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Factors Associated with Stillbirth Autopsy Rates in Georgia and Utah, 2010-2014:
The Importance of Delivery Location

By

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B.A., Carleton College, 2010

Thesis Committee Chair: Lauren Christiansen-Lindquist, PhD, MPH

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
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2017

Abstract

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The Importance of Delivery Location
By Katie Forsberg

OBJECTIVE: To determine whether demographic, operational, and medical factors are associated with the performance of stillbirth autopsies in Georgia and Utah

METHODS: Using Georgia and Utah fetal death certificates from 2010-2014, we evaluated the relationship between demographic, operational, and medical factors and stillbirth autopsy performance. Analysis was conducted using logistic regression with a predicted margins approach. Each state was analyzed separately.

RESULTS: The stillbirth autopsy rate was low in both states, at 11.9% in Georgia (N = 5,610) and 23.9% in Utah (N = 1,425). In Utah, the autopsy rate significantly decreased during the study period ($p = 0.01$). Stillbirths delivered outside of large metropolitan areas were less likely to receive an autopsy (medium/small metropolitans: prevalence $ratio_{GA}$ [PR] = 0.57, 95% confidence interval [CI]: 0.48, 0.68 and PR_{UT} = 0.48, CI: 0.38, 0.59; nonmetropolitans: PR_{GA} = 0.57, CI: 0.43, 0.75 and PR_{UT} = 0.37, CI: 0.21, 0.63). In Georgia, autopsies were less common among stillbirths of Hispanic women than those of white women (PR = 0.57, CI: 0.41, 0.79), of earlier than later gestational ages (PR = 0.59, CI: 0.51, 0.69) and of multiple birth pregnancies (PR = 0.71, CI: 0.53, 0.96).

CONCLUSION: Despite strong evidence supporting the value of stillbirth autopsies, the autopsy rates were low in Georgia and Utah. Stillbirths delivered outside of large metropolitan areas may be particularly underserved. Additional research is needed to determine whether autopsies were not performed because they were not offered or because parental consent was not given.

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Stillbirth Autopsies in the United States: A Review

Stillbirth is a serious adverse pregnancy outcome that remains understudied (1, 2), despite its long-term psychological, social, and economic consequences (3). In the United States (U.S.), stillbirth is typically defined as fetal death occurring at 20 or more gestational weeks. The National Center for Health Statistics defines fetal death as:

> *"death prior to the complete expulsion or extraction from its mother of a product of human conception, irrespective of the duration of pregnancy and which is not an induced termination of pregnancy. The death is indicated by the fact that after such expulsion or extraction, the fetus does not breathe or show any other evidence of life, such as beating of the heart, pulsation of the umbilical cord, or definite movement of voluntary muscles. Heartbeats are to be distinguished from transient cardiac contractions; respirations are to be distinguished from fleeting respiratory efforts or gasps" (4, p. 3).*

Approximately one in 170 pregnancies that were carried to at least 20 weeks' gestation ended in stillbirth in 2013 in the U.S., making stillbirth a significant reproductive health issue (5).

Disparities in stillbirth are well-documented (6). In the U.S., non-Hispanic black women have a stillbirth rate of more than twice that of non-Hispanic white women (5). American Indian and Alaskan native women and Hispanic women also have higher stillbirth rates than non-Hispanic white women (5). Stillbirths are more common in women under 20 and over 35 years old (5, 7). A meta-analysis of stillbirths in high-income countries found additional factors associated with increased risk of stillbirth, including: being an overweight or obese mother, low education level, no or inadequate prenatal care, smoking during pregnancy, primiparity, pre-gestational diabetes, pre-gestational hypertension, gestational hypertension, and preeclampsia (7).

Despite having some understanding of risk, little progress has been made in recent years in prevention. Stillbirth is a persistent issue in the U.S., with a fairly stable rate of occurrence since 2006 (5). In contrast, the rate of infant mortality decreased by 13% from 2005 to 2013 (8).

For the first time, stillbirths became more common than infant deaths in 2011 (5). Accurate data about the causes of stillbirth are needed in order to inform, guide, and evaluate public health interventions to reduce the stillbirth rate. Such data may be obtainable by increasing the proportion of stillbirths that receive complete postmortem investigations.

The pathological evaluation of stillbirths can take different forms. A complete fetal autopsy generally includes gross examination; length, circumference, and weight measurements; x-rays; and photographic documentation (9, 10). Fetal autopsies are performed in a manner conducive to an open-casket funeral service. Ideally, a maternal history is taken and medical records are reviewed prior to the autopsy to better perform examinations and interpret results. Guidelines for fetal autopsy procedures are available elsewhere (11, 12). Other important evaluation methods beyond the autopsy include, but are not limited to, placental pathology, karyotyping for genetic anomalies, and screening for fetal-maternal hemorrhage (9, 10, 13).

Autopsies are considered the gold standard for determining cause(s) of stillbirth (14-17). Fetal autopsies can identify causes of stillbirths in previously unexplained cases (6). Autopsies can also confirm clinical findings, lead to the discovery of unanticipated findings, and help rule out suspected diagnoses (16). A meta-analysis on the value of perinatal autopsies found that about 28% to 75% of stillbirth autopsies reveal new findings, lead to a change of diagnosis, or uncover additional findings that the clinical diagnosis missed (18). The wide percentage range may be explained by heterogeneity in autopsy performance and procedural factors, or the incomplete reporting of those factors. For example, the usefulness of stillbirth autopsies may depend on whether the examination was performed by a perinatal pathologist, which examinations or tests were conducted, which definition of stillbirth was used, and what proportion of the study population received an autopsy (18). A recent study using a standardized methodology found autopsies to be useful in the confirmation or identification of a cause of death or exclusion of a suspected cause of death in 42% of cases overall, but was useful in as many as 90% of cases when fetal anomalies were present (13). These findings indicate that different conditions might affect autopsy usefulness, but that autopsies consistently contribute valuable information. Autopsies markedly improve data quality by providing reassurance when the clinical diagnosis is correct and by revising findings when the clinical diagnosis is missing, incomplete, or incorrect.

Beyond clarifying or identifying the cause of death, autopsies provide additional benefits to families, medical facilities, and researchers. Autopsies can help the families of stillborn children grieve and make future reproductive decisions (10, 15, 16, 19). Health providers can use the autopsy results to treat underlying health problems of the mother and to monitor subsequent pregnancies (10, 15, 19). Further, this information can be used to audit the quality of prenatal and delivery care and thereby improve provider practices and standards (6, 16, 19). Although rare, stillbirth autopsies may also be performed for medicolegal purposes, informing legal proceedings (19). Epidemiologically, autopsies may serve as a method of procuring data on causes of stillbirth and prevalence of disease or anomalies among stillbirths that would otherwise be unobtainable (19, 20). This can help scientists understand the current state of fetal and maternal health and generate hypotheses for and interest in future research.

In recognition of such benefits, the American Congress of Obstetricians and Gynecologists describes the fetal autopsy as one of the “most important” stillbirth evaluations and recommends autopsies as an “essential” step of the stillbirth evaluation, provided the family gives consent (10, p. 752). Similarly, perinatal health experts in the U.S. (9, 13, 21) and other high-income countries (6, 22) have recommended fetal autopsies for all stillbirths based on evidence from the scientific literature.

Despite these endorsements, only about 12% of stillbirths delivered in the U.S. underwent autopsy in 2014 (23). The rate of autopsies for live-born individuals has decreased over time (24) and European data suggest that there may be a downward trend in the perinatal autopsy rate as well (22, 25). There is an urgent need to understand the low stillbirth autopsy rate to prevent further disuse.

In order for a stillbirth autopsy to be performed in the U.S., the healthcare provider must recognize the need for an autopsy, feel comfortable that they have access to a pathologist with the requisite training, and then request consent from the family to perform it. Barriers to autopsy uptake can therefore occur on the provider or the patient/family level.

Providers may face barriers to offering autopsy or speaking convincingly to families about the procedure. Barriers include time constraints, limited resources, a lack of training, language or communications limitations, and emotional or cultural reservations. Studies from the United Kingdom have found that providers often did not feel they had received sufficient training on how to talk to families about stillbirth autopsies, and that the task of requesting consent was often passed on to junior providers or other staff members with minimal fetal pathology-related experience (22, 26, 27). This lack of education and task delegation may result from or contribute to providers' devaluation of autopsy. Providers may be concerned about causing emotional distress, feel that they do not have a strong enough relationship with the family to discuss the procedure (26), feel inadequately prepared to handle stillbirth autopsy requests with families from different cultural backgrounds than themselves (26), or may not have a translator or informational material in the patient's first language. Stillbirth autopsies are best performed by perinatal pathologists who receive special training (16, 19), so the availability of a perinatal pathologist likely affects whether or not providers offer an autopsy (28, 29).

There are barriers to autopsy uptake at the patient or family level as well. Insurance does not always cover fetal autopsies, so cost can be a deterrent. Patients may have personal, cultural, and religious reasons for refusing an autopsy. The autopsy request may come at a time that is too emotional for the mother to make an informed and thought-out decision (26), or parents may be concerned about the procedure (26, 30), the length of time needed to receive the results (26), or that family members or loved ones do not approve of autopsies (30). Researchers have also proposed that negative media portrayals of autopsies or similar medical procedures may influence autopsy decisions (22, 26, 28, 31). Moreover, patients may misunderstand clinical diagnoses as definitive diagnoses without need for additional pathological evaluation (30).

Although we can identify potential barriers to the conduct of fetal autopsies, there has been limited research on demographic, operational, or medical factors associated with the stillbirth autopsy rate. Crude estimates from the U.S. have indicated that stillbirths are less likely to receive an autopsy at community than tertiary hospitals (32), after death occurred during labor or delivery as opposed to antepartum (33), and when the cause of death was infection (33). A large study in Canada found that the mother's language was significantly associated with autopsy rate, with Allophones receiving an autopsy less often than Anglophones or Francophones (34). A Belgium study on perinatal deaths (including stillbirth, abortion, and neonatal death) found that lower autopsy rates were associated with higher order pregnancies, Muslim religion, later gestational ages, and not having a maternal-fetal medicine specialist request parental consent for the autopsy (35). In Australia, the autopsy rate was found to decrease with increasing maternal age and stillbirths with a gestational age of 20 to 29 weeks or 37 or more weeks were less likely to receive an autopsy than stillbirths with a gestational age of 30 to 39 weeks (36). Another Australian study found primigravidity, small-for-gestational age fetuses, antepartum death, and the presence of congenital anomalies were associated with a greater likelihood of autopsy, while stillbirths without an initial clinical diagnosis were less likely to receive an autopsy (37).

The literature on factors associated with autopsy among live-born individuals is slightly more robust. Factors associated with autopsies of live-born individuals, including neonates, include geographic region (38), gender (38-40), race (38), ethnicity (38), gestational age at birth (41), age (24, 38-40, 42, 43), previous pregnancy losses (41), position and previous experience of the staff requesting consent (41), location of death (38, 40), cause of death (24, 38-42), and certainty about pre-autopsy diagnosis (44). Although autopsy is an established, fundamental tool for ascertaining the causes of death among stillbirths, there are still substantial gaps in our understanding of the differences in autopsy rates across populations, particularly in the U.S.

If there are differences in the stillbirth autopsy rate by maternal and operational factors, the benefits of fetal autopsies are likely not equitably distributed. It is possible to develop evidence-based stillbirth reduction interventions for the groups at highest risk of stillbirth. However, these interventions cannot effectively target the causes of stillbirth if the groups with high stillbirth rates *also* have the lowest fetal autopsy rates and, therefore, potentially less accurate cause of death data. Thus, data on differential stillbirth autopsy rates are imperative for meaningful and actionable interpretation of cause of stillbirth data.

In the U.S., every fetal death that meets the reporting requirements of the state or jurisdiction of delivery is required to have a fetal death certificate, regardless of whether or not an autopsy was performed. While fetal death records have the potential to be a great source of data, the cause of death is often left blank or is completed with an ill-defined cause of death. An ill-defined cause of death is one in which a cause of death is listed, but does not provide any meaningful information about the actual causal event sequence (*e.g.*, “stillbirth” or “fetal demise”). The National Center for Health Statistics reported that 30% of stillbirths delivered in 2014 had an unspecified (*i.e.*, ill-defined or unknown) cause of death (23). That figure is an underestimate as only reporting areas where less than 50% of the causes of deaths were unspecified were eligible for study inclusion. Stillbirth records may be substantially more likely to have an ill-defined cause of death or a less nuanced cause of death listed than neonatal records (45), thus underscoring the need for fetal death-specific investigations and interventions. There are a number of different perinatal cause of death classification systems (46) and the percentage of causes of death categorized as unknown or ill-defined will differ by classification system. However, regardless of this heterogeneity, it is clear that the procurement and recording of a well-defined cause of death is a significant and modifiable issue in stillbirth data quality.

This study further investigates factors previously identified in the literature as associated with stillbirth autopsy rates, expands upon those factors to include other potential associated exposures, and explores this issue within the U.S. Specifically, we aimed to identify which factors are associated with stillbirth autopsy status using fetal death certificates from two geographically, demographically, and culturally distinct states: Georgia and Utah. We explored the influence of demographic, behavioral, operational, and medical factors on autopsy status.

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CONCLUSION: Despite strong evidence supporting the value of stillbirth autopsies, the autopsy rates were low in Georgia and Utah. Stillbirths delivered outside of large metropolitan areas may be particularly underserved. Additional research is needed to determine whether autopsies were not performed because they were not offered or because parental consent was not given.

Stillbirth is a serious adverse pregnancy outcome that remains understudied (1, 2), despite its long-term psychological, social, and economic consequences (3). Defined as a fetal death occurring at 20 or more gestational weeks, approximately one in 170 pregnancies carried to 20 weeks' gestation in the United States (U.S.) ended in stillbirth in 2013 (4). This rate has been fairly stable since 2006 (4). In order to decrease the stillbirth rate, accurate information about the causes of stillbirth is needed to inform, guide, and evaluate public health interventions.

Autopsy is considered the gold standard for determining causes of stillbirth (5-8). A meta-analysis found that between 28% and 75% of stillbirth autopsies reveal new findings, lead to a change of diagnosis, or uncover additional findings that the clinical diagnosis missed (9). This wide percentage range may be explained by the heterogeneity of study factors and their incomplete reporting in the literature. For example, the usefulness of stillbirth autopsies may depend on whether the examination was performed by a perinatal pathologist, which examinations or tests were done, which definition of stillbirth was used, and what proportion of the study population received an autopsy (9). Despite this heterogeneity, this finding indicates autopsies consistently contribute valuable information, and, accordingly, the importance of stillbirth autopsies has frequently been noted (9-15).

Despite their importance, limited research has evaluated demographic, operational, and maternal factors associated with the performance of stillbirth autopsies. Internationally, the few studies that have examined such factors have found associations with the mother's language (16), age (17), religion (18), and gravidity (19); type of provider requesting parental consent (18); delivery year (19); higher order pregnancies (18); gestational age (17, 18); congenital anomalies (19); being small-for-gestational age (19); timing of death (19); and whether a clinical diagnosis could be made initially (19). In the U.S., associations have been found with the type of hospital (20), timing of death (21), and cause of death (21). To our knowledge, no previous U.S. studies have examined this issue using the most recent revision of the fetal death certificate (the 2003 revision). Although autopsy is an established, fundamental tool for ascertaining the causes of stillbirth, there continues to be substantial gaps in research on the variations in autopsy rates across populations.

If there are differences in the stillbirth autopsy rate by maternal and operational factors, the benefits of fetal autopsies are likely not equitably distributed. There are known disparities in U.S. stillbirth rates (4, 22), and it is possible to develop evidence-based stillbirth reduction interventions for the groups at highest risk of stillbirth. However, these interventions cannot effectively target the causes of stillbirth if the groups with high stillbirth rates also have low fetal autopsy rates and, therefore, potentially less accurate cause of death data. This concern is driven by documented issues in the accuracy of stillbirth cause of death data. For example, the National Center for Health Statistics reported that over 30% of stillbirths delivered in 2014 had an unspecified cause of death (23). Thus, data on differential stillbirth autopsy rates are imperative for meaningful and actionable interpretation of cause of death data.

The objective of this study was to investigate factors associated with stillbirth autopsy rates, including factors that have been identified in international settings as well as other factors that might be particularly important in the U.S. Specifically, we aimed to identify demographic, behavioral, operational, and medical factors associated with stillbirth autopsy status using fetal death certificates from Georgia and Utah from 2010 to 2014.

Methods

We conducted a cross-sectional study using Georgia and Utah fetal death certificates obtained from the Georgia Department of Public Health and the Utah Department of Health, respectively. Georgia requires reporting of all fetal deaths, irrespective of length of gestation, while Utah requires reporting of fetal deaths occurring at 20 completed gestation weeks or later (4). Georgia and Utah have distinctly different populations geographically, demographically, and culturally, permitting the investigation of stillbirth autopsies in diverse settings.

Eligible stillbirths were fetal deaths occurring at 20 weeks' gestation or later and delivered between January 1, 2010 and December 31, 2014. When gestational age was missing, fetal deaths were included if the birth weight was at least 350 grams, a common alternative to 20 gestational weeks that is officially used for reporting in several states (4). The Fetal Death Edit Specifications for the 2003 Revision of the U.S. Standard Report of Fetal Death (24) was consulted for guidance on the management of implausible values or conflicting data. Based on ranges used in those specifications, birth weights less than or equal to 227 grams or greater than or equal to 8,165 grams and gestational ages greater than 47 weeks were considered implausible and recoded as missing.

On the 2003 revision of the fetal death certificate, autopsy status may be recorded as "performed," "planned," or "not performed or planned." Because fetal death certificates must be registered within five days of delivery in Utah (25) and three days in Georgia (Ga. Code Ann., § 31-10-18[a]), there is not always time to perform the autopsy prior to certificate submission. When this happens, autopsies are categorized as planned. Given this, we considered planned equivalent to performed (based on personal communication with an obstetrician). Accordingly, autopsy status was categorized as "performed or planned" or "not performed or planned."

During data cleaning, it became clear that some of the otherwise eligible records did not qualify as stillbirths. If the free-text cause of death field indicated that the record was for a neonatal death, miscarriage (i.e. fetal loss prior to 20 completed gestational weeks), induced abortion, or a pregnancy that did not produce a fetus (i.e. molar pregnancy or blighted ovum), the record was excluded from the analyses.

The Georgia and Utah data were analyzed separately due to their demographic differences and distinct fetal death reporting requirements. Descriptive, bivariate, and multivariate analyses were performed for the association between autopsy status and 1) demographic factors (maternal age, education, race/ethnicity and birth country; receipt of Special Supplemental Nutrition Program for Women, Infants, and Children [WIC] assistance during pregnancy; prenatal care; gestational age; and multiple birth pregnancy); 2) behavioral factors (smoking); 3) operational factors (delivery year, urbanicity of county of delivery, final delivery route and method, and timing of death); and 4) medical factors (pre-pregnancy body mass index [BMI], diabetes, hypertension, previous poor pregnancy outcome, pregnancy resulted from infertility treatment, previous cesarean section, anencephaly, meningomyelocele/spina bifida, cyanotic congenital heart disease, omphalocele or gastroschisis, cleft lip or palate, limb reduction deficit, diaphragmatic hernia, and chromosomal disorders). Receipt of WIC food assistance was included to serve as a proxy for income status, as income is not captured on the fetal death certificate. Urbanicity of delivery county was classified using the National Center for Health

Statistic's Urban-Rural Classification Scheme as a guide (26). Counties were divided into "large metropolitans" (counties of metropolitan statistical areas [MSAs] of more than one million people), "medium or small metropolitans" (MSAs of 50,000 to 999,999 people), and "nonmetropolitans" (MSAs of less than 50,000 people). The Cochran-Armitage Trend Test was used to evaluate changes in autopsy rates over time.

Due to concerns related to data quality, variables missing 10% or more of the data were not used in the analyses (27). Among variables with ample data, predictors of autopsy status were chosen based on findings from previous literature and theorized relationships with autopsy status. Directed acyclic graphs (DAGs) (28) were created to visualize the relationship between each factor of interest and autopsy status, controlling only for variables thought to be potential confounders of that particular association. The models based on these DAGs were considered the gold standard models. All possible subsets of these models were examined. In each gold standard model, the significance of the interaction between that model's primary predictor of autopsy status and urbanicity of county of delivery was evaluated using a likelihood ratio test. Prevalence ratios and 95% confidence intervals were calculated using a predicted margins approach. A final multivariate model was selected for each variable of interest for each state based on consideration of the DAG, a change-in-estimate approach to confounding, and the precision of the prevalence ratio. Hosmer-Lemeshow goodness of fit testing was used to evaluate the fit of the final model.

Data cleaning and frequency calculations were carried out in SAS 9.4 (Cary, NC), with models using the predicted margins approach calculated using SAS-callable SUDAAN.

This research was approved by the Institutional Review Boards of Emory University and Georgia Department of Public Health. Utah Department of Health did not require formal Institutional Review Board approval, but reviewed our study and executed a data sharing agreement, which was submitted to the Emory University Institutional Review Board.

Results

There were 5,635 records for fetal deaths in Georgia and 1,426 records for fetal deaths in Utah with at least 20 weeks' gestation or a birth weight of at least 350 grams if gestational age was unavailable (Figure 1). In Georgia, 25 records were excluded because the cause of death revealed that they were not stillbirths. In Utah, one record was excluded because it was missing a delivery year. There were 5,610 eligible stillbirths for Georgia and 1,425 eligible stillbirths for Utah used for analysis.

Characteristics of stillbirths delivered between 2010 and 2014 in Georgia and Utah are shown in Table 1. Several variables had a substantial amount of missing data. Although we intended to evaluate the association between timing of death (before or during labor) and the presence of congenital anomalies on stillbirth autopsy status, we were unable to include these variables in the analysis due to the high levels of missing data (greater than 10%) in both states. Disregarding delivery year (which was required to have non-missing entries based on the inclusion and exclusion criteria), Georgia was missing more than 10% of the values for 61% of the variables that were available for study (Table 1). Only variables with less than 10% missing data were used for subsequent analyses.

The autopsy status profile differed by state. Georgia largely did not have planned autopsies (n = 2), while Utah had slightly more planned than performed autopsies (n = 193 vs. 147) (Table 1). Combining performed and planned autopsies, autopsies were more frequently performed in Utah than in Georgia, but were uncommon in both states, with an autopsy reported in 11.9% of stillbirths in Georgia and 23.9% in Utah. Georgia's study population was notably different from Utah in that stillbirths in Georgia were more likely to be delivered large metropolitan areas (55.2% in Georgia vs. 44.5% in Utah) and mothers in Georgia were more likely to be black (black: 54.7% in Georgia vs. 1.5% in Utah; white: 30.1% in Georgia vs. 74.7% in Utah).

Autopsy rates remained relatively stable over time in Georgia (Cochran-Armitage Z = 1.05, 2-sided p = 0.29), but significantly decreased over time in Utah (Cochran-Armitage Z = 2.53, 2-sided p = 0.01) (Figure 2). In both states, the highest proportion of stillbirths receiving an autopsy was in 2010 (P_{GA} = 13.3; P_{UT} = 27.6) and the lowest proportion was in 2014 (P_{GA} = 11.2; P_{UT} = 20.1).

In bivariate analysis, stillbirths were less likely to receive autopsies outside of large metropolitans in both states (compared to large metropolitans, Georgia: $PR_{\text{medium/small}}$ = 0.57, 95% CI: 0.48, 0.68 and $PR_{\text{nonmetropolitan}}$ = 0.55, 95% CI: 0.42, 0.72; Utah: $PR_{\text{medium/small}}$ = 0.46, 95% CI: 0.38, 0.57 and $PR_{\text{nonmetropolitan}}$ = 0.34, 95% CI: 0.20, 0.58) (Tables 2 & 3). In Georgia, vaginal, forceps- or vacuum-assisted deliveries ($PR_{\text{vaginal/assisted vs. vaginal/spontaneous}}$ = 0.43, 95% CI: 0.22, 0.86), stillbirths of earlier gestational ages ($PR_{\text{20-27 weeks vs. 28 or more weeks}}$ = 0.60, 95% CI: 0.52, 0.69), and stillbirths of higher order pregnancies ($PR_{\text{multiple vs. singleton births}}$ = 0.72, 95% CI: 0.53, 0.96) were less likely to receive an autopsy, while cesarean section deliveries were more likely to receive an autopsy ($PR_{\text{cesarean vs. vaginal/spontaneous}}$ = 1.30, 95% CI: 1.09, 1.56). In Utah, stillbirths of mothers who received WIC during pregnancy (PR: 1.29, 95% CI: 1.02, 1.63) were more likely to receive an autopsy than those who did not receive WIC. Race/ethnicity was also strongly associated with stillbirth autopsy status in both states, but not in the same manner. Stillbirths of Hispanics in Georgia were 0.57 times as likely to receive an autopsy as those of non-Hispanic white women (PR = 0.57, 95% CI: 0.41, 0.79), but no association was observed in Utah (PR = 1.12, 95% CI: 0.88, 1.43). In Georgia, the highest likelihood of autopsy was among multiracial mothers ($PR_{\text{multiracial vs. white}}$ = 2.18, 95% CI: 1.18, 4.03), followed by mothers in the "other" race category ($PR_{\text{other vs. white}}$ = 1.43, 95% CI: 1.03, 2.00), but no association was observed for these groups in Utah. In Utah, stillbirth autopsies were most common among non-Hispanic black women ($PR_{\text{black vs. white}}$ = 2.08, 95% CI: 1.31, 3.30).

Georgia's final models only used urbanicity of county of delivery, maternal age, maternal race/ethnicity, gestational age, final route and method of delivery, and plurality as the remaining variables of interest had more than 10% of their observations missing (Table 4). The final models for Utah included the above variables as well as maternal education, receipt of WIC, receipt of prenatal care, and smoking status. There was no evidence of interaction between urbanicity of county of delivery and any of the other factors considered. The final models for maternal age and for maternal race/ethnicity were unadjusted because there were no confounders for their relationship with autopsy status since they are inalterable characteristics of the mother. However, these unadjusted maternal age and race/ethnicity models are included in Table 4 for clarity and ease of comparison.

As was the case in the unadjusted model, the urbanicity of county of delivery was strongly associated with autopsy status in both states after controlling for maternal race/ethnicity in Georgia and maternal race/ethnicity and education level in Utah. In Georgia, stillbirths delivered in medium and small metropolitan or nonmetropolitan counties were nearly half as likely to receive an autopsy than those delivered in large metropolitans (adjusted prevalence $\text{ratio}_{\text{medium/small}}$ [aPR] = 0.57, 95% CI: 0.48, 0.68; $\text{aPR}_{\text{nonmetropolitan}}$ = 0.57, 95% CI: 0.43, 0.75). This effect was even greater in Utah where stillbirths in nonmetropolitan to medium counties were less than half as likely to receive an autopsy ($\text{aPR}_{\text{medium/small}}$ = 0.48, 95% CI: 0.38, 0.59; $\text{aPR}_{\text{nonmetropolitan}}$ = 0.37, 95% CI: 0.21, 0.63).

An association between gestational age and stillbirth autopsy was observed in Georgia, but not Utah. Stillbirths with a gestational age of 20 to 27 completed weeks were 0.60 times as likely as stillbirths occurring later in gestation to receive an autopsy in Georgia (PR = 0.59, 95% CI: 0.51, 0.69). Plurality was also associated with autopsy status in Georgia, but not in Utah. In Georgia, multiple gestation pregnancies were 0.71 times as likely as singleton births to receive an autopsy (PR = 0.71, 95% CI: 0.53, 0.96). In Utah, a similar pattern was observed, but the associations were not quite as strong (gestational age: PR = 0.88, 95% CI: 0.73, 1.07; plurality: PR = 0.80, 95% CI: 0.55, 1.18).

The final model chosen for maternal race/ethnicity was the unadjusted model described above. No association was observed between autopsy status and the final route and method of delivery, maternal age, maternal education level, receipt of WIC, receipt of prenatal care, or smoking in either state.

Discussion

Few stillbirths received an autopsy in Georgia and Utah during the study period. Utah had substantially higher autopsy rates than Georgia, yet Utah only had about a quarter of stillbirths undergoing autopsy. This finding is particularly concerning as our results revealed that the rate of stillbirth autopsies may be decreasing over time. This may reflect changing attitudes towards the procedure by providers or patients, a heavier reliance on technology-based post-mortem investigations, or changing educational or institutional practices and resources. Further research is needed to determine the causes of the reduction and whether this decline is happening in other states as well.

The urbanicity of county of delivery was highly associated with autopsy status, regardless of state. Despite the fact that stillbirths are delivered in both urban and rural settings, stillbirths delivered outside of large metropolitans were far less likely to receive an autopsy. This is particularly of concern since approximately 45% of stillbirths in Georgia and 56% of stillbirths in Utah were delivered outside of large metropolitan areas. This difference in autopsy rate may be related to contrasting levels of access to resources, particularly with regard to perinatal pathologists or other pathologists with the requisite training to perform perinatal autopsies. There is little research on the geographic distribution of perinatal pathologists in the U.S., but the lack of pathologists in rural areas has been raised in other contexts (29) and other research has identified general healthcare workforce shortages in rural locations (30). Non-urban birthing facilities that do not have access to a perinatal pathologist may benefit from perinatal pathology training programs or partnerships with the closest center that does have a perinatal pathologist available.

It is possible that race/ethnicity is an important factor in whether or not an autopsy is performed, but the details of this relationship may depend on the state or region of the country. In Georgia, autopsies were significantly less likely among stillbirths of Hispanic women than of non-Hispanic white women. This could indicate a need for Spanish language interpreters, informational materials, and/or culturally appropriate and acceptable communications about stillbirth autopsies for Hispanic families in Georgia. According to the 2010 U.S. Census, Utah has a higher proportion of Hispanic residents than Georgia (13.0% vs. 8.8%) (31). It is possible that Utah providers have more experience with Hispanic patients or have more resources to serve this population than those in Georgia. Stillbirths of mothers in the multiracial and “other” race categories were more likely to receive an autopsy, but it is hard to draw conclusions about such a diverse group of people without further exploration. It may be beneficial to analyze subgroups within these multiracial and “other” race categories, given the heterogeneity of these populations. Stillbirths of non-Hispanic black mothers in Utah also had an increased likelihood of autopsy. There were small group sizes for the Georgia multiracial and “other” race mothers and the Utah non-Hispanic black mothers, making the estimates vulnerable to random error. Studies with larger sample sizes by racial subgroups may provide more informative data on whether or not they are more likely to undergo an autopsy.

It is unclear why an earlier gestational age or multiple birth pregnancy was associated with a lower autopsy rate in Georgia, but not in Utah. The point estimates in Utah did indicate a lower likelihood of autopsy for both circumstances, but these associations were not as strong. We were not able to control for as many covariates in Georgia as in Utah. In Georgia, we adjusted for maternal age, race/ethnicity, and plurality in the gestational age model, and for maternal age in the plurality model. In Utah, we were further able to adjust for prenatal care, smoking, and WIC, and for smoking and WIC, respectively. However, the modest change in estimates from the crude to the adjusted models in Utah suggests that having the ability to adjust for additional covariates in the Georgia models would be unlikely to make a substantial difference. Causes of stillbirth have been shown to vary by population (32) and are associated with gestational age and plurality, so cause of death, an uncontrolled variable, may have contributed to these between-state differences.

Gestational age and plurality are important factors to consider when examining the stillbirth rate. Earlier stages of pregnancy may be perceived as riskier, making fetal death during earlier gestational ages less unexpected, even if loss at these ages is still traumatic and consequential. Similarly, stillbirth may be more likely to be within the family and provider's realm of expectations for a higher order pregnancy because such pregnancies are known to be riskier than singleton pregnancies. Providers and patients may also be more satisfied with the clinical diagnoses given for stillbirths occurring under these conditions and feel further pathological examination is not necessary.

Fetal autopsies play an important role in clarifying and identifying the cause(s) of stillbirth. Even beyond their basic function, autopsies may assist families with the grieving process and with future reproductive decisions (6, 7, 15, 33). Autopsy data can be used to audit the quality of prenatal and delivery care and thereby improve provider practices and standards (7, 13, 33). Furthermore, autopsies may serve as a method of procuring valuable epidemiological data on causes of stillbirth and prevalence of disease among stillbirths that would otherwise be unobtainable (33, 34). In recognition of these benefits, the American Congress of Obstetricians and Gynecologists describes autopsies as one of the "most important" stillbirth evaluations and recommends autopsies for stillbirths, provided the family gives consent (15, p. 752). Other field experts have similarly recommended fetal autopsies for all stillbirths (10-14). Yet, the findings of this study suggests not only that the autopsy rate is well-below such standards, but also that autopsies are being differentially received across populations, indicating potential inequities in the above benefits.

Strengths and Limitations

To our knowledge, this is the one of the first studies to investigate operational, demographic, and behavioral factors related to stillbirth autopsy uptake in the U.S. The autopsy rate found in this study is substantially lower than that of similar studies that have been conducted abroad (16-19). The U.S. may have unique or more deeply influential factors related to the use of stillbirth autopsy, and we hope this exploratory investigation acts as a catalyst for further research of the American stillbirth autopsy rate.

This investigation examined stillbirth autopsy factors in two demographically, geographically, and culturally different states. Given the major differences between Utah and Georgia, it is noteworthy that the urbanicity of county of delivery had a similar association in both states. This suggests that the importance of the location of delivery may transcend state or regional differences. Our findings by state have also shown that there may be state-specific relationships that need to be taken into consideration when designing interventions. However, our state-specific findings underscore that our results may have limited generalizability to other states.

The use of surveillance data allowed an approximately comprehensive review of stillbirths in Utah and Georgia from 2010 to 2014. A greater understanding of the association between the factors investigated here and autopsy status may help investigators consider the potential quality of the cause of death vital records data by subgroup. The use of vital statistics data is not without limitations. Issues with the validity of vital records data have been explored elsewhere (14, 20). In this study, “planned” autopsies were considered equivalent to “performed” autopsies. Autopsies are marked as “planned” when the fetal death certificate must be submitted prior to the autopsy. Providers are supposed to update these records once the autopsy is completed (35). As many of the records in this study were not updated, it is possible that some of the records in this study in the “performed or planned” group did not ultimately receive an autopsy, which would result in overestimated autopsy rates in Utah.

Our dataset had several missing values that limited our ability to fully compare the two states and comprehensively adjust the final models. This was a particularly notable concern in Georgia. We mitigated this issue by only using variables with less than 10% missing data. However, it is still possible that this missing data has masked differences between the states or that adjustment by additional variables would have changed the final prevalence ratios. Additionally, an Atlanta study found that stillbirths that received an autopsy were more likely to be issued fetal death certificates (36). It is thus possible that entire fetal death certificates were missing and that this may have caused overestimated autopsy rates for both states. These limitations emphasize the need for improvements in data quality for fetal death certificates.

Even when data was present, there may be concern that the recorded information on the fetal death certificate is incorrect. Previous research has found that the receipt of autopsy has high validity on fetal death certificates (37), but that other fields may contain misclassified information (20), which could have resulted in information bias.

We found that stillbirth autopsies are being performed at low rates in both Utah and Georgia and that this rate may be declining over time. Stillbirths delivered outside large metropolitan areas may be underserved, despite making up about half of all stillbirths. This study was exploratory in nature and we recommend further investigation into the factors related to stillbirth autopsy in the U.S. and their root causes as well as the continued identification of groups of mothers and stillbirths that may face autopsy disparities.

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Table 1. Characteristics of Stillbirths Delivered in Georgia and Utah, 2003 Revision of the Fetal Death Certificate Data, 2010-2014

	Georgia (n = 5,610)		Utah (n = 1,425)	
	n	%[a]	n	%[a]
Autopsy performed				
Not performed/planned	4,941	88.1	1,085	76.1
Planned	2	0.0	193	13.5
Performed	667	11.9	147	10.3
Operational				
Delivery year				
2010	1,057	18.8	297	20.8
2011	1,200	21.4	279	19.6
2012	1,105	19.7	264	18.5
2013	1,126	20.1	296	20.8
2014	1,122	20.0	289	20.3
Urbanicity of county of delivery	Missing = 2		Missing = 1	
Large metropolitan	3,098	55.2	633	44.5
Medium or small metropolitan	1,860	33.2	688	48.3
Nonmetropolitan	650	11.6	103	7.2
Final route and method of delivery	Missing = 399			
Vaginal/Spontaneous delivery	4,254	81.6	1,210	84.9
Vaginal/Assisted delivery[b]	152	2.9	28	2.0
Cesarean section	805	15.5	187	13.1
Demographic & Behavioral				
Maternal age	Missing = 1			
Under 20	433	7.7	95	6.7
20-39	4,875	86.9	1,269	89.1
40 and over	301	5.4	61	4.3
Maternal education[c]			Missing = 134	
Less than high school			132	10.2
High school			296	22.9
Some college			371	28.7
Associate degree			143	11.1
Bachelor degree			290	22.5
Graduate degree			59	4.6
Mother race/ethnicity	Missing = 164		Missing = 15	
White, non-Hispanic	1,639	30.1	1,053	74.7
Black, non-Hispanic	2,979	54.7	21	1.5
Hispanic, any race	583	10.7	237	16.8
Multiracial, non-Hispanic	32	0.6	24	1.7
Other race, non-Hispanic	213	3.9	75	5.3
Mother born abroad[c]			Missing = 46	
No			1,169	84.8
Yes			210	15.2
Received WIC during pregnancy[c]				
No			1,222	85.8
Yes			203	14.3
Received any prenatal care[c]			Missing = 54	
No			47	3.4
Yes			1,324	96.6
Smoked before or during pregnancy[c]				
No			1,310	91.9
Yes			115	8.1

Table 1 – Continued

	Georgia (n = 5,610)		Utah (n = 1,425)	
	n	%[a]	n	%[a]
Gestational age of stillbirth	Missing = 270			
20-27 weeks	3,148	59.0	755	53.0
28 weeks or more	2,192	41.1	670	47.0
Plurality of stillbirth	Missing = 49		Missing = 2	
Singleton birth	5,084	91.4	1,309	92.0
Multiple birth	477	8.6	114	8.0
Medical				
Pre-pregnancy BMI (kg/m^2) [c]			Missing = 79	
Underweight, under 18.5			59	4.4
Normal/Healthy, 18.5 – 24.9			633	47.0
Overweight, 25.0 – 29.9			307	22.8
Obese, 30.0 and above			347	25.8
Diabetes[c,d]				
No			1,335	93.7
Yes			90	6.3
Hypertension[c,e]				
No			1,322	92.8
Yes			103	7.2
Previous poor pregnancy outcome[c,f]				
No			1,244	87.3
Yes			181	12.7
Pregnancy resulted from infertility treatment[c,g]				
No			1,385	97.2
Yes			40	2.8
Previous cesarean section[c]				
No			1,243	87.2
Yes			182	12.8

BMI = body mass index; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children

[a] Percentage calculations are only among non-missing observations

[b] Assisted delivery includes forceps- and vacuum-assisted delivery

[c] Analysis not performed for Georgia because more than 10% of data were missing

[d] Includes pre-pregnancy and gestational diabetes

[e] Includes pre-pregnancy and gestational hypertension, preeclampsia, and eclampsia

[f] Includes previous perinatal death, small-for-gestational age or intrauterine growth restriction, or preterm birth

[g] Includes fertility-enhancing drug, artificial insemination, intrauterine insemination, and assisted reproductive technology

Table 2. Unadjusted Estimated Prevalence Ratios (PR) and 95% Confidence Intervals (CI) for Autopsy Among Stillbirths Delivered in Georgia, Fetal Death Certificate Data, 2010-2014 (n = 5,610)

	Autopsy n (%)	PR	95% CI
Operational			
Delivery year			
2010	141 (13.3)	1.00	
2011	136 (11.3)	0.85	0.68, 1.06
2012	129 (11.7)	0.88	0.70, 1.09
2013	137 (12.2)	0.91	0.73, 1.14
2014	126 (11.2)	0.84	0.67, 1.05
Urbanicity of county of delivery			
Large metropolitan	459 (14.8)	1.00	
Medium or small metropolitan	157 (8.4)	0.57	0.48, 0.68
Nonmetropolitan	53 (8.2)	0.55	0.42, 0.72
Final route and method of delivery			
Vaginal/Spontaneous delivery	516 (12.1)	1.00	
Vaginal/Assisted delivery[a]	8 (5.3)	0.43	0.22, 0.86
Cesarean	127 (15.8)	1.30	1.09, 1.56
Demographic			
Maternal age			
Under 20	46 (10.6)	0.87	0.66, 1.16
20-39	592 (12.1)	1.00	
40 and over	31 (10.3)	0.85	0.60, 1.19
Maternal race/ethnicity			
White, non-Hispanic	188 (11.5)	1.00	
Black, non-Hispanic	380 (12.8)	1.11	0.94, 1.31
Hispanic, any race	38 (6.5)	0.57	0.41, 0.79
Multiracial, non-Hispanic	8 (25.0)	2.18	1.18, 4.03
Other race, non-Hispanic	35 (16.4)	1.43	1.03, 2.00
Gestational age of stillbirth			
20-27 weeks	305 (9.7)	0.60	0.52, 0.69
28 weeks or more	353 (16.1)	1.00	
Plurality of stillbirth			
Singleton birth	625 (12.3)	1.00	
Multiple birth	42 (8.8)	0.72	0.53, 0.97

[a] Assisted delivery includes forceps- and vacuum-assisted delivery

Table 3. Unadjusted Prevalence Ratios (PR) and 95% Confidence Intervals (CI) for Autopsy among Stillbirths Delivered in Utah, Fetal Death Certificate Data, 2010-2014 (n = 1,425)

	Autopsy n (%)	PR	95% CI
Operational			
Delivery year			
2010	82 (27.6)	1.00	
2011	72 (25.8)	0.93	0.71, 1.23
2012	66 (25.0)	0.91	0.69, 1.20
2013	62 (20.9)	0.76	0.57, 1.01
2014	58 (20.1)	0.73	0.54, 0.98
Urbanicity of county of delivery			
Large metropolitan	218 (34.4)	1.00	
Medium or small metropolitan	110 (16.0)	0.46	0.38, 0.57
Nonmetropolitan	12 (11.7)	0.34	0.20, 0.58
Final route and method of delivery			
Vaginal/Spontaneous delivery	291 (24.0)	1.00	
Vaginal/Assisted delivery[a]	8 (28.6)	1.19	0.66, 2.15
Cesarean	41 (21.9)	0.91	0.68, 1.22
Demographic & Behavioral			
Maternal age			
Under 20	21 (22.1)	0.91	0.62, 1.35
20-39	308 (24.3)	1.00	
40 and over	11 (18.0)	0.74	0.43, 1.28
Maternal education			
Less than high school	33 (25.0)	1.12	0.78, 1.61
High school	66 (22.3)	1.00	
Some college	84 (22.6)	1.02	0.76, 1.35
Associate degree	30 (21.0)	0.94	0.64, 1.38
Bachelor degree	70 (24.1)	1.08	0.81, 1.45
Graduate degree	18 (30.5)	1.37	0.88, 2.13
Maternal race/ethnicity			
White, non-Hispanic	241 (22.9)	1.00	
Black, non-Hispanic	10 (47.6)	2.08	1.31, 3.30
Hispanic, any race	61 (25.7)	1.12	0.88, 1.43
Multiracial, non-Hispanic	5 (20.8)	0.91	0.41, 2.00
Other race, non-Hispanic	18 (24.0)	1.05	0.69, 1.59
Received WIC during pregnancy			
No	280 (22.9)	1.00	
Yes	60 (29.6)	1.29	1.02, 1.63
Received any prenatal care			
No	9 (19.1)	1.00	
Yes	312 (23.6)	1.23	0.68, 2.23
Smoked before or during pregnancy			
No	309 (23.6)	1.00	
Yes	31 (27.0)	1.14	0.83, 1.57
Gestational age of stillbirth			
20-27 weeks	168 (22.3)	0.87	0.72, 1.04
28 weeks or more	172 (25.7)	1.00	
Plurality of stillbirth			
Singleton birth	317 (24.2)	1.00	
Multiple birth	22 (19.3)	0.80	0.54, 1.17

WIC = Special Supplemental Nutrition Program for Women, Infants, and Children

[a] Assisted delivery includes forceps- and vacuum-assisted delivery

Table 4. Prevalence Ratios (PR) and 95% Confidence Intervals (CI) for Final Models of Autopsy Among Stillbirths Delivered in Georgia and Utah, Fetal Death Certificate Data, 2010-2014

	Georgia		Utah	
	Final PR	95% CI	Final PR	95% CI
Operational				
Urbanicity of county of delivery[a,b]				
Large metropolitan	1.00		1.00	
Medium or small metropolitan	0.57	0.48, 0.68	0.48	0.38, 0.59
Nonmetropolitan	0.57	0.43, 0.75	0.37	0.21, 0.63
Final route and method of delivery[c]				
Vaginal/Spontaneous delivery	1.00		1.00	
Vaginal/Assisted delivery[d]	0.57	0.28, 1.15	1.20	0.67, 2.15
Cesarean	1.05	0.86, 1.28	0.86	0.64, 1.17
Demographic & Behavioral				
Maternal age[e]				
Under 20	0.87	0.66, 1.16	0.91	0.62, 1.35
20-39	1.00		1.00	
40 and over	0.85	0.60, 1.19	0.74	0.43, 1.28
Maternal education[f,g]				
Less than high school			1.05	0.72, 1.53
High school			1.00	
Some college			1.03	0.77, 1.38
Associate degree			0.96	0.66, 1.39
Bachelor degree			1.14	0.83, 1.55
Graduate degree			1.42	0.92, 2.20
Maternal race/ethnicity[e]				
White, non-Hispanic	1.00		1.00	
Black, non-Hispanic	1.11	0.94, 1.31	2.08	1.31, 3.30
Hispanic, any race	0.57	0.41, 0.79	1.12	0.88, 1.43
Multiracial, non-Hispanic	2.18	1.18, 4.03	0.91	0.41, 2.00
Other race, non-Hispanic	1.43	1.03, 2.00	1.05	0.69, 1.59
Received WIC during pregnancy[f,h]				
No			1.00	
Yes			1.22	0.94, 1.58
Received any prenatal care[f,i]				
No			1.00	
Yes			1.47	0.76, 2.85
Smoked before or during pregnancy[f,j]				
No			1.00	
Yes			1.12	0.78, 1.60
Gestational age of stillbirth[k,l]				
20-27 weeks	0.59	0.51, 0.69	0.88	0.73, 1.07
28 weeks or more	1.00		1.00	
Plurality of stillbirth[m,n]				
Singleton birth	1.00		1.00	
Multiple birth	0.71	0.53, 0.96	0.80	0.55, 1.18

WIC = Special Supplemental Nutrition Program for Women, Infants, and Children
[a] For Georgia, adjusted for maternal race/ethnicity
[b] For Utah, adjusted for maternal race/ethnicity and education
[c] Adjusted for maternal age and race/ethnicity, gestational age, and plurality
[d] Assisted delivery includes forceps- and vacuum-assisted delivery
[e] Unadjusted because it is an inalterable characteristic and, thus, is not subject to confounding
[f] Analysis not performed for Georgia because more than 10% of data were missing
[g] Adjusted for maternal age and race/ethnicity and urbanicity of delivery county
[h] Adjusted for maternal age, education, and race/ethnicity and urbanicity of delivery county

[i] Adjusted for maternal age, education, and race/ethnicity; urbanicity of delivery county; and receipt of WIC during pregnancy
[j] Adjusted for maternal age, education, and race/ethnicity and receipt of WIC during pregnancy
[k] For Georgia, adjusted for maternal age and race/ethnicity and plurality
[l] For Utah, adjusted for maternal age and race/ethnicity, prenatal care, smoking before or during pregnancy, plurality, and receipt of WIC during pregnancy
[m] For Georgia, adjusted for maternal age
[n] For Utah, adjusted for maternal age, smoking before or during pregnancy, and receipt of WIC during pregnancy

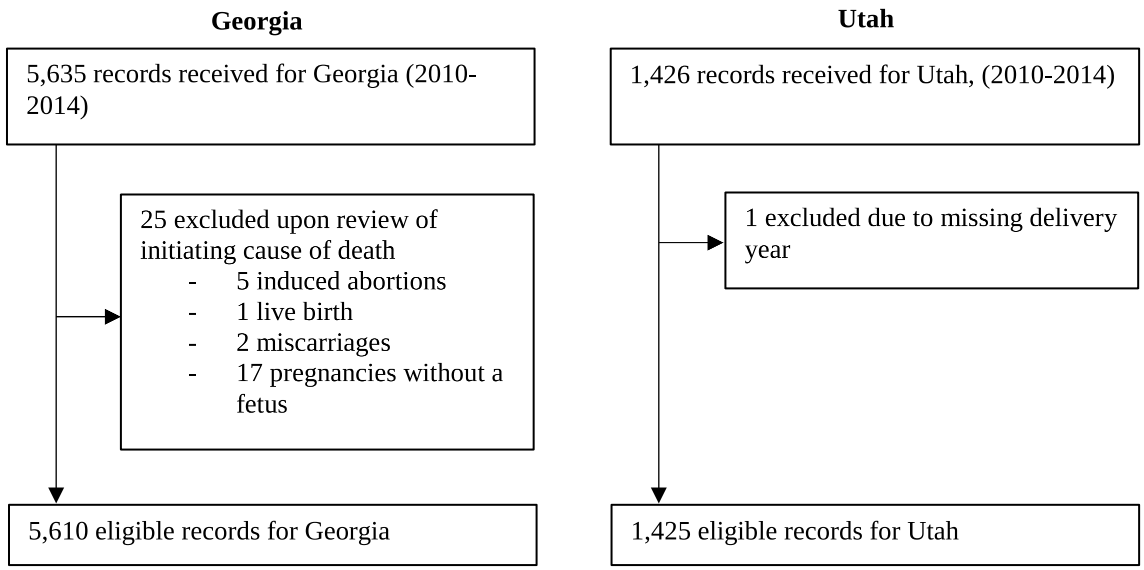

Figure 1. Study Eligibility of Stillbirths Delivered in Georgia and Utah, 2003 Revision of the Fetal Death Certificate Data, 2010-2014.

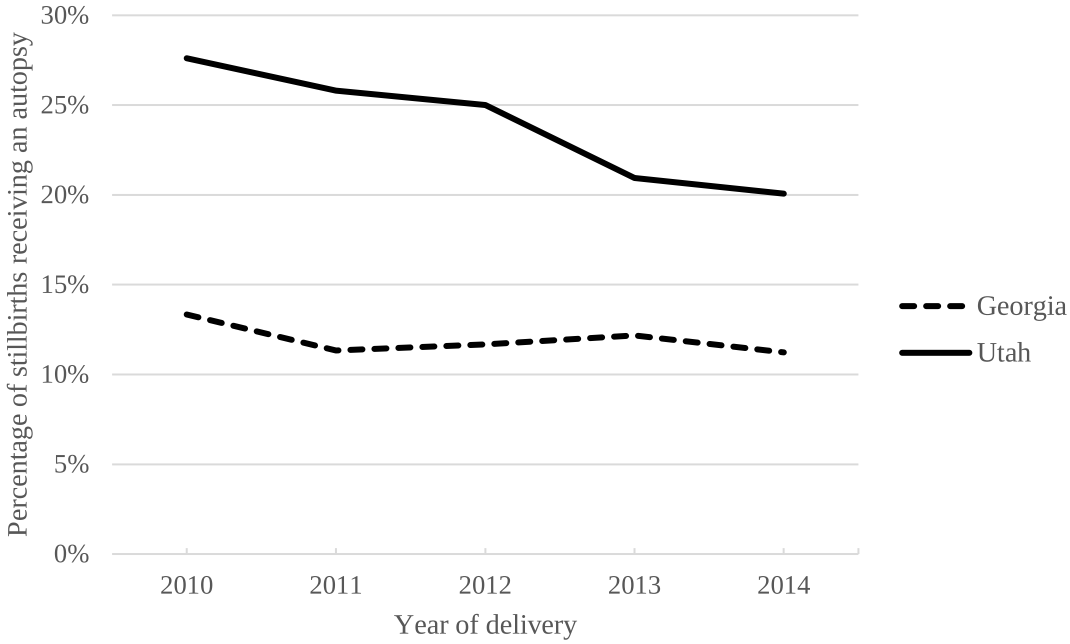

Figure 2. Proportion of Stillbirths Delivered in Georgia and Utah Who Received an Autopsy, Fetal Death Certificate Data, 2010-2014.

Future Directions in Stillbirth Autopsy Research

Our results highlight that there may be state-to-state differences in the fetal autopsy rate, even if the rate is low throughout the country. Future research may examine whether state-level differences, as opposed to simply individual- or subgroup-level differences, help explain the factors associated with low stillbirth autopsy rates. For instance, state-level healthcare policies may affect the frequency of autopsies within that state. Different states also have slightly different fetal death certificates and the certificates' questions, design, ease of use, and related procedures may affect the data quality or how autopsies are recorded (as we found for the high number of "planned" autopsies in Utah compared to the scarce "planned" autopsies in Georgia). A better understanding of the way state-level factors influence autopsy rates may help facilitate state-level interventions or inform best practices that could reach large proportions of people at once and maximize returns on investment.

Our findings also indicate that further research of the relationship between location of delivery and stillbirth autopsies is warranted. Given the importance of perinatal pathologists in conducting stillbirth autopsies, we hypothesize that reduced access to perinatal pathologists in rural areas may contribute to these disparities by delivery location. It is possible that people, including providers, in rural areas have different cultural attitudes towards autopsy or may need information about the procedure written and designed for a rural audience. Future research into the role of race/ethnicity, gestational age, and plurality could similarly lead to intervention-informing insights.

Finally, additional research should examine demographic, behavioral, operational, and medical differences in relation to the step at which the disparities occur. Effective interventions must be targeted at the correct audience. The stillbirth autopsy process requires the coordination and cooperation of different systems and players, meaning disparities could be rooted at the patient-, provider-, or even higher structural levels. Integrating the research on barriers to stillbirth autopsies with new studies on stillbirth autopsy disparities could greatly improve the efficiency and effectiveness of intervention efforts and promote equitable autopsy rates.