answer
- Investigators are key to accuracy
- Thorough work improves outcomes
- Every case counts

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THANK YOU

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Violent Death During Pregnancy: an Overview
National Association of Medical Examiners
Interim Meeting
April 14, 2026

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Enhanced surveillance – foundational work by Cheng and Horon

- Used "enhanced surveillance" to determine pregnancy status at death
- Found that ~20 percent of deaths during pregnancy were due to homicide
- In some jurisdictions, homicide was the leading manner of death for pregnant women
- Noted that their findings likely underestimated the scope of the problem
- Distinguished between:
    - *Pregnancy-related deaths*: amniotic fluid embolism, cardiomyopathy, ruptured ectopic pregnancy, and infection
    - *Pregnancy-associated deaths*: deaths due to violence temporally associated with pregnancy
- Found that pregnancy *itself* was a risk factor for homicide
- References:
    - Horon IL. Underreporting of maternal deaths on death certificates and the magnitude of the problem of maternal mortality. *Am J Public Health.* 2005;95:478–482.
    - Horon IL, Cheng D. Enhanced surveillance for pregnancy-associated mortality—Maryland, 1993–1998. *JAMA.* 2001;285:1455–1459.
    - Horon IL, Cheng D. Enhanced surveillance for pregnancy-associated mortality—Maryland, 1993–1998. *JAMA.* 2001;285:1455–1459.
    - Cheng D, Horon IL. Intimate-partner homicide among pregnant and postpartum women. *Obstet Gynecol.* 2010;115:1181–1186.

Post-mortem pregnancy testing

- Home pregnancy tests first marketed to the public in 1977 – "private little revolution"
- Accuracy: 97% positive, 80% negative
- Detected beta subunit of human chorionic gonadotropin (β-hCG) produced by placental cells
- Over the counter home pregnancy tests are exquisitely sensitive, inexpensive, easy to obtain, remarkably accurate, and – most importantly – can purportedly detect early pregnancy as early as 9 days post-conception
- Can be run at the autopsy table on post-mortem urine *or* vitreous fluid to determine pregnancy status independent of the identification of products of conception
- Test should be used as triage tool for additional examination of pregnancy status – i.e., confirmatory blood testing or histological examination of endometrium
- Worth testing all female decedents between 12 and 50

Jurisprudence surrounding death during pregnancy

- "**Fetal personhood**" refers to legal doctrines or laws that assert that an embryo, fertilized egg, or fetus has legal status of a person (or "human being") under civil, criminal, or constitutional law; this can include rights such as the "right to life," protection from harm, or legal claims in tort or criminal law
- Fetal personhood laws put the burden of determining the decedent's pregnancy status on the medical examiner, despite the lack of a protocol for determining same

Natural Maternal Deaths

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Connecticut Office of the Chief Medical Examiner

1

Objectives

- Basic epidemiologic review of natural maternal deaths
- Overview of common causes of natural maternal death: with special focus on:
  - Chronic Diseases
  - Venous Thromboses with Embolism
  - Hypertensive Disorders of Pregnancy
  - Postpartum Hemorrhage
  - Ectopic Pregnancy
  - Cardiomyopathies and Spontaneous Coronary Artery Dissection (Duncanson)
  - Amniotic Fluid Embolism (Klassen/Pasquale)

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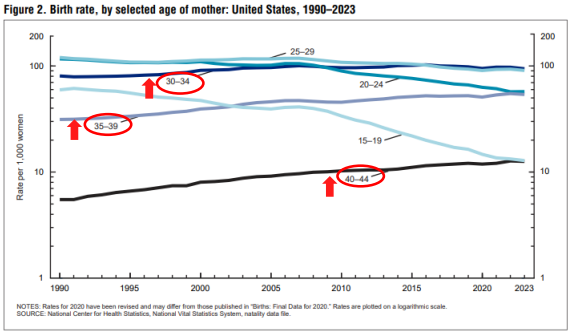
Births at Later Maternal Age

Figure 2. Birth rate, by selected age of mother: United States, 1990–2023



NOTES: Rates for 2020 have been revised and may differ from those published in "Births: Final Data for 2020." Rates are plotted on a logarithmic scale.
SOURCE: National Center for Health Statistics, National Vital Statistics System, natality data file.

Reference: Osterman MJK, et al. NVSR Vol. 74;1, 2025

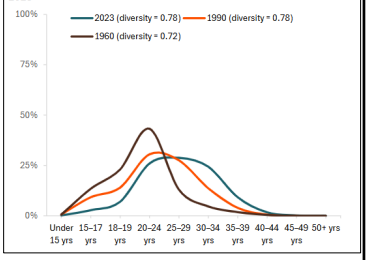
3

2023 data

27 years age
Median maternal age at 1st birth
- 1960 – 22 years
- 1990 – 24 years age

76.1%
Prenatal care in 1st trimester

Figure 1. Distributions of Women's Age at First Birth, 1960, 1990, & 2023



References: Osterman MJK, et al. NVSR Vol. 74:1, 2025.
Figure 1 from Julian CA and Manning WD. BGSU. No. 28, 2025

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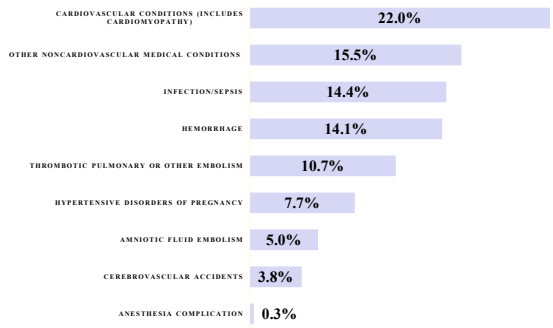
Pregnancy-Related Deaths



Source: CDC.gov, 2024 data

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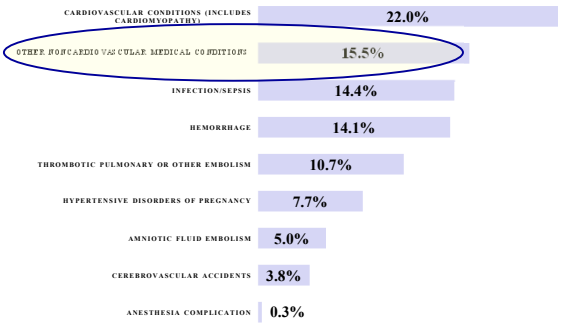
Pregnancy-Related Deaths



Source: CDC.gov, 2024 data

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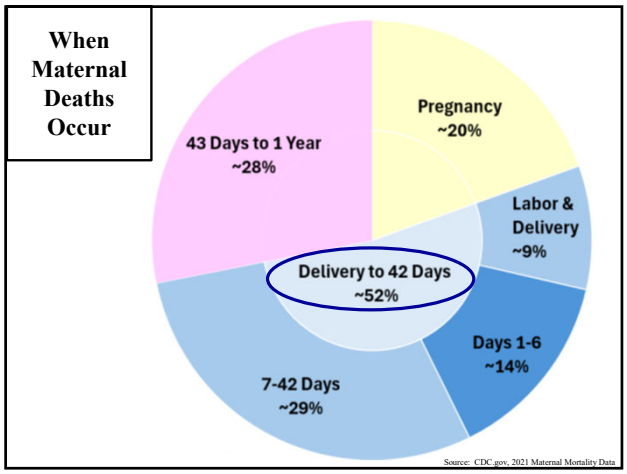

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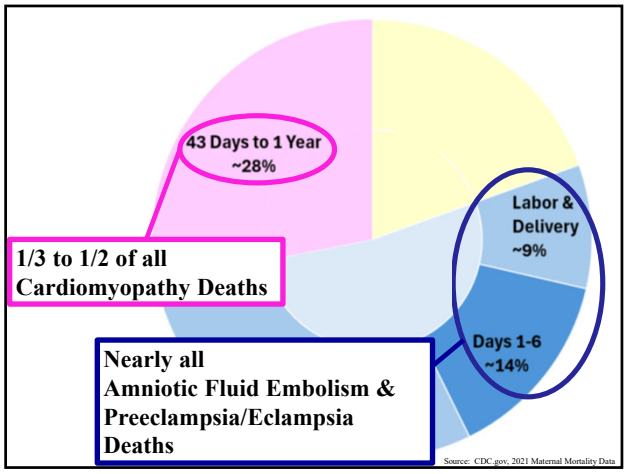

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Chronic Disease and Pregnancy

- Hypertension/Cardiovascular disease
- Diabetes mellitus
- Obesity
- Lung disease
  - Asthma
- Epilepsy
- Autoimmune disorders
- Collagen vascular disease
- Metabolic/endocrine disease
- Cancer

9

Cardiorespiratory Changes in Pregnancy

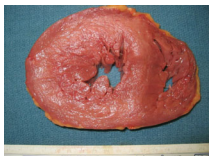
Parameter	Change	Amount
Heart rate	Increases	10%-30%
Stroke volume	Increases	…
Systemic vascular resistance	Decreases	20%-30%
Cardiac output	Increases	30%-50%
Blood pressure	Decreases	10%-20%
Respiratory rate	May increase	Minimally
Tidal volume	Increases	…
Minute ventilation	Increases	20%-40%

Table 1 from Bonham CA, Patterson KC and Strek ME. *Chest.* 2018;153:515-527.

10

Cardiovascular Diseases

- **Pre-Existing (Diagnosed or Previously Undiagnosed)**
  - Hypertensive and/or atherosclerotic cardiovascular disease
  - Congenital heart disease
  - Valvular disease
  - Vascular aneurysms/malformations
  - Conduction defects/hereditary arrhythmias
  - Dilated cardiomyopathy
    - Remote myocarditis
    - Alcohol or obesity
    - Genetic predisposition



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Cardiovascular Diseases

- **Acquired During Pregnancy**
  - Myocarditis
  - Pregnancy-related dilated cardiomyopathy
  - Pregnancy-related spontaneous coronary artery dissection

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Diabetes Mellitus

- Pre-Gestational DM
  - 1 in 15 women
  - ~2% pregnancies affected by DM, type 2
  - Dramatic increase driven by obesity and sedentary lifestyle
- Classical Gestational DM
  - Detected ~24-28 weeks gestation
  - Generally less severe than overt DM

References: Wilkie 2026,

13

Diabetes Mellitus

- Increased risk:
  - >3x risk of preeclampsia
  - Cesarean delivery
  - Fetal/neonatal risks

References: Wilkie 2026,

14

Gestational Diabetes Mellitus

- Normal 50-60% decrease in insulin sensitivity during later gestation
  - Helps ensure supply of nutrients to fetus, including glucose
  - Normal glucose-tolerant and GDM women produce insulin in a glucose challenge
    - GDM women don't produce enough
- Maternal obesity exacerbates insulin resistance
- Defects in insulin resistance and secretion most likely antedate pregnancy in many cases
  - 7-10x risk of GDM developing type 2 DM post-pregnancy

References: McIntyre 2025

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Obesity

- **Most common health problem in women of reproductive age**
- 33% relative increase in prevalence of obesity among of reproductive age since 2001-02
- Nearly 60% of women current begin pregnancy overweight or obese
- Cause or contributing factor in multiple co-morbidities

Reference: Creanga AA, et al. NEJM, 2022

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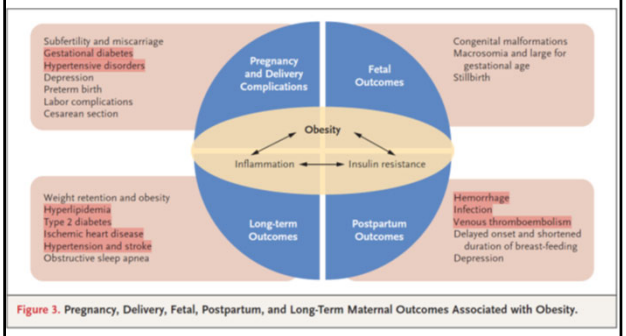


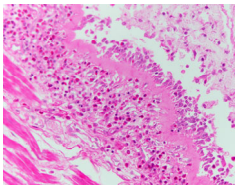
Figure 3. Pregnancy, Delivery, Fetal, Postpartum, and Long-Term Maternal Outcomes Associated with Obesity.

Reference: Figure 3 from Creanga AA, et al. NEJM, 2022

17

Asthma

- 5-10% of pregnant women in the United States have asthma
- Most common respiratory disorder to complicate pregnancy
  - Pregnancy-associated new-onset asthma
  - Severe asthma may worsen
- Strong associations with:
  - Preeclampsia
  - Placental abruption
  - Placenta previa
  - Obstetric hemorrhage
  - Increased spontaneous abortion
  - Increased rate of Cesarean section



- Risks higher for those with severe asthma

Reference: Bonham C, 2018.

18

Epilepsy
Relative Higher Risk of Pregnancy Complication

- >90% will have normal course
  - 2/3 will be seizure-free during pregnancy
  - **1/3 may experience increase in seizures**
- Seizures
  - **Antiseizure pharmacokinetics altered** during pregnancy
    - Decreased serum levels of drug
    - Switch to monotherapy to avoid teratogenic effects
  - Fear-associated **noncompliance** with medications
  - Reduced seizure threshold
    - Sleep deprivation, stress

Reference: Blaszczyk B, 2022

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Epilepsy
Fetal Risks

- **Premature placental detachment** or fetal hypoxia during seizure
  - Secondary neurodevelopmental deficits from hypoxia during maternal seizures
- **Teratogenic effect** of antiseizure medication
  - Valproate

Reference: Blaszczyk B, 2022

20

Deep Venous Thromboses with Pulmonary Embolism

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Peripartum Relative Hypercoagulability

- 3rd trimester until 6 weeks postpartum – DVT risk is 4-6x higher than non-pregnant women
- Pro-coagulable state (evolutionary protective effect against hemorrhage)
  - Increase in multiple clotting factors
  - Decrease in natural anticoagulant protein S
  - Inhibition of fibrinolysis
- Impaired flow in lower extremities – big uterus

References: Bremme 2003; Heit, 2005; James 2005

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Highest Maternal Risk for DVT

- Pre-existing thrombophilia
  - Factor V Leiden or antithrombin deficiencies
- Pregnant women > 35 years
- Cesarean deliveries
- Postpartum infections
- Underlying medical conditions:
  - HTN/heart disease
  - Sickle cell disease
  - Lupus
  - Obesity
  - Past thrombosis

References: James, 2005, James, 2006

23

Hypertensive Disorders of Pregnancy

- Chronic HTN
  - Diagnosed before pregnancy or before 20 weeks
    - BP ≥ 140/90 mmHg at least two consecutive measurements
  - 1-5% of women of reproductive age
  - Increased risk:
    - Preeclampsia
    - Intrauterine growth restriction
    - Placental abruption
    - Preterm delivery
- Gestational HTN
  - ~6.4% pregnancies
  - Develops after 20 weeks without proteinuria
  - Increased risk of cesarean delivery & preterm birth

Reference: Fan, 2026

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Hypertensive Disorders of Pregnancy

- Preeclampsia
  - 3-5% of pregnancies
  - Multiorgan dysfunction
    - Liver, Renal, Neurologic Impairment
  - Thrombocytopenia
  - Systemic inflammation
- Severe Preeclampsia/Eclampsia
  - Marked HTN ≥160/110
  - Severe organ dysfunction
    - HELLP syndrome
  - Eclampsia = Preclampsia with Seizures/Coma

Reference: Fan, 2026

25

Preeclampsia/Eclampsia

- More common in:
  - Primiparas
  - Preexisting kidney disease
  - Genetic predisposition
- Generally presents in 3rd trimester
- Etiology believed to be related to abnormal placentation:
  - Endothelial dysfunction
    - Stimulation of vasoconstrictor production (endothelin, thromboxane, angiotensin)
    - Inhibition of vasodilator production (prostaglandins)
  - Shallow implantation
  - Placenta release of antiangiogenic factors
  - Defect in decidual vessels leads to placental ischemia

Reference: Tyrmi 2023, Fan 2026

26

Preeclampsia/Eclampsia

Primary Signs/Symptoms

- Headache
- Visual disturbances
  - Scotoma – partial blind spot in visual field
  - Phosphene signals – seeing colors/light spots
- Tinnitus
- Right upper quadrant abdominal pain
- Dyspnea/hypoxemia/pulmonary edema

Reference: Fan 2026, Uzan 2011

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Preeclampsia/Eclampsia

Physical Examination and Laboratory Findings

- HTN
- Pulmonary edema
- Brisk reflexes
- Elevated creatinine
- Proteinuria (24 hour ≥ 0.3 grams)
- Hemolysis
- Elevated liver enzymes
- Low platelets (severe if <100k/µL)
- Clinical evidence of DIC
  - Decreased fibrinogen, elevated D-dimers, elevated PT/PTT

Reference: Fan 2026, Uzan 2011

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Preeclampsia/Eclampsia

Supportive Autopsy Findings

- Cerebral edema
- Pulmonary edema
- Periportal or wider hepatic necrosis
- Autopsy evidence of DIC
  - None to minimal postmortem clotting
    - Visceral petechiae
    - "Oozing from every cut surface"
  - Fibrin microthrombi in viscera

Reference: Fan 2026

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42 G7 P5025 with Eclampsia

- Complained of feeling dizzy
- Sat down on chair and became unresponsive
- "Urinated"
- Seizure activity
- DOA
- Ruptured membranes
- Full term fetus in utero

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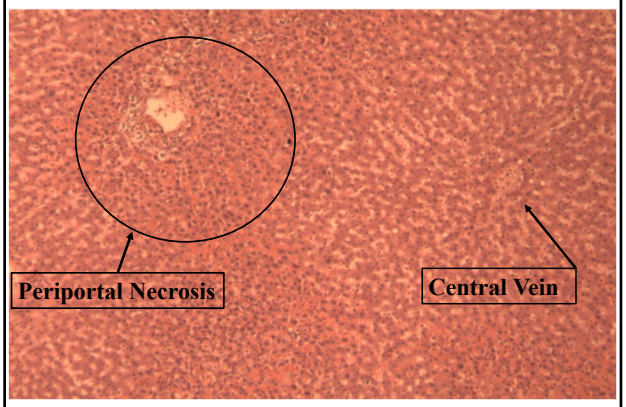

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Hypertensive Disorders of Pregnancy

- Gestational HTN – 80% will have chronic postpartum HTN
- HHD - Predictive of long-term cardiovascular disease

Reference: Fan, 2026

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Hemorrhagic Disorders of Pregnancy

2012-2019 CDC data –

– Hemorrhage 12.1% of maternal deaths

- Postpartum hemorrhage (1/3)
  - Includes placenta accreta spectrum
- Ruptured ectopic pregnancy (22.9%)
- Placental abruption
- Uterine rupture
- Other hemorrhage

Reference: Hollier 2024, Giouleka 2022

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Common Causes of Postpartum Hemorrhage

- Uterine atony (70-80%)
- Genital tract lacerations / iatrogenic injuries
- Placenta accreta spectrum
- Retained products of conception
- Placental abruption
- Maternal inherited or acquired coagulation disorders

References: Oyelese, 2010; Wang, 2024; Krakowiak, 2025

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Postpartum Hemorrhage – Definition (ACOG)

- Early
  - Blood loss ≥ 1000 mL OR Accompanied by signs/Sx of hypovolemia within 24 hours
    - Uterine atony
    - Trauma
- Late
  - 24 hours-12 weeks postpartum
  - 0.2-2.5%
  - Retained products of conception, placenta accreta, subinvolution of placental bed, infection

Reference: Giouleka 2022

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"4 T's" of Postpartum Hemorrhage

- Tone
  - Uterine atony (70% of postpartum hemorrhage worldwide)
- Trauma
  - Genital Tract
- Tissue
  - Retained products of conception
- Thrombin
  - Coagulopathy

Reference: Giouleka 2022

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Placenta Accreta Spectrum

- Placenta accreta
  - Placenta attaches to myometrium
  - Partial or complete absence of decidua
  - Common over uterine scar
- Placenta increta
  - Invades into myometrium
- Placenta percreta
  - Perforates myometrium to serosa

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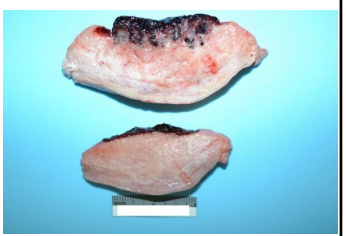
Placenta Accreta Spectrum
Risk Factors

- Past cesarean delivery – most common
- Other past uterine operations
  - Uterine myomectomy
  - Curettage
- Placenta previa or low-lying placenta
- Other less consistent risk factors:
  - Advanced maternal age
  - Multiparity
  - Multiple pregnancies
  - In vitro fertilization
  - Anemia
  - Smoking
  - Cocaine use

Reference: Bonanni 2025

38

Placenta Accreta in Postpartum Uterus



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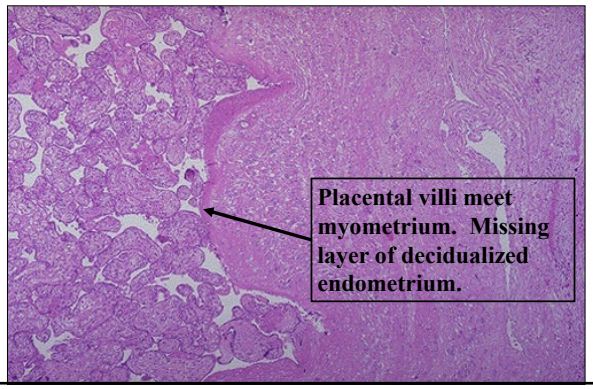
Placenta accreta



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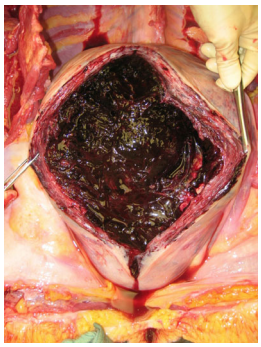
Placental Abruption Presentation

- Vaginal bleeding
- Uterine rigidity
- Hypotension
- Abdominal pain



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Risk factors for Placental abruption

- HTN
- Substance abuse (stimulants; cocaine)
- Abdominal trauma
- Premature rupture of membranes
- Coagulopathy
- Multiparity

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Ruptured Ectopic Pregnancy

- Represents 22.9% of Maternal Hemorrhage Deaths
- Risk Factors:
  - Hx Pelvic Inflammatory Disease
  - Tubal Disease
  - Smoking
  - Past use of IUD
  - Pregnancy with IUD
    - •Prevalence as high as 53% with IUD

References: Stabile 1990, Bouyer 2003, Hendriks 2020

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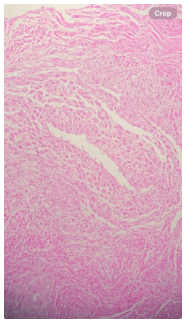
Ruptured Ectopic Pregnancy

- Endometrium will show decidualized change without products of conception



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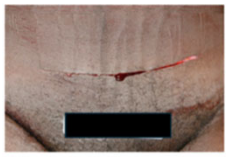
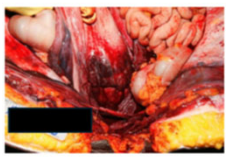
Many Roads Lead to Obstetric DIC

- Amniotic fluid embolism
- Eclampsia/Pre-eclampsia/HELLP
- Septic shock or viremia
- Placental abruption
- Transfusion reaction
- Placenta previa
- Retained fetus
- Retained products of conception
- Abortion





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DIC

Two main mechanisms:

-Widespread endothelial injury (infection, hypoxia/shock/acidosis)

-Release of tissue factor or thromboplastins in the circulation (retained placenta or fetus, amniotic fluid)

Labs:

-High D-dimers

-Low fibrinogen

-Low platelets

-prolonged PT/aPTT

Autopsy:

-Oozing of blood from cut surfaces / hemorrhage

-Fibrin microthrombi

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Sheehan's Syndrome

- Usually presents as long-term consequence of maternal hemorrhage
  - Amenorrhea is most common presenting symptom
- Acute pituitary infarction - UNCOMMON
  - Hypotension
  - Shock
  - Seizures
  - Altered mental status
  - Hypoglycemia
  - Hyponatremia
  - Failure to lactate (hypoprolactinemia)
  - Central diabetes insipidus
  - Adrenal insufficiency

Reference: Diri, 2016

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Investigation of Peripartum Maternal Deaths

- History and clinical presentation
  - Emphasis on:
    - Timeline of symptoms and events
    - Vital signs – BP, pulse, temp, RR, oxygen saturations
    - Blood loss
    - Creatinine
    - Urinalysis results (proteinuria?)
    - Liver enzymes
    - CBC with platelet counts
    - Hg/Hct, coagulation profile (PT, PTT, d-dimers, fibrinogen)
  - Clues in prenatal care history
- Autopsy/Histology

Not always a correlation between clinical severity and anatomic findings!

48

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Cardiovascular deaths in pregnancy and peripartum

Emily R. Duncanson, MD
Jesse E. Edwards Registry of Cardiovascular Disease

1

Heart-related disease in pregnancy

- Pregnancy is a "cardiovascular stress test"
  - Even in uncomplicated pregnancy there is marked hemodynamic stress
  - Increased blood volume
  - Dilutional anemia
  - Shunting of 25% of blood volume to fetus
  - Increased LV mass and volume
- May unmask existing cardiac conditions (hypertension, familial cardiomyopathy, valve disease, undetected ASD/VSD/PDA)

2

Natural death in pregnancy/postpartum

- Hypertension
- Pulmonary embolus
- Amniotic fluid embolus
- Pre-eclampsia
- Sepsis
- Peripartum cardiomyopathy
- Coronary artery dissection

3

Peripartum cardiomyopathy

- Rare cause of heart failure occurring in late pregnancy or in the first six weeks after childbirth
- May occur up to 5 months following childbirth
- CLINICAL DIAGNOSIS!!

4

Peripartum cardiomyopathy

- It is a *clinical diagnosis of exclusion* that presents with heart failure
- NOT considered a cause of sudden death without previous complaints or signs of CHF
- NOT on the differential if the heart is normal and no history of CHF signs or symptoms
- Criteria:
  - Development of HF toward the end of pregnancy or in the 5 months following delivery
  - Absence of other cause of HF
  - LV dysfunction with EF <45%

5

Peripartum cardiomyopathy

- Cardiac findings are mild and nonspecific
- Dilated morphology, but usually normal weight or mild cardiomegaly; "floppy"
- Diagnosis *very much* based on history
- Other "unmasked" cardiomyopathy (HCM, AC, DCM), htn, PE, valve disease, coronary artery dissection/infarct can be ruled out on exam
- Etiology unknown
  - Genetic- family and racial/ethnic clusters (higher rates in black women in US and aboriginal Canadian women)
  - Cytokines
  - Maternal autoantibodies in response to fetal antigen
  - Myocarditis

6

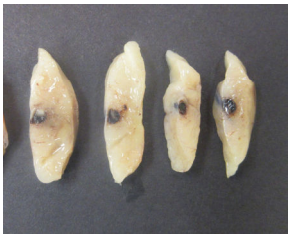
Spontaneous coronary artery dissection (SCAD)

- Nontraumatic, noniatrogenic separation of coronary arterial wall
- Large studies including 10 million+ patients with acute coronary syndromes show 0.1 to 4% of cases caused by SCAD
- 85-90% female
- Women <50 yrs account for 25% of SCAD cases
- Mean age around 50 yrs for both men and women
- Unknown mechanism

7

Predisposing factors

- "Fibromuscular dysplasia" in other arteries
- Connective tissue disorder
- Exogenous hormones (IVF, OCP, HRT, gender transition)
- *Endogenous hormones esp. pregnancy or postpartum*
  - *Hormonal changes continue into postpartum period*
- Previous SCAD (10-15% recurrence)



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Coronary artery dissection

- 2-18% postpartum
  - Hormonal
- May have eosinophils in *adventitia* in dissection segments
- Take sections of uninvolved arteries
  - Arteritis
  - Medial degenerative changes
- Molecular studies for connective tissue disorders
- Sections of other arteries to look for FMD

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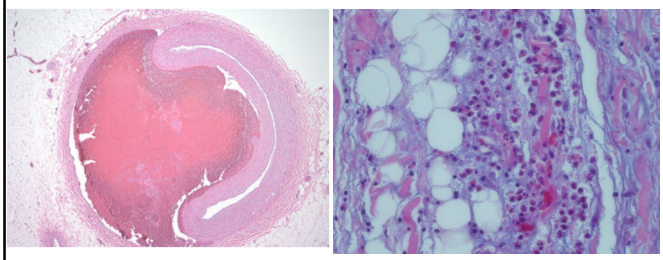

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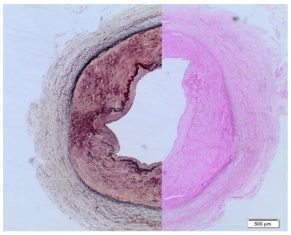
Fibromuscular dysplasia

- Non inflammatory, non atherosclerotic vascular disease affecting small to medium vessels
- May have medial smooth muscle hyperplasia or fibroplasia
- Or fibrotic intimal hyperplasia



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Pregnancy-associated SCAD

- Major peaks and valleys of estrogen during and after pregnancy
- Usually early postpartum, 80% within first month
- Death is rare (studies w 70 women had no deaths)
- Pregnancy-associated SCAD more severe- multivessel, proximal dissection, worse CHF
- Previous SCAD may recur in association with pregnancy
- SCAD in general also thought to be precipitated by stress

12

Pregnancy-associated SCAD- risk factors

- Pre-existing hypertension (27-32% of SCAD in pregnancy)
- Gestational htn (14%)
- Previous fertility treatments (15%)
- Smoking (11 or 22%)
- Dyslipidemia (20%)

13

Other arterial dissections in pregnancy

- Increased risk of aortic dissection
  - Still very low incidence overall 0.0004%
  - 50% of aortic dissection in women of childbearing age are pregnancy-related
  - Increased hemodynamic stress
  - Hormonally induced changes in aortic media
  - All risk factors are magnified in people with connective tissue disease
- Carotid artery/arch branch dissection

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15

Amniotic Fluid Embolism:
100 Years Since Medical Examiner Discovery

Miranda Klassen, Executive Director AFE Foundation

1

First Pathologic Observation of AFE

- JR Myers 1926 in Brazil
- ROM, fever, intrauterine fetal demise
- Delivered 15 days later
- Respiratory distress, seizure, pph, death
- Fetal material in lungs, ovarian veins, chorio
- First link between fetal debris in circulation and sudden maternal collapse


Brazil-Medico

https://pubmed.ncbi.nlm.nih.gov/27512417/

2

Steiner and Lushbaugh Contributions

- 1941 defined AFE based on post-mortem findings of fetal squames in pulmonary vasculature in 8 maternal deaths
- Mechanical obstruction from PE and activation of anaphylactoid reaction
- In 34 maternal death controls (19 in labor or died 9 hours later) only 1 had mucin, all others had no fetal squames.
- Scientific uncertainty, while still trying to build early theories based on available observations

https://pubmed.ncbi.nlm.nih.gov/27512417/

3

Steiner and Lushbaugh: Animal Models

- Meconium of recent fetal death of varying amounts injected into rabbits
  - Dyspnea, seizure, death
  - Pulmonary- no gross significance, but microscopically significant stringy material stained similarly to mucin in arterioles
- Human Amniotic Fluid with waxy vernix
  - Pulmonary edema, petechial hemorrhage, no mucous
- Clear Amniotic Fluid

4

85 Years Later

Remains True
AFE is a sudden, severe obstetric syndrome triggered by amniotic fluid exposure that incites hypoxia hypotension, and bleeding.

Disproven
Primarily caused by physical blockage (embolism) of the lungs."

Revised
Fetal squames in the lungs are not diagnostic, but rather highly suggestive

5

Prophetic Words

"Let us be careful not to make the diagnosis of amniotic fluid embolism a waste basket for cases of unexplained death during labor."

-Nicholson Eastman, MD 1948

6

Clark Contributions to Understanding

- 1980'-1990's S.L. Clark registry, increased diagnostic tools, and case reviews disprove the previous theory. Swan Gans specimens reveal squames found in critically ill pregnant patients w/o AFE
- 1995 opposes a new name based on his registry data collection: Anaphylactoid Syndrome of Pregnancy- despite its greater relevance, the name is not widely adopted
- 2008 IRB approved, HIPAA-compliant AFE Registry through the AFE Foundation
- 2016- Diagnostic criteria for research purposes
- 2018 – Pulmonary obstruction is not involved

7

The #1 impediment to progress is DIAGNOSIS

8

Clark Criteria for Research Purposes

TABLE 2
Uniform diagnostic criteria for research reporting of amniotic fluid embolism

1. Sudden onset of cardiorespiratory arrest, or both hypotension (systolic blood pressure <90 mm Hg) and respiratory compromise (dyspnea, cyanosis, or peripheral capillary oxygen saturation [S_pO_2] <90%).
2. Documentation of overt DIC following appearance of these initial signs or symptoms, using scoring system of Scientific and Standardization Committee on DIC of the ISTH, modified for pregnancy.[19] Coagulopathy must be detected prior to loss of sufficient blood to itself account for dilutional or shock-related consumptive coagulopathy.
3. Clinical onset during labor or within 30 min of delivery of placenta.
4. No fever (≥38.0°C) during labor.

DIC, disseminated intravascular coagulation; *ISTH*, International Society on Thrombosis and Hemostasis.

Clark. Case definition of amniotic fluid embolism to improve quality of clinical and translational research. Am J Obstet Gynecol 2016.

9

Hope on the Horizon

"The Amniotic Fluid Embolism Registry is the most promising opportunity in better exploring this condition and developing a means of prevention and treatment."

- Steven L. Clark, MD, 2016

10

Incidence & Mortality Rates

- How strictly do you define it?
  - Administrative data – high incidence, low mortality.
  - Clinical records review – low incidence, high mortality.
- Current estimate is 1 in 40,000 deliveries
- How catastrophic is the presentation?
  - Classic triad with arrest (80%)
  - Form Fruste (20%)

11

Risk Factors

- Advanced maternal age
- Multifetal gestation
- Placenta previa
- Placental abruption
- Polyhydramnios
- Instrumentation
- Uterine rupture

12

Underlying Cause?

- Multifactorial, non-IgE immune-mediated, maternal response to amniotic fluid
- Evidence of complement activation, extrinsic pathway of the coagulation cascade
- Transient pulmonary hypertension with R-sided heart failure and hypoxia, then L-sided heart failure

13

How Can We Determine the Mechanism?

- We need to investigate ALL maternal deaths
- Pregnancy related: death from any cause during pregnancy or within 1 year of end of pregnancy related to or aggravated by the pregnancy
- Pregnancy associated: death during and within 1 year of end of pregnancy of any cause

14

Role of the Medical Examiner

- Essential role: uncover causes & mechanisms of maternal deaths
- Reality: some unexplained maternal deaths not automatically accepted
- Opportunity: early collaboration = full autopsy + expanded sampling
- Goal: Clarity for ME involvement in unexplained peripartum deaths
- Impact: each investigation brings us closer to preventing AFE deaths

15

Clinical vs. Autopsy Findings

- 42 maternal death autopsies → 36% discordant with clinical diagnosis
- 38% of non-autopsied cases cause could not be clarified from chart
- Without autopsy, misclassification & missed diagnoses persist

Wakasa, T., Ishibashi-Ueda, H., & Takeuchi, M. (2021). Maternal death analysis based on data from the nationwide registration system in Japan (2010-2018). Pathology International, 71(4), 223–231. https://doi.org/10.1111/pin.13076

Ghalib Yassin, B. A., Hassan Al-Safi, A. M., & Al-Saneed, E. H. (2022). Autopsy versus Clinical Decisions Regarding Causes of Maternal Death in Iraq. Indian Journal of Community Medicine: Official Publication of Indian Association of Preventive & Social Medicine, 47(2), 177–181. https://doi.org/10.4103/ijcm.ijcm_571_21

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AMNIOTIC FLUID EMBOLISM FOUNDATION

New Opportunity for Investigation

- Expanded autopsy sections: heart, lung, brain, ectocervix, endocervix, full-thickness LUS
- Blood sampling: pre-event admission & discarded event specimens (will come from hospital)
- Compare pre- and post-onset for biomarkers & histology

17

Specimens

- Pre-event blood specimens: hospital admission bloods
- Blood taken during the event but before transfusion
- Autopsy blood and tissue

18

Potential Impact

- Earlier recognition & targeted interventions
- Evidence-based prevention strategies
- Reduce maternal & neonatal mortality

19

Be Curious

AMNIOTIC FLUID EMBOLISM FOUNDATION

- Collaboration with AFE Foundation
  - Enroll, tissue procurement, or determine if patient qualifies for state or AFE Foundation autopsy funding
- Expand ME involvement in unexpected maternal deaths
  - Maternal Mortality Review Committee (MMRC)
  - Jurisdictional clarity for your county / state
  - Legislation - funding to support investigations (know your data)

20

Amniotic Fluid Embolism:

Autopsy Findings that Support Diagnosis

Melissa Pasquale, MD
Associate Medical Examiner
Connecticut Office of the Chief Medical Examiner

21

Amniotic Fluid Embolism

- **Highly dependent on clinical presentation**
  - **Hemodynamic collapse**
  - **Respiratory distress**
  - **Coagulopathy**
- **Autopsy**
  - **Exclusion of other causes**

TABLE 3
Differential diagnosis of amniotic fluid embolism

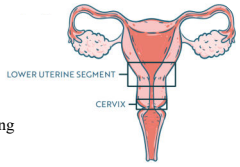
Pulmonary thromboembolism
Air embolism
Anesthetic complications (total spinal or high epidural block)
Drug-induced allergic anaphylaxis
Myocardial infarction
Cardiac arrhythmia
Peripartum cardiomyopathy
Aortic dissection
Aspiration of gastric contents
Reaction to local anesthetic drugs
Blood transfusion reaction
Sepsis
Postpartum hemorrhage
Uterine rupture
Placental abruption
Eclampsia

Conde-Agudelo. AFE: an evidence-based review. Am J Obstet Gynecol 2009.

22

Autopsy Sections in Suspected Amniotic Fluid Embolism

- Brain
- Heart
- Ectocervix/Endocervix
- Lower uterine segment
- 1-2 Sections of each lobe of lung



Slide Courtesy of Dr. Katherine Maloney

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Signs of Coagulopathy

- Oozing of blood from small vessels at autopsy
- Fibrin microthrombi

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Fetal Debris in Maternal Pulmonary Arterioles

Fetal Debris	Stain
Squamous Epithelial Cells	Cytokeratin AE1/AE3
Mucin	Alcian Blue, Mucicarmine, PAS, IHC TKH-2
Meconium	IHC ZnCp-1, TKH-2
Lanugo	Polarized Light
Vernix Caseosa	Oil-Red-O

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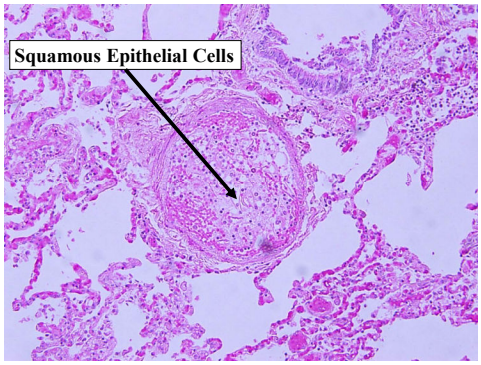

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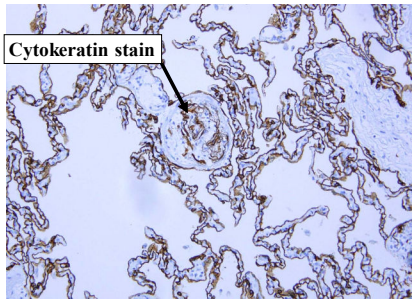

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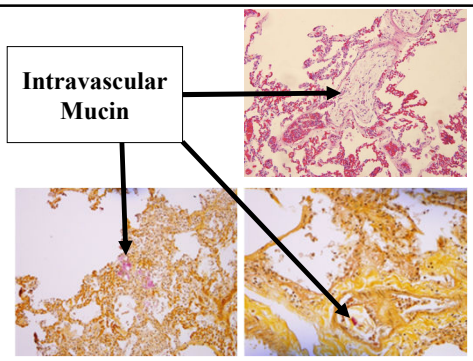

Mucicarmine photos courtesy of Dr. Kristen Landi, NYC OCME

28

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14 Amniotic Fluid Embolism Deaths

NYC OCME, Jan/2000 and Oct/2012

Fetal Debris	# Autopsies	%
Squamous cells	12/14	**85.7%**
Mucin	3/14	**21.4%**
Vernix caseosa	5/14	**35.7%**
Lanugo	1/14	**7.1%**
Meconium	"Possible" 1/14	**7.1%**

30

Published AFE Autopsy Studies:

73-100% with Fetal Debris in Maternal Circulation

Study	# Autopsies	Findings
Attwood 1958	13	100% with fetal debris NOS
Lumley 1979	1	Squamous cells, mucin and lanugo
Lau 1994	10	• 100% with squamous cells • 1 autopsy with mucin
Clark 1995	22	73% with fetal debris NOS
Sinicina 2010	7	• 100% with squamous cells • 3 with mucin • 2 with meconium

31

Squamous Cells in Maternal Circulation

- Good sensitivity, poor specificity
  - Most common finding in amniotic fluid embolism
- Found in 21-100% of pregnant women without AFE and in non-pregnant women with intravascular catheterization (Conde-Agudelo 2009)
- Mucin stains have higher specificity

32

Tryptase – Elevated or Normal

- Benson 2001 – 7 women with AFE did NOT have elevated tryptase
- Nishio 2002 – 1 AFE with elevated tryptase (67.2 ng/mL)

33

Amniotic Fluid Embolism

- Cannot be predicted or prevented
- It is a clinical syndrome
  - No good diagnostic criteria
  - No clinical laboratory test can confirm or exclude
- Mechanism is thought to be primarily humoral rather than obstructive
  - Research suggests activation of complement

34

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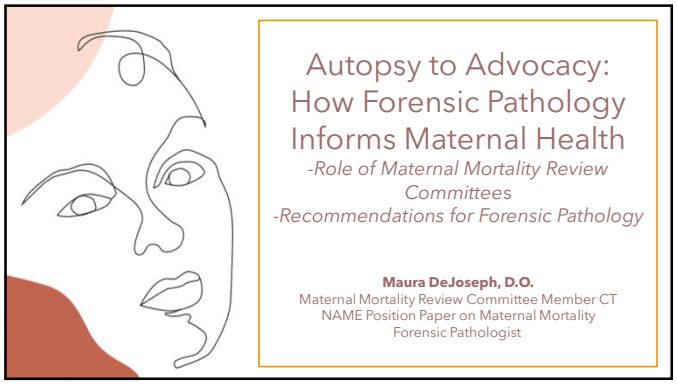
Autopsy to Advocacy:
How Forensic Pathology Informs Maternal Health
-Role of Maternal Mortality Review Committees
-Recommendations for Forensic Pathology
Maura DeJoseph, D.O.
Maternal Mortality Review Committee Member CT
NAME Position Paper on Maternal Mortality
Forensic Pathologist

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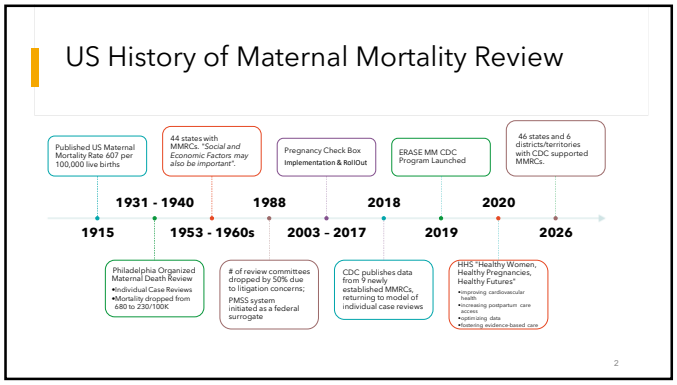
US History of Maternal Mortality Review
Published US Maternal Mortality Rate 607 per 100,000 live births
44 states with MMRCs. "Social and Economic Factors may also be important".
Pregnancy Check Box Implementation & RollOut
ERASE MM CDC Program Launched
46 states and 6 districts/territories with CDC supported MMRCs.
1915
1931 - 1940
1953 - 1960s
1988
2003 - 2017
2018
2019
2020
2026
Philadelphia Organized Maternal Death Review
•Individual Case Reviews
•Mortality dropped from 680 to 230/100K
# of review committees dropped by 50% due to litigation concerns;
PMSS system initiated as a federal surrogate
CDC publishes data from 9 newly established MMRCs, returning to model of individual case reviews
HHS "Healthy Women, Healthy Pregnancies, Healthy Futures"
•Improving cardiovascular health
•Increasing postpartum care access
•optimizing data
•fostering evidence-based care
2

2


Pregnancy Mortality Surveillance System
MMRIA
INFORMATION APP

3

Maternal Mortality Review Committee (MMRC) Design

- Legislation Supported or Free Standing
- Defined Composition of Subject Matter Experts
  - ***CDC Recommends ME/C be a member of MMRC***
- Meet Regularly
  - Individual Review of Maternal Deaths
  - Educational Opportunities
  - Health Promotion / Campaigns
  - Recommendation Development

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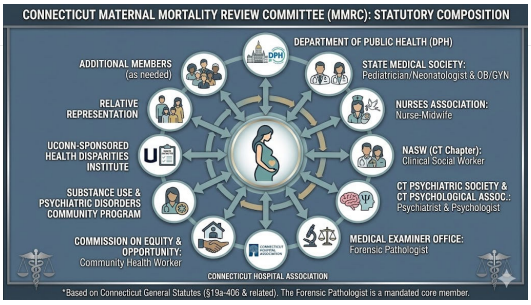
MMRC Composition



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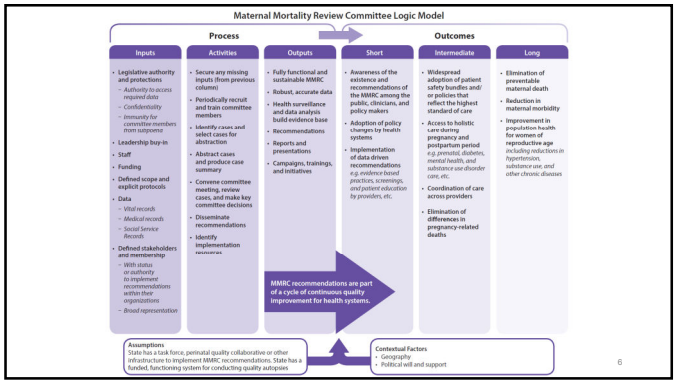

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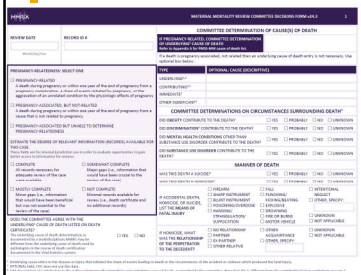
The Specific Work of the MMRC



- Case Abstraction by Designated Member(s)
- Review of De-identified case – Medical and Social
- Use of MMRIA Form to Facilitate Case Review
  - Cause of Death
  - Contributory Causation (Obesity, Mental Health, Substance Use)
  - **Pregnancy Related, Pregnancy Associated, Unable to Determine**
  - Preventability – None, Some, Significant, Unable
  - Recommendations for Prevention and Level of Impact
- Annual Data / Publications / Education / Interventions

7

7

The Forensic Pathologist on MMRC

- Cause of Death Review and Explanation / Clarification
- Interpretation of Complex Autopsy Findings and Physiologic Mechanisms
- Correct or Refine Death Certification
- Assist in Determination of Pregnancy-Relatedness
- Development of Professional Relationships
- Feedback to Death Investigation System

8

8

Number of Deaths During or within 1yr of Pregnancy

- **Total US Annual Deaths During or within 1 yr of Pregnancy**
  - 3,600 deaths
- **Pregnancy-Related**
  - 800 - 1000 across the United States, Natural Deaths
- **Pregnancy-Associated**
  - 2,600- 2,800 Predominantly Non-Natural Deaths,
  - Likely already under ME/C Jurisdiction

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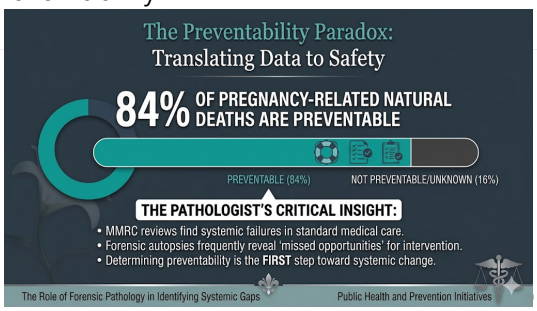
Preventability



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MMRC Outcomes

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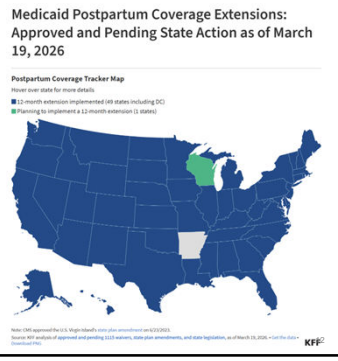
MMRC Outcomes - National Impact



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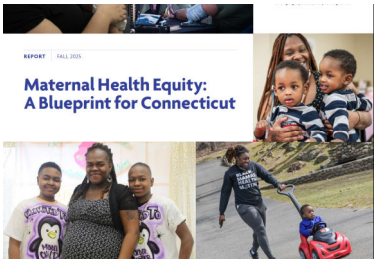
MMRC Outcomes - State Level



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So …. Can Your Jurisdiction Conduct a Few More Maternal Death Investigations?

- Marked decrease in maternal mortality with the initiation of individualized granular death reviews.
- Improved consistency of death certification, therefore better data
- Improved understanding of pathologies occuring during pregnancy and postpartum period
- The information makes a difference and can lead to prevention.

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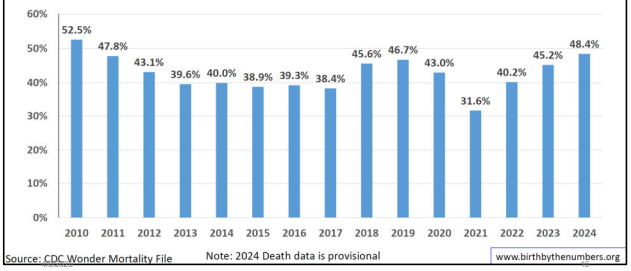
Rate of Autopsies in Maternal Deaths

In national death certificate data from 2018-2024, only 41.0% of maternal deaths involved an autopsy



Source: CDC Wonder Mortality File Note: 2024 Death data is provisional www.birthbythenumbers.org

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NAME Position Paper on Maternal Mortality

Jurisdiction	Make Maternal Deaths Reportable in your ME/C Jurisdiction
Disposition	These are Rare, and Unexpected - so ME/C Should Consider Taking Jurisdiction
Examination	Low Threshold for Thorough Full Autopsy; Standardized Protocols
Public Health	Be a part of a MMRC; Forensic Pathologists are Important!
Accuracy	Accurate Death Certification is paramount. Use the Pregnancy Checkbox accurately. Utilize etiologically specific underlying causes of death
Support	Education and Peer Community through NAME

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Small Ask with Big Impact

Economic Cost of US Maternal Deaths

- Value of Statistical Life (VSL) for Maternal Deaths is estimated to be **$10.4 billion dollars annually**
  - Young persons
  - Medical costs
  - Child Care Labor Costs
  - Children with Risks of Developmental Delays, Mental Health Disorders

Additional US Autopsies

- Average 800 - 1000 **pregnancy-related** deaths per year, about 3 per day across the country
  - Fewest Vermont (<10/yr)
  - Most Mississippi (~80/yr)
- **80% of these deaths are deemed preventable**; ME/C can add to prevention efforts

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A Little More Work for **A LOT** of Good Cause

NAME Can Support Your Role in Maternal Death Prevention

- Upcoming Survey of Membership to Determine Extent of Participation on MMRCs
- Consider Ad-Hoc Maternal Mortality NAME Committee for Peer Support
- Position Paper
  - Autopsy Protocols, Ancillary Studies, Report Writing Tips
- Encouragement to Join or Build MMRC
- Reach-Out to the Speakers Here Today!

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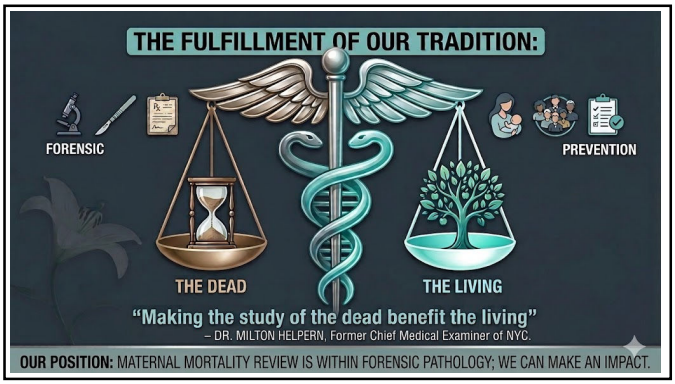

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