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Maternal age and risk of labor and delivery complications

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Abstract

Objective—We utilized an updated nationally representative database to examine associations between maternal age and prevalence of maternal morbidity during complications of labor and delivery.

Study design—We used hospital inpatient billing data from the 2009 United States Nationwide Inpatient Sample (NIS), part of the Healthcare Cost and Utilization Project (HCUP). To determine whether the likelihood that maternal morbidity during complications of labor and delivery differed among age groups, separate logistic regression models were run for each complication. Age was the main independent variable of interest.

Results—In analyses that controlled for demographics and clinical confounders, we found that complications with the highest odds among women, 11–18 years of age, compared to 25–29 year old women, included preterm delivery, chorioamnionitis, endometritis, and mild preeclampsia. Pregnant women who were 15–19 years old had greater odds for severe preeclampsia, eclampsia, postpartum hemorrhage, poor fetal growth, and fetal distress. Pregnant women who were ≥35 years old had greater odds for preterm delivery, hypertension, superimposed preeclampsia, severe preeclampsia, and decreased risk for chorioamnionitis. Older women (≥40 years old) had increased odds for mild preeclampsia, fetal distress, and poor fetal growth.

Conclusions—Our findings underscore the need for pregnant women to be aware of the risks associated with extremes of age so that they can watch for signs and symptoms of such complications.

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Keywords

labor and delivery; maternal morbidity; young maternal age

Introduction

Childbirth at a young (i.e., ≤ 19 years old) or advanced maternal age (i.e., ≥ 35 years old) is associated with increased risk of adverse maternal perinatal outcomes, such as postpartum hemorrhage, eclampsia, and cephalopelvic disproportion, as well as adverse infant outcomes including preterm birth, poor fetal growth, low birth weight, and neonatal mortality.[1–8] Most complications remain independent of important known confounders such as poverty, inadequate prenatal care and/or weight gain during pregnancy.[2,9–13] Large-scale population-based studies using current data to examine maternal age associations with labor and delivery complications are needed to help delineate the contributions of maternal age to perinatal maternal morbidity. Such findings could help the management of risks during pregnancy, especially when the signs and symptoms of complications can be monitored by the clinician and/or the pregnant woman.

In our review of studies published in the last decade we found that much of the evidence about associations between age and perinatal maternal morbidity comes from study participants that reside in one city or were treated in one hospital. In addition, the existing research has tended to use small sample sizes that limit generalizability. For instance, Hoffman et al. examined over 125,000 singleton pregnancies delivered at the University of Miami/Jackson Memorial Hospital between the years 1989 and 2004 and found that pregnancy at or beyond age 40 years is associated with an increased risk of fetal death and other adverse outcomes including preterm delivery and low and very low birth weight.[6] Similarly, Cleary-Goldman et al. and Yogev et al. found associations of advanced maternal age (high risk group included women ≥40 and ≥45 years of age, respectively) with increased maternal and fetal risk (e.g., higher rates of hypertensive complications, placenta previa, postpartum hemorrhage, preeclampsia, and preterm delivery); however, their respective sample sizes were relatively small (i.e., < 2,000 participants).[8,14] In a French study, women 18 years of age and younger had significantly decreased risks of obstetric complications (preeclampsia, caesarean section, operative vaginal delivery and postpartum hemorrhage); however, generalizability is limited given that the small sample size of the teen participants (n < 1,000) and the setting (i.e., one French university hospital).[10]

In an effort to present a more comprehensive and updated picture of maternal age associations with labor and delivery complications, we examined associations between maternal age and perinatal maternal morbidity using 2009 data for U.S. delivery and postpartum hospitalizations. Unlike past studies, we utilized a nationally representative database that enabled the stratification of different age groups among girls and young vs. older women (i.e., age groups: 11–14 years old, 15–19 years old, 20–24 years old, 30–34 years old, 35–39 years old, and ≥40 years old versus 25–29 years old as the reference group). We hypothesized that younger and advanced maternal ages (i.e., younger maternal ages: 11–14 years old, 15–19 years old and advanced maternal ages: 35–39 years old, ≥40

years old) are associated with increased risk for many labor and delivery complications even after accounting for important confounders linked to maternal health such as medical comorbidities and substance abuse disorders. We additionally examined fetal outcomes that may also be associated with maternal age, as these risks are important for women considering pregnancy at extremes of maternal ages.

Materials and Methods

We used hospital inpatient stay data from the 2009 United States Nationwide Inpatient Sample (NIS), part of the Healthcare Cost and Utilization Project (HCUP) sponsored by the Agency for Healthcare Research and Quality. The NIS is a stratified sample of hospitals which are drawn from states that provide data to the HCUP project. The hospitals are stratified by geographic region, location/teaching status, bed size category, and ownership. The NIS includes all discharges, regardless of payer, from the sampled hospitals. The data elements included are clinical and resource information typically available from discharge abstracts, including primary and secondary diagnoses and procedures, admission and discharge status, patient demographics, expected payment source, length of hospitalization after delivery, hospital characteristics, and total charges. The NIS is the largest publicly available all-payer inpatient care database in the United States. The 2009 NIS contains data from 7,810,762 sample discharges in 1,050 hospitals in 44 states, approximating a 20% stratified sample of community hospitals in the U.S. Discharge weights are provided for calculation of national estimates.[15,16]

We extracted obstetric delivery discharges from the NIS using Kuklina et al.'s enhanced delivery identification method.[17] This method identifies deliveries in a hierarchical manner, looking for International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM disease codes for (1) outcome of delivery (ICD-9-CM diagnosis codes V27.X), (2) normal delivery (ICD-9-CM diagnosis code 650), (3) Diagnosis Related Group (DRG) delivery codes (370, 371, 372, 373, 374, 375), and (4) selected delivery-related procedures (ICD-9-CM procedure codes 72.0, 72.1, 72.21, 72.29, 72.31, 72.39, 72.4, 72.6, 72.51, 72.52, 72.53, 72.54, 72.71, 72.79, 72.8, 72.9, 73.22, 73.59, 73.6, 74.0, 74.1, 74.2, 74.4, 74.99). Discharges with abnormal (e.g., molar or ectopic pregnancies) or abortive pregnancy outcomes were excluded (ICD-9-CM diagnosis codes 630, 631, 632, 633.X, 634.X, 635.X, 636.X, 637.X, 638.X, 639.X, and ICD-9-CM procedure codes 69.01, 69.51, 74.91, 75.0). Kuklina et al.'s enhanced method was shown to identify 3.4% more deliveries than using the ICD-9-CM diagnosis codes V27.X alone.[17] Furthermore, severe obstetric complications were more likely to be missed when using the V27.X codes alone compared to Kuklina et al.'s enhanced method.[17]

Complications of interest for the delivery discharges were coded using the ICD-9-CM codes specified in Table 1, with the fifth-digit sub classification where applicable including 0 (unspecified as to episode of care/not applicable), 1 (delivered, with or without mention of antepartum condition), or 2 (delivered, with mention of postpartum complication). Our analysis focused on labor and delivery complications, not antepartum or postpartum complications (with the exception of postpartum hemorrhage which was considered because it is a leading cause of maternal morbidity and mortality for U.S. women who are ≥ 35 years

or older[18]). Thus, we excluded fifth-digit sub classifications 3 (antepartum condition or complication) and 4 (postpartum condition or complication). These exclusions only apply to coding complications of delivery, not to the abstraction of our population of delivery discharges. Because the number of ICD-9-CM diagnosis and procedure codes provided for each discharge vary by state, in order to be consistent across all states we used the first 9 diagnosis codes and the first 6 procedure codes to identify our population of interest (i.e., deliveries) and our delivery complications of interest. Each discharge could be coded for more than one complication. However, hypertension with pregnancy, preeclampsia, and eclampsia were treated as mutually exclusive: if a discharge was coded for more than one of these (e.g., hypertension in pregnancy and preeclampsia), the code for the more severe condition was used (e.g., preeclampsia).

Delivery discharges with each complication of interest were described by age group (11–14 years old, 15–19 years old, 20–24 years old, 25–29 years old, 30–34 years old, 35–39 years old, ≥40 years old). Adolescents were split into younger (<15 years old) and older (15–19 years old) teens because they represent different stages of sexual maturation[19] and are often separated as distinct obstetric groups.[20–22] National estimates were obtained by using discharge weights in the NIS.[15] Delivery complication rates were calculated by dividing the number of delivery discharges with the complication of interest by the total number of delivery discharges, stratified by age group. The 2009 HCUP cost-to-charge ratio file was used to estimate the resource cost of inpatient care, using the group average all-payer inpatient cost/charge ratio. The cost-charge ratio file uses all-payer, inpatient cost and charge information from detailed hospital reports to the Centers for Medicare and Medicaid Services (CMS). An estimate of all-payer inpatient cost-to-charge ratio for nearly every HCUP NIS hospital in 2009 is provided. We linked this cost-to-charge ratio file to the NIS charges file using hospital identification number, and then estimated the cost of inpatient care for each discharge by multiplying the total charge from the discharge record by the group average all-payer inpatient cost/charge ratio.[23] To determine whether the likelihood of each type of complication was higher among younger age groups, separate logistic regression models were run for each complication, with age as the main independent variable of interest. We used pregnant women between the ages of 25–29 years old as the reference group because the U.S. average age of a woman's first birth is 25 years old, and the greatest proportion of births in the dataset was among this group of women.[24]

All models accounted for clinical confounders available in the dataset that have been identified in existing literature as associated with labor and delivery complications (i.e., non-pregnancy related hypertension, diabetes, gestational diabetes, substance use disorders, alcohol disorders, cardiac disease, sexually transmitted diseases, insufficient prenatal care, and multiple gestation).[25–34] ICD-9-CM diagnosis codes used to identify these conditions are listed in Table 2. Patient and hospital characteristics were also accounted for including race, urban/rural patient location, median community household income for patient's zip code of residence, expected payment source/insurance type, and hospital region of the country. Finally, for the outcomes of endometritis and postpartum hemorrhage, type of delivery (cesarean or vaginal), retained placenta, and manual removal of placenta were also included as covariates, as these are known risk factors.[34,35] Assessment of potential multicollinearity among the independent variables showed no collinearity issues; all

variance inflation factors (VIF) were < 2.6. Race was missing for nearly 15% of the discharges; thus, when adjusting for race, "missing" was included as one of the categories of race. Missing data for other demographic covariates represented only 4% of the sample, and the missing data issue does not apply to diagnosis and procedure codes. Race/ethnicity is not a core uniform billing data element and is often unreported by states and/or hospitals. Race/ethnicity is not typically submitted to insurance companies whereas delivery diagnosis data are more precise because they are collected by licensed/certified professional medical records coders and are necessary for appropriate reimbursement. We present odds ratios with 99% confidence intervals due to the large number of records and the examination of several complications of interest. Statistical analyses were performed using survey procedures in SAS version 9.2 (SAS Institute, Cary, NC) to take into account the sampling design of the NIS (hospital and NIS stratum) and sample discharge weights.[16] We also ran all models using multi-level logistic regression (random intercept models accounting for clustering within hospital), which produced similar results. We present results using survey procedures as this is the more conventional method to analyze the NIS.[36] This study was granted exempt status by the Washington University Institutional Review Board.

Results

Demographic characteristics of delivery discharges in 2009 are presented in Table 3, and complication rates and length of hospitalization after delivery for 2009 are stratified by age group and presented in Table 4. Numbers are weighted to provide national estimates, and complication rates are per 1000 deliveries. Of all births in 2009, 0.1% occurred to women age 11–14 years old, 10.0% to women 15–19 year olds, 24.2% to women age 20–24 years old, 27.9% to women 25–29 years old, 23.2% to women 30–34 years old, 11.7% to women 35–39 years old, and 2.8% to women 40 years or older. Length of hospitalization after delivery was slightly longer for the youngest women (11–14 years old) and the oldest women (≥ 40 years old). The costs of inpatient care increased as the age of woman increased, as did the cesarean delivery rate.

Odds ratios and 99% confidence intervals for complications for each age group, adjusting for demographics and comorbidities are presented in Table 5. The odds of many of the complications were greater among young women (≤ 19 years old) compared to 25–29 year olds at the time of delivery. Furthermore, for many of the complications, the odds increased as age of the woman decreased. Complications with elevated odds among young women (≤ 19 years old) compared to 25–29 year old women, included preterm delivery, chorioamnionitis, endometritis, and mild preeclampsia. Pregnant women who were 15–19 years old (but not 11–14 years) also had significantly elevated odds for severe preeclampsia, eclampsia, postpartum hemorrhage, fetal distress, and poor fetal growth, and lower odds for hypertension and preeclampsia superimposed on pre-existing hypertension. Compared to 25–29 year olds, women of advanced maternal age (≥35 years old) had greater odds of preterm delivery, hypertension, severe preeclampsia, and superimposed preeclampsia; women of advanced maternal age had lower odds of chorioamnionitis. Age of women ≥40 years old at the time of delivery was also associated with increased odds of mild preeclampsia, poor fetal growth and fetal distress.

Comment

This study uses large-scale U.S. hospital billing data to examine associations between maternal age and prevalence of maternal morbidity during labor and delivery. The results show that younger and advanced maternal ages at the time of delivery are associated with greater odds of complications even after controlling for demographics, type of birth, and clinical confounders. Specifically, both younger and older pregnant women were at increased odds of preterm delivery, poor fetal growth, fetal distress, and severe preeclampsia. For some complications, risk patterns differed for younger and older women. Younger women were at increased odds for chorioamnionitis and endometrits, while older women appeared to have decreased or negligible difference in odds for these infections compared to 25–29 year olds. Older women were at increased odds of hypertension with pregnancy or superimposed preeclampsia while younger women had decreased or negligible difference in odds for these complications versus 25–29 year olds. For the majority of significant associations, odds of complications increased as maternal age shifted in both directions away from the 25–29 year old reference group. In addition, the number of significant associations between age and complications was relatively comparable in the older age groups as in the younger groups.

Our findings extend the existing scientific literature by underscoring that young age is associated with increased odds of puerperal infection (as much as 5-fold increased odds for endometritis among the women who were 11–14 years old). The odds decrease as the age of woman increases. The dose-response effect that age has on the odds for infection of chorioamnionitis and endometritis during labor and delivery (Cochran-Armitage trend tests $p<.001$) supports past studies[11,37–39] and is of high clinical relevance. Bacteria from intrauterine infections during pregnancy can harm the fetus through systemic inflammation (a fetal inflammatory response syndrome)[40,41] and cause damage to multiple organs.[42] There is also mounting evidence on the potentially preventable role of intrauterine infection on premature birth.[43–45] The pathways leading to intrauterine infection during pregnancy are not fully understood. The increased odds for both chorioamnionitis and endometritis could be due to an immature immune system of young women that makes them more susceptible to uterine infection.[11,46,47]

Young maternal age (≤ 19 years old) was associated with elevated odds of mild preeclampsia (60% increase in odds for ages 15–19 years, 2.5-fold increase in odds for ages 11–14 years) and severe preeclampsia (40% increase in odds for ages 15–19 years) but not with hypertension (i.e., hypertension complicating pregnancy/childbirth/puerperium), or preeclampsia superimposed on pre-existing hypertension. In contrast, advanced maternal age was associated with a 30% increase in odds (for 35–39 year olds) and nearly 80% increase in odds (for ≥40 year olds) of hypertension and a two to three-fold increase in odds for superimposed preeclampsia. Past research using California discharge data similarly found an age-related risk for incidence of eclampsia at the extremes of maternal age.[48] Parity is not available in the HCUP dataset; nevertheless, we note that nulliparity is also a known risk factor for preeclampsia and adolescent pregnant women are more often nulliparious when compared to adult women.[49,50] Additionally, hypertension has a low prevalence among youths who are less than 20 years old.[51] It is likely the case that higher prevalence of

preeclampsia among teens is due, at least in part, to social determinants of health that are associated with teen pregnancy. Moreover, the increased risk of hypertension and superimposed preeclampsia that is associated with age is likely due to age-related increases in hypertension that occurs among women of reproductive age which corroborates existing research on this topic.[52]

Our findings confirm the labor and delivery complications that are associated with age at the time of pregnancy and lend support to the proactive delivery of these messages to girls and adult women. It is important for adult women who are contemplating whether and when to have children, to know the associated risks and complications of delaying childbirth. This is especially timely given the progressive increase in the age of women at childbirth.[53] Likewise, our findings could be incorporated into the sexuality and contraception educational programs that are delivered in schools to increase awareness of the labor and delivery complications among teens. It is important for pregnant women to receive counseling from their physicians to increase awareness of the signs and symptoms of pregnancy complications.

There are a number of limitations to note in this study. First, the present analysis was based on ICD-9-CM codes, which may not completely describe the severity of complications or the procedure/condition being examined may be distributed across multiple diagnostic and/or procedure codes.[54] The study relies on ICD-9 codes which are subject to a number of issues including the patient's ability to provide a thorough medical history, the hospital's accuracy at record keeping during admission and throughout the patient's stay, and/or inaccurate coding or miscoding. However, our use of recent data (2009) might be less impacted by these issues than earlier studies using ICD coding given recent evidence that ICD coding has improved over time.[55] To maintain uniformity across states, we examined only the first nine ICD-9-CM diagnosis codes and the first six ICD-9-CM procedure codes. Some states report more ICD-9-CM codes (up to 25) and excluding these could bias results. The southern U.S. is under-represented in the NIS (Mississippi and Alabama do not participate) which may bias results and render results less generalizable to the entire U.S. In addition, we only present maternal complications that occurred during labor and delivery and selected fetal outcomes, but not maternal antepartum complications. Data on the health outcomes for the neonates were not available and thus not examined. It is possible that some risk factors included in analysis were under-coded (e.g., alcohol and/or substance use disorders, insufficient prenatal care). Some states do not release codes on substance use. Furthermore, some potential confounders, such as parity and maternal weight, are important to consider when measuring risks for obstetric complications[56–67] but were not available in the dataset.

Despite the limitations of this study, using the HCUP NIS enabled us to identify and control for many variables that may contribute to maternal health such as hospital region, medical comorbidities, and other risk factors. This prospective computerized database further reduced the biases of self-report. We also examined a large population of women, and thus had sufficient power to detect differences between girls and young women (i.e., 11–14 years old and 15–19 years old) as well as older women (i.e., 35–39 years old and ≥40 years old) versus collapsing all of these women into less defined subgroups as is typically done. Our

large-scale study notably verifies the labor and delivery complications that are associated with women who are at the extremes of maternal age. Our findings encourage the proactive communication of these risks to pregnant women and/or women contemplating pregnancy or delaying pregnancy. Awareness of such risks could play a role in their contraceptive and/or reproductive planning. It is also important for pregnant women to fully understand their personal risk of complications given their age and discuss early-on in their pregnancy the signs and symptoms of complications that should be monitored with their obstetrician and/or be treated for infection prior to delivery.

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Conflicts of Interest

Dr. Madden receives research support from Merck and Co, Inc. and honorarium from Bayer Healthcare Pharmaceuticals. Dr. Peipert receives research support from Merck and Bayer Healthcare Pharmaceuticals Co, Inc. and served on an advisory board for Teva. Dr. Bierut is listed as an inventor on Issued U.S. Patent 8,080,371,"Markers for Addiction" covering the use of certain SNPs in determining the diagnosis, prognosis, and treatment of addiction.

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Table 1

ICD-9-CM codes for complications during labor and delivery

Complication	ICD-9 Codes
Pre-term delivery	644.20, 644.21 (early onset of delivery)
Infection of amniotic cavity	658.40, 658.41
Major puerperal infection	670.00, 670.02 (Major puerperal infection, unspecified) 670.10, 670.12 (Puerperal endometritis) 670.20, 670.22 (Puerperal sepsis) 670.30, 670.32 (Puerperal septic thrombophlebitis) 670.80, 670.82 (Other major puerperal infection)
Poor fetal growth	656.50, 656.51
Postpartum hemorrhage	666.00, 666.02 (Third stage hemorrhage) 666.10, 666.12 (Other immediate postpartum hemorrhage) 666.20, 666.22 (Delayed and secondary postpartum hemorrhage) 666.30, 666.32 (Postpartum coagulation defects)
Fetal distress	656.30, 656.31
Hypertension with pregnancy	642.00–642.02 (Benign essential hypertension complicating pregnancy, childbirth and the puerperium) 642.10–642.12 (Hypertension secondary to renal disease, complicating pregnancy, childbirth and the puerperium) 642.20–642.22 (Other pre-existing hypertension complicating pregnancy, childbirth and the puerperium) 642.30–642.32 (Transient hypertension of pregnancy) 642.90–642.92 (Unspecified hypertension complicating pregnancy, childbirth, or the puerperium)
Mild preeclampsia	642.40–642.42
Severe preeclampsia	642.50–642.52
Eclampsia	642.60–642.62
Superimposed preeclampsia[a]	642.70–642.72

Note: Hypertension with pregnancy, mild preeclampsia, severe preeclampsia, eclampsia, and preeclampsia/eclampsia superimposed on pre-existing hypertension were defined as mutually exclusive of each other. These *codes apply to girls and women of childbearing age*.

[a]Preeclampsia or eclampsia superimposed on pre-existing hypertension

Table 2

ICD-9 codes for covariates

Covariate	ICD-9 Codes
Non-pregnancy related hypertension	401.0, 401.1, 401.9, 402.00, 402.01, 402.10, 402.11, 402.90, 402.91, 403.0–403.01, 403.1–403.11, 403.9–403.91, 404.0–404.03, 404.1–404.13, 404.9–404.93, 405.01, 405.09, 405.11, 405.19, 405.91, 405.99, 437.2
Diabetes	249.00, 249.01, 249.10, 249.11, 249.20, 249.21, 249.30, 249.31, 249.40, 249.41, 249.50, 249.51, 249.60, 249.61, 249.70, 249.71, 249.80, 249.81, 249.90, 249.91, 250.00- 250.03, 250.10–250.13, 250.20–250.23, 250.30–250.33, 250.40–250.43, 250.50–250.53, 250.60–250.63, 250.70–250.73, 250.80–250.83, 250.90–250.93, 648.00–648.02
Gestational diabetes	648.80–648.82
Alcohol disorders	291.0–291.5, 291.8–291.82, 291.89, 291.9, 303.00–303.03, 303.90–303.93, 305.00–305.03, 760.71, 980.0
Other substance disorders	292.0, 292.11, 292.12, 292.2, 292.81–292.85, 292.89, 292.9, 304.00–304.03, 304.10–304.13, 304.20–304.23, 304.30–304.33, 304.40–304.43, 304.50–304.53, 304.60–304.63, 304.70–304.73, 304.80–304.83, 304.90–304.93, 305.1–305.13, 305.20–305.23, 305.30–305.33, 305.40–305.43, 305.50–305.53, 305.60–305.63, 305.70–305.73, 305.80–305.83, 305.90–305.93, 648.30–648.34, 649.00–649.04, 655.50, 655.51, 655.53, 760.72, 760.73, 760.75, 779.5, 965.00–965.02, 965.09, V15.82, V65.42
Cardiac disease	032.82, 036.40–036.43, 074.20–074.23, 112.81, 115.03, 115.04, 115.13, 115.14, 115.93, 115.94, 130.3, 391.0–391.2, 391.8, 391.9, 392.0, 393, 394.0–394.2, 394.9, 395.0–395.2, 395.9, 396.0–396.3, 396.8, 396.9, 397.0, 397.1, 397.9, 398.0, 398.90, 398.91, 398.99, 412, 413.0, 413.1, 413.9, 414.00–414.07, 414.10–414.12, 414.19, 414.2, 414.3, 414.8, 414.9, 415.0–415.12, 415.19, 416.0, 416.1, 416.8, 416.9, 417.0, 417.1, 417.8, 417.9, 420.0, 420.90, 420.91, 420.99, 421.0, 421.1, 421.9, 422.0, 422.90–422.93, 422.99, 423.0–423.3, 423.8, 423.9, 424.0–424.3, 424.90, 424.91, 424.99, 425.0- 425.5, 425.7–425.9, 426.0, 426.10–426.13, 426.2–426.4, 426.50–426.54, 426.6, 426.7, 426.81, 426.82, 426.89, 426.9, 427.0–427.2, 427.31, 427.32, 427.41, 427.42, 427.60, 427.61, 427.69, 427.81, 427.89, 427.9, 428.0, 428.1, 428.20–428.23, 428.30–428.33, 428.40–428.43, 428.9, 429.0–429.6, 429.71, 429.79, 429.81–429.83, 429.89, 429.9, 668.10–668.14, 674.5, 785.0–785.3, V42.1, V42.2, V43.2, V43.3, V45.81, V45.82, V45.00-V45.02, V45.09, V53.31, 53.32, V53.39
Sexually transmitted diseases (syphilis, gonorrhea, herpes, other venereal diseases)	647.00– 647.02, 647.10–647.12, 647.20– 647.22, 054.10–054.12, 054.19
Multiple gestation	651.01, 651.02, 651.11, 651.12, 651.21, 651.22, 651.31, 651.32, 651.41, 651.42, 651.51, 651.52, 651.61, 651.62, 651.81, 651.82, 651.91, 651.92, V27.2 – V27.7, 662.31, 662.32
Cesarean delivery [a]	Procedure codes 74.0–74.2, 74.4, and 74.99 (all delivery stays Without these codes were considered vaginal deliveries)
Retained placenta [a]	667.0 – 667.1
Manual removal of retained placenta [a]	Procedure code 75.4

[a]Only included in models for endometritis and postpartum hemorrhage.

Table 3

Demographic characteristics of delivery discharges in 2009 (Weighted N=4,109,297)

Demographic characteristic	Weighted n (weighted %)
Age of mother	
11–14 years old[a]	4,734 (0.1)
15–19 years old	411,545 (10.0)
20–24 years old	994,494 (24.2)
25–29 years old	1,147,222 (27.9)
30–34 years old	954,421 (23.2)
35–39 years old	481,990 (11.7)
≥ 40 years old	114,889 (2.8)
Race of mother	
White	1,812,074 (44.1)
Black	493,212 (12.0)
Hispanic	812,728 (19.8)
Asian/Pacific Islander	168,185 (4.1)
Native American	35,159 (0.9)
Other	189,947 (4.6)
Missing	597,992 (14.6)
Median household income national quartile for patient zip code	
Lowest quartile ($1-38,999)	1,046,329 (26.2)
Second quartile ($39,000–47,999)	1,045,925 (26.2)
Third quartile ($48,000–62,999)	974,287 (24.4)
Highest quartile (≥$63,000)	929,205 (23.3)
Primary expected payer	
Medicare	21,601 (0.5)
Medicaid	1,813,998 (44.2)
Private insurance	1,994,822 (48.6)
Self-pay	154,309 (3.8)
No charge	11,511 (0.3)
Other	105,480 (2.6)
Region of hospital	
Northeast	626,735 (15.3)
Midwest/North Central	876,456 (21.3)
South	1,656,204 (40.3)
West	949,902 (23.1)
Patient location	
Large central metro [b]	1,315,972 (32.4)
Large fringe metro [c]	1,074,635 (26.5)

Demographic characteristic	Weighted n (weighted %)
Medium metro [d]	727,534 (17.9)
Small metro [e]	327,406 (8.1)
Micropolitan	388,715 (9.6)
Noncore [f]	223,202 (5.5)

[a] 11 years olds represented only 5 (weighted n) of the discharges. The rest were 12–14 year olds.

[b] Central counties of metro areas of ≥1 million population

[c] Fringe counties of metro areas of ≥1 million population

[d] Counties in metro areas of 250,000–999,999 population

[e] Counties in metro areas of 50,000–249,999 populations

[f] Not metropolitan or micropolitan counties

Table 4

Complications during labor and delivery in 2009, stratified by age group

Deliveries	**11–14 years old**		**15–19 years Old**		**20–24 years old**		**25–29 year olds**		**30–34 years old**		**35–39 years olds**		**≥40 years old**	
	4,734		**411,455**		**994,494**		**1,147,222**		**954,421**		**481,990**		**114,889**	
Length of hospitalization														
Mean (SE)	2.87(0.10)		2.62 (0.02)		2.56 (0.02)		2.59(0.02)		2.69(0.02)		2.89(0.04)		3.11(0.04)	
Median (IQR)	2.0(1.4–2.7)		1.9(1.3–2.6)		1.8(1.3–2.5)		1.8(1.3–2.6)		1.9(1.3–2.6)		2.0(1.4–2.8)		2.2(1.5–3.0)	
Hospital costs	$4,137(194)		$4,214(117)		$4,244 (107)		$4,311($3,107)		$4,560(145)		$5,011(211)		$5,521(279)	
Mean (SE)	$3,386		$3,491		$3,501		$3,570		$3,748		$4,002		$4,331	
Median (IQR)	(2,354–4,829)		(2,491–4,953)		(2,488–4,986)		(2.536–5,067)		(2,653–5,317)		(2,829–5,752		(3,028–9-6,280)	
Type of delivery	**Number**[a]	**Rate**[b]	**Number**[a]	**Rate**[b]	**Number**[a]	**Rate**[b]	**Number**[a]	**Rate**[b]	**Number**[a]	**Rate**[b]	**Number**[a]	**Rate**[b]	**Number**[a]	**Rate**[b]
Cesarean	1,034	218. 4	97,263	236. 3	289,64 9	291. 3	373,2 97	325.4	352,501	369.3	208,92 1	433.5	57,5 63	501. 0
Complication	**Number**[a]	**Rate**[b]	**Number**[a]	**Rate**[b]	**Number**[a]	**Rate**[b]	**Number**[a]	**Rate**[b]	**Number**[a]	**Rate**[b]	**Number**[a]	**Rate**[b]	**Number**[a]	**Rate**[b]
Preterm delivery	511	107. 9	33,770	82.1	73,484	73.9	77,438	67.5	66,0 03	69.2	36,329	75.4	10,6 34	92.6
Chorioamnionitis	124	26.3	10,254	24.9	18,417	18.5	17,890	15.6	13,9 96	14.7	6,394	13.3	1,37 4	12.0
Endometritis	70	14.7	2,722	6.6	4,004	4.0	3,595	3.1	2,47 9	2.6	1,336	2.8	399	3.5
Poor fetal growth	126	26.7	11,336	27.5	22,388	22.5	20,477	17.8	16,2 86	17.1	8,659	18.0	2,65 4	23.1
Postpartum hemorrhage	186	39.3	11,873	28.8	25,965	26.1	29,298	25.5	24,3 08	25.5	13,077	27.1	3,38 8	29.5
Fetal distress	**	**	953	2.3	1,981	2.0	1,712	1.5	1,36 7	1.4	627	1.3	265	2.3
Hypertension[c]	221	46.6	17,124	41.6	43.074	43.3	57,139	49.8	49,6 25	52.0	30,832	64.0	9,91 4	86.3
Mild preeclampsia	242	51.1	12,989	31.6	24,159	24.3	24,322	21.2	18,2 71	19.1	10,000	20.7	3,13 7	27.3
Severe preeclampsia	115	24.3	6,837	16.6	12,836	12.9	13,140	11.5	10,5 11	11.0	6,632	13.8	2,20 3	19.2
Eclampsia	**	**	734	1.8	864	0.9	665	0.6	560	0.6	215	0.4	65	0.6

Deliveries	11–14 years old		15–19 years Old		20–24 years old		25–29 year olds		30–34 years old		35–39 years olds		≥40 years old	
	4,734		411,455		994,494		1,147,222		954,421		481,990		114,889	
Superimposed preeclampsia[d]	20	4.1	779	1.9	3,040	3.1	5,405	4.7	5,990	6.3	4,403	9.1	1,676	14.6
Any of the above	1,355	286. 3	93,290	226. 7	198,15 5	199. 3	215,605	187.9	178, 183	186. 7	99,088	205.6	29,0 50	252. 9

SE=standard error; IQR=inter-quartile range

[a] Numbers are weighted to provide national estimates.

[b] Rate per 1000 deliveries

[c] Hypertension is with pregnancy

[d] Preeclampsia superimposed on pre-existing hypertension

** Counts and rates suppressed due to small cell size (< 11).

Table 5

Odds of complication during labor and delivery for age groups, adjusted for demographics, type of birth, and comorbidities

Complication	11–14 years old OR (99% CI)	15–19 years old OR (99% CI)	20–24 years old OR (99% CI)	25–29 years old OR (99% CI)	30–34 years old OR (99% CI)	35–39 years old OR (99% CI)	≥40 years old OR (99% CI)
Preterm delivery	**1.57 (1.18 – 2.10)**	**1.19 (1.14 – 1.25)**	**1.06 (1.03 – 1.10)**	Reference	1.01 (0.98 – 1.05)	**1.08 (1.03 – 1.12)**	**1.26 (1.18 – 1.36)**
Chorioamnionitis	**1.92 (1.14 – 3.25)**	**1.72 (1.55 – 1.91)**	**1.24 (1.16 – 1.34)**	Reference	**0.88 (0.79 – 0.99)**	**0.78 (0.68 – 0.89)**	**0.70 (0.56 – 0.87)**
Endometritis [a]	**5.29 (2.54 – 11.01)**	**2.56 (2.16 – 3.04)**	**1.35 (1.18 – 1.55)**	Reference	**0.74 (0.62 – 0.88)**	**0.70 (0.56 – 0.89)**	0.86 (0.58 – 1.28)
Poor fetal growth	1.65 (0.98 – 2.76)	**1.58 (1.46 – 1.71)**	**1.24 (1.17 – 1.32)**	Reference	0.96 (0.90 – 1.02)	0.98 (0.90 – 1.07)	**1.26 (1.11 – 1.43)**
Postpartum hemorrhage [a]	1.60 (0.97 – 2.66)	**1.11 (1.02 – 1.20)**	1.02 (0.96 – 1.08)	Reference	1.00 (0.94 – 1.06)	1.06 (0.98 – 1.14)	1.13 (0.98 – 1.29)
Fetal distress	1.49 (0.26 – 8.64)	**1.47 (1.12 – 1.93)**	**1.27 (1.03 – 1.56)**	Reference	1.01 (0.80 – 1.29)	0.91 (0.64 – 1.29)	**1.60 (1.09 – 2.36)**
Hypertension [b]	0.95 (0.64 – 1.41)	**0.85 (0.79 – 0.90)**	**0.87 (0.83 – 0.90)**	Reference	**1.06 (1.02 – 1.11)**	**1.31 (1.23 – 1.38)**	**1.76 (1.63 – 1.91)**
Mild preeclampsia	**2.54 (1.73 – 3.74)**	**1.57 (1.47 – 1.68)**	**1.19 (1.12 – 1.26)**	Reference	**0.88 (0.82 – 0.93)**	**0.92 (0.85 – 0.99)**	**1.17 (1.04 – 1.31)**
Severe preeclampsia	1.77 (0.996 – 3.13)	**1.41 (1.27 – 1.58)**	**1.10 (1.02 – 1.20)**	Reference	0.94 (0.86 – 1.02)	**1.13 (1.03 – 1.24)**	**1.50 (1.29 – 1.75)**
Eclampsia	2.01 (0.15 – 26.22)	**3.07 (2.21 – 4.27)**	**1.47 (1.07 – 2.03)**	Reference	1.01 (0.71 – 1.45)	0.83 (0.52 – 1.33)	0.99 (0.45 – 2.19)
Superimposed preeclampsia[c]	0.73 (0.20 – 2.65)	**0.34 (0.27 – 0.44)**	**0.58 (0.51 – 0.65)**	Reference	**1.40 (1.25 – 1.56)**	**2.00 (1.76 – 2.27)**	**2.95 (2.48– 3.52)**
Any of the above	**1.73 (1.38 – 2.18)**	**1.28 (1.23 – 1.32)**	**1.07 (1.04 – 1.10)**	Reference	0.98 (0.96 – 1.00)	**1.07 (1.03 – 1.11)**	**1.34 (1.26 – 1.42)**

Adjusting for race, hospital region, patient's residence location (measure of urban/rural), median community household income (for patient's zip code of residence), insurance type, non-pregnancy related hypertension, diabetes, gestational diabetes, substance use disorders, alcohol disorders, cardiac disease, sexually transmitted diseases, insufficient prenatal care and multiple gestation.

[a] Also adjusts for cesarean delivery, retained placenta, and manual removal of retained placenta.

[b] Hypertension is with pregnancy

[c] Preeclampsia superimposed on pre-existing hypertension. This model does not adjust for non-pregnancy related (pre-existing) hypertension.