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Cost of Gestational Diabetes Mellitus in the United States in 2007

Yaozhu Chen, M.P.A.,[1] William W. Quick, M.D., F.A.C.P., F.A.C.E.,[2] Wenya Yang, M.P.A.,[1] Yiduo Zhang, Ph.D.,[1] Alan Baldwin, M.S.,[3] Jane Moran, M.D.,[2] Victoria Moore, B.S.,[3] Navita Sahai, B.A.,[1] and Timothy M. Dall, M.S.[1]

Abstract

The objective of this study was to estimate the national medical costs associated with gestational diabetes mellitus (GDM) in 2007. We analyzed the National Hospital Discharge Survey to estimate the national prevalence of GDM. Using Poisson regression analysis with medical claims for about 27,000 newborns and their mothers, we estimated rate ratios that reflect the increase in use of health care services associated with GDM. Combining GDM prevalence rates with these rate ratios, we calculated etiological fractions that reflect the proportion of national health care resource use associated with GDM. We then multiplied these fractions by estimates of national health care use and costs in 2007.

GDM prevalence increases with age, rising from 1.3% of pregnancies of women younger than age 21 to 8.7% of pregnancies of women older than age 35. For the estimated 180,000 GDM pregnancies resulting in delivery, average expenditures increased $3,305 per pregnancy plus $209 in the newborn's first year of life. GDM increased national medical costs by $636 million in 2007—$596 million for maternal costs and $40 million for neonatal costs. Approximately $230 million (36%) of GDM-related medical costs are covered by government programs (primarily Medicaid), $355 million (56%) are covered by private insurers, and $51 million (8%) are covered by self-pay and charity care.

GDM imposes a significant economic burden. These estimates of the economic burden of GDM are likely conservative because we focus on near-term medical costs, omitting the increased risk for long-term sequelae. (*Population Health Management.* 2009;12:165–174)

Introduction

Gestational diabetes mellitus (GDM), defined as any degree of glucose intolerance with onset or first recognition during pregnancy, is present in approximately 4%–7% of pregnancies.[1–4] The prevalence of GDM has risen over time, due in part to the rising prevalence of obesity among women of child-bearing age.[3,5,6]

GDM is associated with increased risk for perinatal morbidity, maternal trauma, preeclampsia and eclampsia, and operative deliveries.[2,7] Poor control of glycemic levels increases rates of delivery by cesarean and shoulder dystocia.[8] GDM is a significant predictor of type 2 diabetes.[9] After pregnancy, 5% to 10% of women with GDM are found to have type 2 diabetes, and women with GDM have a 20% to 50% probability of developing diabetes in the 5 to 10 years following pregnancy (although these rates partially reflect correlation with other risk factors).[10]

An elevated glucose level is toxic to the developing fetus and contributes to embryopathy.[11] Adverse outcomes may include macrosomia, neonatal intensive care unit admission, and perinatal death (stillbirths and neonatal deaths).[12–15] Macrosomia is present in 20% of patients with GDM, but present in only 12% of pregnancies in which GDM is absent.[14] Neonates have increased risk of hypoglycemia, jaundice, polycythemia, hypocalcemia, hypomagnesemia, and

[1]The Lewin Group, Falls Church, Virginia.
[2]Ingenix/i3research, Basking Ridge, New Jersey.
[3]Ingenix/ i3 Pharmainformatics, Cary, North Carolina.

respiratory distress syndrome.[13] Maternal obesity and GDM may increase the risk of a range of structural birth defects through shared causal mechanisms.[12,15] Adult offspring of mothers with GDM have increased risk of type 2 diabetes and cardiovascular disease.[16–20]

While the studies referenced and others have found an increase in rate of pregnancy and newborn complications associated with GDM, few have analyzed the economics of GDM and we identified no studies that estimate the national economic burden associated with GDM.[21–24] Such information is needed to better understand the business case for initiatives to improve screening, awareness, and treatment of GDM to meet the Healthy People 2010 goal to decrease the proportion of pregnant women with GDM.[25]

Research Design and Methods

This analysis focuses on pregnancies that result in delivery (including both live births and stillbirths). Analysis of mothers' health care use covers the period 9 months preceding delivery through 12 months following delivery. The newborn analysis covers perinatal outcomes and associated health care use during the 12 months following delivery.

We estimate national maternal and newborn health service use and cost associated with GDM using an attributable risk method widely used in cost of illness studies.[26–28] This approach requires the calculation of etiological fractions constructed from estimates of (1) GDM prevalence rates, and (2) rate ratios that reflect per capita health care use when GDM is present divided by per capita health care use when GDM is absent, controlling for other determinants of health care use. Multiplying estimates of national health care use by these fractions provides estimates of national health resource use provided to GDM mothers and their newborns in excess of the required level of care if GDM were absent. For estimates of maternal and perinatal costs associated with GDM, we combine information from each component of the analysis by mother's age ($\leq$20, 21–25, 26–30, 31–35, and $\geq$36) at delivery or by newborn's sex.

We analyze national health care use and costs associated with GDM for the following complication categories[29]:

- direct treatment of GDM;
- 8 categories of maternal outcomes—cesarean delivery, polyhydramnios, urinary tract infection, amniotic cavity infection, preeclampsia and eclampsia, other hypertension complicating pregnancy, other pregnancy-related events, and all other events with pregnancy codes shown in secondary diagnosis fields; and
- 10 categories of perinatal outcomes—intrauterine hypoxia and birth asphyxia, macrosomia, endocrine and metabolic disturbances specific to the fetus and newborn, birth trauma due to long gestation and high birth weight, fetus or newborn affected by other complications of labor and delivery, respiratory distress syndrome, jaundice, congenital anomalies, other neonatal events, and all other events with neonatal codes shown in secondary diagnosis fields.

Primary and secondary diagnosis codes and procedure codes are used to assign medical claims to these complication categories, with the codes provided in Appendix Table A-1.

Etiological fractions

The etiological fractions (ε) are constructed using the following equation that combines GDM prevalence rates (P) with the health care use rate ratios (RR):

$$\varepsilon_{c,d,o} = \frac{P_d \times (RR_{c,d,o} - 1)}{P_d \times (RR_{c,d,o} - 1) + 1}.$$

Separate fractions are calculated for women and newborns by complication category (c) and demographic (d) for 3 outcome (o) measures—hospital inpatient days, emergency visits, and other ambulatory visits (ie, hospital/clinic outpatient visits and physician office visits combined). The demographic dimension consists of mother's age (for the maternal analysis) and newborn's sex (for the newborn analysis).

Estimating GDM prevalence

GDM is defined as any degree of glucose intolerance with onset or first recognition during pregnancy, which acknowledges the possibility that patients may have previously undiagnosed diabetes mellitus or may have developed diabetes coincidentally with pregnancy.[30]

To estimate total cases of GDM in 2007, we first combined the 2003 through 2005 samples of the National Hospital Discharge Survey to estimate the proportion of deliveries in which the mother has GDM. Pregnancies with GDM are identified using the discharge diagnosis for GDM (*International Classification of Diseases,* Ninth Revision, Clinical Modification [ICD-9-CM] code 648.8) at time of delivery.[3,31,32] Included in the GDM prevalence rates are pregnancies that result in delivery—whether singleton live birth, multi-fetal live birth, or stillbirth. We calculated this proportion by mothers' age group, and race and ethnicity (non-Hispanic White, non-Hispanic Black, non-Hispanic Other, and Hispanic). Then, we multiplied these proportions by Census Bureau projected birth counts for 2007 for each demographic group.[33]

Estimating rate ratios for health resource use

The rate ratios describe how per capita use of health care services differs by GDM status, controlling for other determinants of care. The rate ratios come from a series of Poisson regressions of medical claims from a longitudinal database, the Ingenix Research Data Mart (RDM).

The RDM contains medical records for 32,735 women who gave birth in 2005 and who were continuously enrolled from January 1, 2004 through December 31, 2006. The population in RDM is largely commercially insured, a limitation discussed later. The number of multi-fetal live births in the RDM is relatively small, so we restrict our medical claims analysis to singleton live births. The Poisson regressions are based on medical records for 26,911 deliveries (82% of deliveries in 2005 in the original data extraction). The final sample excludes 105 stillbirths, 6 women with multiple pregnancies in 2005, 717 multi-fetal live births, 1,853 cases for which a missing family identification code prevents linking newborns to their mothers, and 3,143 cases in which more than 1 infant shares a same family identification code although there are no multi-fetal diagnosis codes to indicate a multi-fetal birth.

Mother's GDM status is determined by the presence of ICD-9-CM diagnosis code 648.8 in claims data during the 9 months preceding and including delivery.

We estimated 39 Poisson regressions (19 for the maternal analysis and 20 for the newborn analysis) reflecting the 39 combinations of health care measures and complication categories. The regression specifications and results are summarized in Appendix Tables A-2 and A-3.

The dependent variables are the health care service measures (ie, hospital inpatient days, emergency visits, other ambulatory visits) for the 8 maternal and 10 perinatal complication groups (not all health care service measures apply to each complication group). Health care use covers the period 9 months preceding delivery through 12 months following delivery for mothers, and the 12 months following delivery for newborns.

The explanatory variables in the Poisson regressions are dichotomous variables for mother's GDM status (1 = present, 0 = absent), mother's age group at time of delivery (for the maternity analysis only), sex of the newborn (for the newborn analysis only), Census Region, presence of HIV/AIDS, presence of cancer, presence of other pregnancy related high risk (for the maternity analysis only), presence of preterm or post-term conditions (for the newborn analysis only), and presence of maternal or perinatal complications. Race and ethnicity are unavailable for most records, so these characteristics are excluded from the regressions. Also, the study population is primarily covered by private insurers (>99%), so no variables reflecting payer type are included in the regressions.

The coefficient for GDM represents an adjusted, logged rate ratio: average health care use when GDM is present, divided by average health care use when GDM is absent, controlling for demographics and other determinants of care.

Estimating national health resource use and cost

Using multiple nationally representative surveys of health care use, we estimate annual national maternal and newborn hospital inpatient days, hospital/clinic outpatient visits, emergency visits, and physician office visits by outcome category. These estimates include care provided for all women in pregnancy and postpartum periods and infants no older than 1 year, including both GDM and non-GDM cases. Estimates are based on survey data for years prior to 2007, but are extrapolated to 2007 based on the Census Bureau's estimates of total births in 2007 compared to total births in prior years.

Estimates of total physician office visits come from an analysis of the 2000 to 2005 National Ambulatory Medical Care Survey (NAMCS). We combined multiple years of data to increase sample size, thereby obtaining more reliable estimates of the prevalence of rare complications. Estimates of outpatient visits and emergency visits come from an analysis of the 2000 to 2005 National Hospital Ambulatory Medical Care Survey (NHAMCS). We analyzed the 2005 Nationwide Inpatient Sample (NIS) to estimate total hospital inpatient days. Estimates of prescriptions per ambulatory visit are from the NAMCS and NHAMCS. Excluded from the analysis are home health, hospice, and nursing home care.

We combined the 2003 to 2005 samples of the Medical Expenditure Panel Survey to calculate national estimates of the average medical cost per outpatient, emergency, and physician office visits, as well as the average cost per prescription. The average cost per inpatient day was calculated using the NIS, and converted from discharge-level charges using hospital-specific cost-to-charge ratios. Cost estimates are calculated for each outcome category, reflecting the total spending and the mix of payers for care (ie, private insurers, Medicaid, Medicare, other insurance programs, self-pay, charity care). All cost estimates are inflated to 2007 dollars using the medical cost component of the consumer price index.

We calculate medical expenditures associated with GDM by combining the etiological fractions, total national health resource use, and average cost per unit per service using the following formula:

$$\text{Cost Attributed to GDM} = \sum_{c}\sum_{d}\sum_{o} \varepsilon_{c,d,o} \times TotalUtilization_{c,d,o} \times AverageCost_{c,o}$$

Results

Our analysis finds that GDM is present in approximately 4.5% of pregnancies that result in delivery (Table 1). This rate is at the lower bound of the 4% to 7% range reported in the literature, but also reflects GDM prevalence among pregnancies resulting in delivery versus all pregnancies.[3,4,32,34,35] In 2007, there were an estimated 180,000 cases of GDM (higher than the 135,000 estimated in previous years to reflect population growth and higher GDM prevalence, and lower than the 200,000 estimated for all pregnancies).[2,4,36] GDM prevalence increases with the mother's age. Although not shown, GDM prevalence is highest among Hispanics, followed by the non-Hispanic Other group, followed by non-Hispanic Blacks, and with prevalence lowest among non-Hispanic Whites.

To prevent double counting when health care use involves multiple outcome categories (eg, cesarean delivery with urinary tract infection present), we use the primary ICD-9-CM diagnosis code to categorize each medical claim. For some outcomes, we use a combination of diagnosis codes and procedure codes (see Appendix Table A-1).

Rate ratios from the Poisson regression (full regression results are in Appendix Tables A-2 and A-3) suggest that, relative to women with no indication of glucose intolerance during their pregnancy, GDM significantly increases rates of hospital inpatient days for cesarean delivery, preeclampsia

Table 1. Prevalence and population with GDM in the United States, 2007

Mother's Age at Delivery	*GDM Prevalence in All Deliveries*	*GDM Population in 2007*
Age ≤20	1.3%	8,000
Age 21–25	2.5%	27,000
Age 26–30	4.7%	55,000
Age 31–35	5.9%	50,000
Age ≥36	8.7%	40,000
Total	4.5%	180,000

GDM, gestational diabetes mellitus.

Table 2. Rate Ratios (from Poisson Regression) of Health Care Use for GDM Women and Their Offspring

	Hospital Inpatient Day	*Emergency Visit*	*Other Ambulatory Visit*
Mother			
Cesarean delivery	1.195**	NA	1.221**
Polyhydramnios	1.440	NA	1.855**
Urinary tract infection	0.683	1.170	1.119**
Amniotic cavity infection	0.466*	NA	0.950
Preeclampsia and eclampsia	1.499**	NA	1.454**
Other hypertension complicating pregnancy	1.560*	NA	1.495**
Other pregnancy-related event	1.286**	1.187	1.368**
All other events with pregnancy codes shown in secondary diagnosis fields	1.101	1.426**	1.123**
Newborn			
Intrauterine hypoxia and birth asphyxia	NA	NA	0.805
Macrosomia	NA	NA	1.826**
Endocrine and metabolic disturbances	2.907**	NA	3.443**
Birth trauma	NA	NA	0.620*
Fetus or newborn affected by other complications of labor and delivery	2.550	NA	1.315**
Respiratory distress syndrome	0.701**	NA	0.820**
Jaundice	1.754**	1.590	1.213**
Congenital anomalies	0.676**	NA	1.127**
Other neonatal event	1.035**	0.590	1.027**
All other events with neonatal codes shown in secondary diagnosis fields	0.977	0.824	1.002

*$P < 0.05$, **$P < 0.01$.
GDM, gestational diabetes mellitus.

and eclampsia, other hypertension complicating pregnancy, and other pregnancy-related events for mothers (Table 2). For example, a rate ratio of 1.195 for hospital inpatient days for cesarean delivery means that the presence of GDM increases inpatient days associated with cesarean delivery by 19.5%. GDM also is associated with a significant increase in ambulatory visits for 7 of the 8 complication categories. Due to the rare incidence of certain complications in some health service settings, rate ratios may not be applicable or may be large but statistically insignificant for some complications by setting combinations.

GDM appears to increase newborns' average inpatient days for endocrine and metabolic disturbances, "other" complications of labor and delivery that affect the fetus or newborn, jaundice, other neonatal events, and all other events with a neonatal diagnosis in the secondary diagnosis field. The increase is statistically significant for endocrine and metabolic disturbances, jaundice, and other neonatal events identified by primary diagnosis. GDM also increases ambulatory visits associated with 7 newborn complication categories, with the increase statistically significant in 6 categories.

For some outcome categories, women with GDM and their newborns have significantly lower use of health care services (eg, inpatient days for amniotic cavity infection for women; ambulatory visits for birth trauma, inpatient days, and ambulatory visits for respiratory distress syndrome; inpatient days for congenital anomalies for newborns). One possible explanation for these anomalies is that these outcomes are rarely listed as the primary diagnosis.

Applying the etiological fractions to total national maternal and neonatal resource use in 2007, we calculate the proportion of health care utilization and cost attributed to GDM (Table 3). For example, of the total predicted 17 million hospital inpatient days for new mothers, approximately 4.8% (838,000 days) are incurred by women with GDM and 1.5% (269,000 days) reflect higher per capita use of services that are attributed to GDM.

The total national cost estimates attributable to GDM are $596 million for mothers (approximately $3,305 per woman with GDM) and $40 million for their newborn offspring (approximately $209 per newborn whose mother has GDM).

We estimate that about 36% ($230 million) of GDM-attributed medical costs are paid for through government programs (primarily Medicaid); 56% ($355 million) are paid by private insurers; and 8% ($51 million) are incurred by uninsured and self-pay patients, which includes charity care for patients unable to pay.

Discussion

The findings of the medical claims analysis are generally consistent with findings in the literature—that GDM is associated with increased risk for select pregnancy and newborn complications, which increases use of health care services. Our national estimate of $636 million in excess medical costs associated with GDM suggests that GDM is responsible for approximately 1% of all pregnancy-related and neonatal-related costs. GDM increases the medical cost of a pregnancy by an average of $3,305. Newborn medical costs during the first year rise by an average $209 per newborn of a GDM mother.

The major strengths of our study include: (1) analysis of a comprehensive list of pregnancy and newborn complications that the literature suggests may be associated with GDM; (2) use of multiple, nationally representative data sources to provide estimates of national health care use and spending

Table 3. Health Care Use and Expenditures in the United States in 2007

	Attributable to GDM		*Incurred by Pregnant Women with GDM and Their Offspring*		*US Total Pregnant Women and Their Offspring*
Health Resource Use	*Unit (thousands)*	*% US Total*	*Unit (thousands)*	*% US Total*	*Unit (thousands)*
Mother					
Hospital inpatient day	269	1.54%	838	4.81%	17,423
Emergency visit	36	0.95%	170	4.47%	3,808
Ambulatory visit	651	1.57%	1,958	4.73%	41,438
Prescription	735	1.91%	2,085	5.43%	38,435
Newborn					
Hospital inpatient day	28	0.15%	873	4.60%	18,969
Emergency visit	1	0.62%	8	4.63%	169
Ambulatory visit	30	0.56%	248	4.62%	5,372
Prescription	27	0.55%	227	4.61%	4,928
Medical Cost	*Dollars (millions)*	*% U.S. Total*	*Dollars (millions)*	*% U.S. Total*	*Dollars (millions)*
Mother					
Hospital inpatient day	$386	1.52%	$1,260	4.95%	$25,452
Emergency visit	$20	0.93%	$92	4.31%	$2,125
Ambulatory visit	$130	1.49%	$418	4.81%	$8,699
Prescription	$60	1.91%	$171	5.43%	$3,146
Subtotal	$596	1.51%	$1,940	4.92%	$39,423
Newborn					
Hospital inpatient day	$28	0.12%	$1,092	4.50%	$24,287
Emergency visit	$1	0.70%	$4	4.50%	$100
Ambulatory visit	$9	0.55%	$70	4.48%	$1,566
Prescription	$2	0.53%	$19	4.47%	$416
Subtotal	$40	0.15%	$1,185	4.50%	$26,368
Total (Mother and Newborn)	$635	0.97%	$3,125	4.75%	$65,791

Numbers might not add to totals because of rounding.
GDM, gestational diabetes mellitus.

for pregnancy and neonatal care; (3) a large ($n \approx 27{,}000$) sample of women (and their newborns) with multiple years of medical claims data to analyze the impact of GDM on per capita use of health care services; and (4) use of a standardized method that recently was used to calculate the national cost associated with diagnosed cases of diabetes.[26]

The database used to analyze differences in per capita health resources use by GDM status consists primarily of a privately insured population. The implicit assumption in this analysis, therefore, is that the percent increase in per capita use of health resources attributed to GDM is similar for the privately insured population and for the Medicaid and other payer type populations. This analysis omits long-term sequelae. Women with GDM are at high risk of developing diabetes and cardiovascular diseases after pregnancy[18,20]; while their offspring are prone to developing childhood obesity, glucose intolerance, and diabetes later in life.[2,16,37] An independent association between exposure to maternal obesity in uterus and the development of type 2 diabetes in offspring has recently been reported.[38,39]

This study focuses on medical costs, but to the extent that women with GDM have higher rates of complications and higher use of health care services, GDM might also have indirect costs—such as increased time off from work or school, psychological stress, and reduced performance by offspring in school. Therefore, these findings might underestimate the total national economic burden of GDM.

The national economic burden of GDM can potentially be reduced through prevention of GDM and improved control of glucose levels among women diagnosed with GDM.[40–43] Universal screening for GDM has been recommended, although this recommendation is controversial as the business case for universal screening has yet to be established.[44–46]

Our study suggests that, together, the average pregnancy and newborn costs per case of GDM exceed $3,500. This information is particularly important to conclude whether any form of diagnosis and treatment is cost-effective or has a positive cost/benefit ratio. Such interventions could include a combination of screening and education for all pregnant women, with particular emphasis on high-risk groups and treatments directed at controlling glucose levels among diagnosed cases of GDM.

The potential of prevention and treatment of GDM to impact the current epidemic of childhood obesity cannot be ignored.[47] Prevention of and interventions targeted at GDM may be keys to interrupting the generational succession of obesity and type 2 diabetes and have far-reaching economic implications.

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Address reprint requests to:
Yaozhu Chen
3130 Fairview Park Drive
Suite 800
Falls Church, VA 22042

E-mail: Juliette.Chen@Lewin.Com

Appendix

Table A-1. Diagnosis and Procedure Codes Used to Define Complications and Conditions

#	*Mother*	*ICD-9-CM Diagnosis*	*DRG*	*MDC*	*ICD-9-CM Procedure*	*CPT*	*Note*
M1	Pregnancy	630–677, V22–V24, V27–V29, 792.3, 796.5	370–384				Apply to any code fields, to define the scope of pregnancy health care use
M2	Cesarean delivery		370–371		74.0–74.2, 74.4, 74.99	59510, 59514, 59515, 59618, 59620, 59622	
M3	Polyhydramnios	657					
M4	Urinary tract infection	599.0, 646.6, 996.64, V13.02					
M5	Amniotic cavity infection	658.4					
M6	Preeclampsia and eclampsia	642.4, 642.5, 642.6					
M7	Other hypertension complicating pregnancy	642.3					
M8	Other pregnancy-related event	Any primary diagnosis codes for pregnancy that are captured in M1 but not shown in maternal complication groups					
M9	All other events	Pregnancy codes shown in secondary diagnosis fields					

#	*Newborn*	*ICD-9-CM Diagnosis*	*DRG*	*MDC*	*ICD-9-CM Procedure*	*CPT*	*Note*
N1	Newborn	760–779, V30–V39, 277.01, 747.83	385–391,469	15			Apply to any code fields, to define the scope of newborn health care use
N2	Intrauterine hypoxia and birth asphyxia	768.0–768.6, 768.9					
N3	Macrosomia	766.0, 766.1					
N4	Endocrine and metabolic disturbances	775.0, 775.4–775.9					
N5	Birth trauma	767.0–767.9					
N6	Fetus or newborn affected by other complications of labor & delivery	763.0–763.9					
N7	Respiratory distress syndrome	769					
N8	Jaundice	782.4, 774.2, 774.5, 774.6					
N9	Congenital anomalies	740–759					
N10	Other neonatal event	Any primary diagnosis codes for newborn that are captured in N1 but not shown in neonatal complication groups					
N11	All other events	Neonatal codes shown in secondary diagnosis fields					

The codes based on DRG, MDC, ICD-9-CM Procedure, and CPT were verified against the primary ICD-9-CM diagnosis codes.
DRG, diagnosis related group; MDC, Major Diagnostic Categories; CPT, Current Procedural Terminology.

Table A-2. Poisson Regression for Maternal Analysis

Utilization	*Variable*	*Category*	*Cesarean delivery*		*Polyhydramnios*		*Urinary tract infection*		*Amniotic cavity infection*		*Preeclampsia and eclampsia*		*Other hypertension complicating pregnancy*		*Other pregnancy-related event*		*All other non pregnancy related event*	
Inpatient Day	GDM status	Present vs. absent	1.20	**	1.44		0.68		0.47	*	1.50	**	1.56	*	1.29	**	1.10	
	Age Group	Age 21–25	1.12	*	NA		0.14	**	0.33	**	0.73	**	NA		0.49	**	0.50	**
	(vs. Age ≤20)	Age 26–30	1.29	**	NA		0.15	**	0.31	**	0.46	**	NA		0.44	**	0.54	**
		Age 31–35	1.47	**	NA		0.09	**	0.30	**	0.47	**	NA		0.37	**	0.45	**
		Age > 35	1.72	**	NA		0.04	**	0.24	**	0.46	**	NA		0.42	**	0.39	**
	Cancer	Present vs. absent	0.99		0.73		1.68	**	1.35		0.91		0.53	*	1.00		1.82	**
	Other pregnancy related high risk	Present vs. absent	1.31	**	1.79	**	2.12	**	1.50	*	1.83	**	2.05	**	2.68	**	1.27	**
	HIV/AIDS	Present vs. absent	0.84		6.47	**	0.00		0.00		2.40	**	0.00		3.72	**	3.50	**
	Region (vs. Northeast)	Midwest	0.80	**	0.38	**	1.03		0.84		1.11		0.98		0.93		1.48	**
		South	0.99		0.54	**	0.97		0.90		1.31	**	1.97	*	1.15	**	1.78	**
		West	0.86	**	0.39	**	1.01		0.93		0.91		0.42	*	1.15	**	1.24	*
Emergency Visit	GDM status	Present vs. absent	NA		NA		1.17		NA		NA		NA		1.19		1.43	**
	Age Group (vs. Age ≤20)	Age 21–25	NA		NA		0.30	*	NA		NA		NA		0.42	**	0.52	**
		Age 26–30	NA		NA		0.09	**	NA		NA		NA		0.30	**	0.38	**
		Age 31–35	NA		NA		0.09	**	NA		NA		NA		0.18	**	0.29	**
		Age > 35	NA		NA		0.04	**	NA		NA		NA		0.17	**	0.25	**
	Cancer	Present vs. absent	NA		NA		1.73		NA		NA		NA		0.93		1.35	**
	Other pregnancy related high risk	Present vs. absent	NA		NA		2.38	**	NA		NA		NA		1.49	**	1.49	**
	HIV/AIDS	Present vs. absent	NA		NA		0.00		NA		NA		NA		0.00		0.00	
	Region (vs. Northeast)	Midwest	NA		NA		NA		NA		NA		NA		4.71	**	3.52	**
		South	NA		NA		NA		NA		NA		NA		0.40	**	0.78	
		West	NA		NA		NA		NA		NA		NA		0.11	**	0.67	*
Other Ambulatory Visit	GDM status	Present vs. absent	1.22	**	1.85	**	1.12	**	0.95		1.45	**	1.50	**	1.37	**	1.12	**
	Age Group (vs. Age ≤20)	Age 21–25	1.22	*	1.27		0.76	**	0.53	*	0.81		1.13		1.00		0.94	**
		Age 26–30	1.43	**	1.04		0.58	**	0.55	*	0.64	**	0.95		0.96	**	0.96	**
		Age 31–35	1.61	**	1.07		0.48	**	0.47	**	0.67	**	0.87		0.97	*	1.00	
		Age > 35	1.85	**	1.34		0.40	**	0.52	*	0.57	**	0.72	*	1.02		1.08	**
	Cancer	Present vs. absent	1.00		1.09		1.18	**	0.95		0.92		1.00		1.03	**	1.47	**
	Other pregnancy related high risk	Present vs. absent	1.20	**	1.86	**	1.23	**	1.24		2.01	**	1.60	**	1.26	**	1.35	**
	HIV/AIDS	Present vs. absent	0.93		1.42		1.14		0.00		0.00		0.00		0.90	**	1.11	**
	Region (vs. Northeast)	Midwest	0.80	**	0.70	**	0.82	**	1.45	*	0.91		1.70	**	0.88	**	0.85	**
		South	1.09	**	0.87		1.08	*	0.70		1.37	**	1.46	**	0.88	**	0.79	**
		West	0.95		0.73	**	0.81	**	1.15		0.86		1.05		0.90	**	0.85	**

*$p < 0.05$, **$p < 0.01$.
GDM, gestational diabetes mellitus.

Table A-3. Poisson Regression for Newborn Analysis

Utilization	*Variable*	*Category*	*Intrauterine hypoxia and birth asphyxia*	*Macrosomia*	*Endocrine and metabolic disturbances*	*Birth trauma*	*Newborn affected by other complications*	*Respiratory distress syndrome*	*Jaundice*	*Congenital anomalies*	*Other neonatal event*	*All other non-neonatal care related event*
Inpatient Day	GDM status of newborn's mother	Present vs. absent	NA	NA	2.91 **	NA	2.55	0.70 **	1.75 **	0.68 **	1.04 **	0.98
	Cancer	Present vs. absent	NA	NA	4.00	NA	14.90 *	0.00	0.46	26.55 **	1.41 **	15.61 **
	Sex	Male v. Female	NA	NA	1.12	NA	7.94 *	2.70 **	1.20 *	1.25 **	1.03 **	1.32 **
	HIV/AIDS	Present vs. absent	NA	NA	0.00	NA	0.00	0.00	0.00	0.00	1.07	0.00
	Post-term	Present vs. absent	NA	NA	3.29	NA	0.00	0.91	1.28	0.76	0.84 **	0.81
	Preterm	Present vs. absent	NA	NA	0.00	NA	0.00	0.00	0.00	61.54 **	7.52 **	14.06 **
	Region (vs. Northeast)	Midwest	NA	NA	0.30 **	NA	NA	10.81 **	0.97	0.67 **	0.91 **	0.51 **
		South	NA	NA	0.10 **	NA	NA	5.98 **	0.69 *	0.65 **	0.97 *	0.73 **
		West	NA	NA	0.42 *	NA	NA	19.20 **	0.87	0.84 *	0.70 **	0.61 **
ED Visits	GDM status of newborn's mother	Present vs. absent	NA	NA	NA	NA	NA	NA	1.59	NA	0.59	0.82
	Cancer	Present vs. absent	NA	NA	NA	NA	NA	NA	0.00	NA	0.00	0.79
	Sex	Male vs. Female	NA	NA	NA	NA	NA	NA	1.14	NA	1.38	1.19 **
	HIV/AIDS	Present vs. absent	NA	NA	NA	NA	NA	NA	0.00	NA	0.00	0.00
	Post-term	Present vs. absent	NA	NA	NA	NA	NA	NA	0.00	NA	0.00	0.66
	Preterm	Present vs. absent	NA	NA	NA	NA	NA	NA	0.00	NA	0.00	0.00
	Region (vs. Northeast)	Midwest	NA	NA	NA	NA	NA	NA	NA	NA	NA	52.47 **
		South	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.99 **
		West	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.04
Other Ambulatory Visits	GDM status of newborn's mother	Present vs. absent	0.80	1.83 **	3.44 **	0.62 *	1.32 **	0.82 **	1.21 **	1.13 **	1.03 **	1.00
	Cancer	Present vs. absent	1.41	1.86	2.01 *	0.39	1.27	2.65 **	1.03	4.78 **	1.58 **	2.16 **
	Sex	Male vs. Female	0.96	1.99 **	0.82 *	1.05	0.97	1.57 **	1.13 **	1.40 **	0.99	1.13 **
	HIV/AIDS	Present vs. absent	0.00	0.00	0.00	0.00	10.30 **	0.00	0.00	0.00	0.91	1.05
	Post-term	Present vs. absent	1.72	3.23 **	2.58 **	4.50 **	1.52 *	0.06 **	0.62 **	0.59 **	0.84 **	1.03
	Preterm	Present vs. absent	0.00	0.00	0.00	0.00	2.48	9.10 **	1.26	12.03 **	7.03 **	1.19
	Region (vs. Northeast)	Midwest	0.95	0.70	0.80	0.68 *	0.65 **	1.54 **	1.28 **	0.96	0.92 **	0.89 **
		South	1.32	0.89	1.07	0.46 **	1.33 **	3.87 **	1.25 **	0.83 **	1.05 **	0.90 **
		West	1.05	0.61 *	0.99	0.35 **	1.06	2.33 **	1.42 **	0.73 **	0.99	0.87 **

*$P < 0.05$, **$P < 0.01$.
GDM, gestational diabetes mellitus.