

Congenital Syphilis and How It Links to Stillborn Pregnancies

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Congenital syphilis remains a critical public health challenge in the United States, with consequences that extend far beyond the well-documented effects in adults. Recent research has drawn attention to its profound impact on pregnancy outcomes, particularly the risk of stillbirth (Labudde & Lee, 2024; Machefsky et al., 2024; Su et al., 2016). While non-syphilis-related pregnancies experience a stillbirth rate of approximately 1 in 160, syphilis-related pregnancies face a dramatically higher rate of 1 in 20 (Machefsky et al., 2024). This disparity is especially troubling given that timely and adequate treatment can prevent fetal transmission in nearly 75% of cases (Eppes et al., 2022). The rising incidence of congenital syphilis highlights systemic gaps in prenatal care, inequities in access to treatment, and challenges in surveillance, underscoring the need for not only clinical interventions but also stronger data infrastructure to monitor and respond effectively to syphilis-related pregnancy outcomes. To support these efforts, this project proposes the development of a data linkage pipeline that connects fetal death records with maternal syphilis diagnoses in Marion County Indiana.

Syphilis is a bacterial infection that is transmitted from mother to child during pregnancy and has been on the rise nationally (Su et al., 2016). It has been linked to noticeable gaps in prenatal care and delays in diagnoses (Machefsky et al., 2022). While the rise in stillbirths is one serious consequence of congenital syphilis, another concern lies in the lifelong developmental delays it can cause, with manifestations appearing as early as three months of age. These abnormalities may include mucous membrane gummas, Hutchinson teeth, intellectual and developmental disabilities, as well as other neurological and physical impairments (What Is Congenital Syphilis?, n.d.).

The criteria for what the Centers for Disease Control and Prevention (CDC) and Marion County Public Health Department consider a stillborn birth is a loss of a pregnancy from week 20 to any time before the birth. Stillbirths are categorized into three groups: early (20-27 weeks), late (28-36 weeks), and term (37 or more weeks) (CDC, 2025). The deaths are recorded in the County where the death occurred rather than where the mother resides, which often presents problems with fetal deaths. Items included in a stillborn certificate are, but are not limited to mother's name, race, ethnicity, current County, zip code, and date of birth. There are also questions about whether the mother had syphilis, but this is not always accurately reported. If available, the father's information is also recorded; however, it is not always available or requested.

Stillborn death certificates face several limitations, including processing delays and difficulty linking them to maternal records. At hospitals, information is often collected by bereavement counselors—who may lack training in data collection—rather than clinical staff, leading to

incomplete documentation. Funeral homes then attempt to fill in missing details before submitting the certificate to the local health department. After local review, the records are forwarded to the State, where official death codes are assigned. By law, stillborn deaths must be reported to the local health department and registered within six weeks (Team, n.d.). However, families rarely have a pressing need to receive the certificate quickly. The assignment of cause-of-death codes by the State Department of Health can also be time-consuming, especially in facilities without dedicated staff to enter the data promptly.

A pipeline for linking fetal death records to maternal syphilis diagnoses involves four key stages: data ingestion, preprocessing, matching, and visualization. In the ingestion phase, two primary data sources are incorporated. Stillbirth data are collected from the vital records department and organized into a structured format suitable for linkage. In parallel, state investigation data are drawn from case reports and surveillance systems maintained by the health department, which often include narrative fields and structured case forms. Both datasets require harmonization at the ingestion stage to ensure compatibility for downstream preprocessing and matching. Preprocessing then standardizes variables such as date of birth, reporting county, and maternal residence, while also identifying missing or incomplete fields that require follow-up. This stage uses data merging to connect maternal records with fetal death certificates and addresses patient-matching challenges through regular expression searches and fuzzy name matching, which help reconcile discrepancies between legal and preferred names. Records that remain incomplete or mismatched are flagged for human review, ensuring data integrity before analysis.

Once the data have been cleaned and accurately linked, the matching phase focuses on identifying patterns in social determinants of health—such as access to prenatal care, insurance coverage, and neighborhood-level indicators—that may be associated with syphilis-related stillbirths. Statistical modeling can then estimate risk factors and detect geographic or demographic clusters of concern, providing insight into populations at heightened risk. The final stage of the pipeline involves visualization, where findings are translated into clear, interpretable graphics that highlight disparities, track trends, and guide resource allocation. By adopting this structured approach, Marion County can enhance the precision of congenital syphilis surveillance and strengthen its ability to respond effectively to preventable stillbirths.

Congenital syphilis remains a pressing public health challenge, disproportionately impacting marginalized populations and contributing to preventable stillbirths. The dual burden on mothers and infants highlights the urgent need for more integrated surveillance systems and targeted interventions. The proposed pipeline introduces a novel, reproducible framework that enhances congenital syphilis monitoring by standardizing data inputs, linking maternal records to fetal outcomes, and applying statistical modeling to uncover patterns and risk factors. This data-driven approach not only improves reporting accuracy and reduces delays but also empowers local health agencies with actionable insights to support equitable treatment distribution and proactive prevention strategies.

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