Variation in Infant Birth Weight: Socioeconomic Factors versus Medical Conditions

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ABSTRACT

This paper seeks to determine the relative effect of socioeconomic variables and medical conditions in explaining changes in infant birth weight, specifically, low birth weight (LBW). Using ordinary least squares regression, we first analyze the effects of these variables on the birth weight of 621 infants. Four of the independent variables – gestational age in number of days, sex, parity, and health insurance – are statistically significant ($P<.05$) and explain 64 percent of the variation in infant birth weight. But in a subset of 18 infants born with LBW to mothers $\leq$18 years of age or 35$\geq$ years of age, only gestational age in number of days is statistically significant.

INTRODUCTION

Previous investigations often explained variations in infant birth weight, particularly low birth weight rate (LBW, <2,500g), through physiologic variables such as gestational age and the presence of complicating medical factors. These investigations ignored the fact that such socioeconomic factors as insurance coverage, race, and marital status may also be important. Unfortunately, few studies have simultaneously examined medical conditions and socioeconomic factors to determine their total effect on infant birth weight (e.g., see Hueston, Gilbert, Davis, & Sturgill, 2003; Lee, Sobal, Frongillo, Olson, & Wolfe, 2005).

Moreover, the pattern has been for studies to rely on a handful of variables and simple descriptive statistics (e.g., see McCarton, Wallace, & Bennett, 1995; Moawad, Lee, Fisher, Ferguson, & Phillippe, 1990; Stewart & Nimrod, 1993; United States [U.S.]. Department of Health and Human Services 1991; U.S. General Accounting Office 1994, Warner, 1998). Only in recent years have health care professionals begun to employ more elaborate research designs, but these studies remain the exception and not the rule (see Baldwin et al., 2002; Bennett, 2002; Goldenberg & Culhane, 2007; Heaphy & Bernard, 2000; Lee et al., 2005; Leonardson, Loudenburg, & Struck, 2007; Mittendorf et al., 1994; Serwint, Wilson, Vogelhut, Repke, & Seidel, 1996; Shi et al., 2004; Stevens, Seid, & Halfon, 2006). Furthermore, the vast majority of rural studies examine populations in South America, Africa, or the Far East, whose demographics are very dissimilar from the rural population of the United States. Consequently, the previous studies may have little value for developing policy solutions to deal with the LBW in rural America.

Why should policy makers be concerned with a medical issue such as LBW? First, among developed nations, the LBW rate for the United States historically has been high. Indeed, the rate of births at <2,500g increased between 1980 and 1995, and the proportion still exceeds that of most other industrialized societies (Baker, 1991; Goldenberg & Culhane, 2007; U.S. Department of Health and Human Services, 1991; Zavis, 1997). Second, despite Federal and state programs developed specifically for pregnant women; e.g., *Women, Infant and Children*, the *California Sweet Success Program* (Anderson, Smiley, Flick, & Lewis, 2000; Mittendorf et al., 1994; Stevens, Seid, & Halfon, 2006), the rate of LBW has not declined consistently and continuously across the United States (see Thompson, Goodman, Chang, & Stukel, 2005). Third, the rate of LBW in the United States remains abnormally high in rural versus urban locations and in comparison to such other demographic variables as race and level of education (Baldwin et al, 2002; Yoder & Young, 1997).

Our study is an effort to bridge the gap regarding what we know about the factors contributing to LBW in rural areas by analyzing *together* medical conditions and socioeconomic factors. Such an approach mirrors the practice of treating the whole patient, and it provides a better picture of what affects LBW, particularly for females living in rural areas. Pregnant females living in rural areas are more likely to encounter obstacles to prenatal care than their counterparts living in such major urban areas as Boston and Chicago, or even in such smaller communities such as Knoxville, Tennessee, or Sioux Falls, South Dakota. We believe that these obstacles include traveling further for medical care, lesser access to specialist care, inadequate diets and access to dietary supplements, diminished likelihood of private health care coverage, and bearing more children than their urban counterparts.

RESEARCH DESIGN

CONCEPTUAL FRAMEWORK

We used the data that was prospectively collected on clients of the South-East Tennessee Rural Perinatal Network Program to look for correlates of low birth weight among a mostly low-income rural population. The "Network" was designed to bring high-quality streamlined pregnancy and newborn care to women and infants in a historically under-served region. As a novel program, we incorporated rigorous data collection and ongoing analysis for quality assurance. This paper presents social and economic determinants of low birth weight among the clients of the "Network".

HYPOTHESES

This study tests two hypotheses:

1) Socioeconomic conditions and medical conditions are similarly important regarding differences in infant birth weight.
2) The variables that explain differences in infant birth weight are not the same variables as those for LBW.

Our hypotheses stem from the fact the role of medical variables in explaining LBW have been amply documented in the literature, and physicians have worked to reduce their detrimental role through early detection and treatment. But despite the best efforts of physicians, particularly obstetricians, LBW continues to be a problem, especially in rural areas of the United States. If we assume that physicians are using their accumulated knowledge about the role of medical variables and treating the problem to the best of their abilities why has LBW not yet been reduced to a negligible issue? *There must be other factors at work*. One possible group of factors is socioeconomic variables. While medicine may not deal directly with these variables, physicians should be cognizant of their effects on birth weight when dealing with females residing in rural areas, who are at potentially greater risk for LBW infants.

DATA AND METHODOLOGY

Our data consist of medical conditions and socioeconomic factors for 621 females receiving clinical prenatal care in rural Tennessee between 1989 and 2000 under the auspices of the Southeast Tennessee Perinatal Network. This provider network includes: 1) eight primary care clinics serving ten rural counties within a sixty-mile radius of Chattanooga, Tennessee; 2) obstetric and gynecology specialists in four regional towns; 3) maternal and fetal and pediatric sub-specialists at the University of Tennessee College of Medicine-Chattanooga Unit.

Providers were selected from existing private practitioners and quasi-government health care organizations who are interested in adding perinatal services to their practices. In this novel approach to rural prenatal care, a pregnant female would choose a participating rural primary care provider. Then she and her children would return to the rural primary care provider for routine and maintenance care. A nurse-educator liaison from the University also provided on-site education to the rural practices on contemporary and comprehensive prenatal care based on the guidelines of the American College of Obstetrics and Gynecology.

Patients were given a comprehensive health screening survey as part of their first prenatal visit, and then monitored for pregnancy complications until the end of their pregnancy. If a patient was diagnosed with maternal or fetal complications, she was referred to the University's tertiary care center. We excluded females from our analysis if they: 1) Miscarried prior to 20 weeks gestation: 2) Transferred out of the program: 3) Carried multiple fetuses: 4) Delivered an infant with a major birth defect such as cleft palate: 5) Did not deliver: 6) Did not live in a rural area as determined by their zip code.

Even though a number of our independent variables are dichotomous measures (e.g., marital status and the infant's gender), the dependent variable is a continuous measure. Therefore, the most appropriate methodology for this study is ordinary least squares (OLS) regression. As per standard social science procedure, we used all of the variables in a single equation for each of the analyses.

Variables.

We employ a series of medical conditions that physicians know from previous studies have a statistically significant correlation with birth weight. First is gestational age as days at birth since the mother's last menstrual period. As gestational age at birth increases, the likelihood of LBW decreases. Second, parity (parous), which is a mother's number of previous births. Parity is potentially a dual-edged sword regarding LBW. The trend is that more births increases birth weight. On the other hand, a greater number of births may contribute to LBW because mothers with previous births tend to deliver sooner.

Third, the degree of adequacy of prenatal care a mother receives throughout her pregnancy. We documented the date and frequency of each patient's prenatal visits using a modified Kessner's scale of adequacy of prenatal care, which is based on the number of visits per trimester. In general, obstetricians believe that a greater number of visits lead to timely detection of pregnancy complications and to an improved pregnancy outcome (e.g., see Hueston et al., 2003; Kotelchuck, 1994; Shi et al., 2004).

Fourth, whether or not gestational diabetes is present during the mother's current pregnancy. This is coded as non-diabetic (0), impaired carbohydrate tolerance (1), and frank diabetes (2). Gestational diabetes is a situation unique to pregnancy and it has links to a range of pregnancy complications, particularly birth weight (Allen. 1990; Homko, Hagay, & Reece, 1992).

Our first socioeconomic variable is the mother's age at the time of delivery. The previous research indicates that very young mothers and older mothers are more at risk for pregnancy complications because of the stress that pregnancy places on a female's anatomy (e.g., see Bennett et al., 1997; Creatsas et al., 1991; Leonardson, Loudenburg, & Struck, 2007; Skatrud, Bennett, & Loda, 1998). Indeed, this stress may be due to both medical and socioeconomic factors, including greater incidence of single-motherhood, inadequate diet, and a lack of comprehensive health insurance.

The second socioeconomic variable is the mother's health insurance status. This is coded as self-pay (0), indemnity (private insurance) (1), and TennCare (2). TennCare is the Tennessee state insurance program for indigent and uninsured persons, which in 1992 replaced the state's participation in Medicaid. We created a measure with TennCare at one end of the scale because we believe the program may contribute to LBW in similar ways to having no insurance. We also want to differentiate between paying for one's own health care costs or self-pay (some patients do have health care coverage but for various reasons elect to pay for certain procedures out of their own pocket) and having state coverage, which may not be as generous as private insurance. Thus it seems logical to put self-pay and TennCare at opposite ends of the scale in order to accent the effect of TennCare (for more discussion about the possible link between insurance coverage and LBW, see Bennett, 2002; Schwartz, Muri, Overpeck, Pezzullo, & Kogan, 2000; U.S. General Accounting Office, 1994, 1996, 1997). Therefore, our measure is in effect, one of "TennCareness".

The third socioeconomic variable is marital status. Single-females are more likely to lack access to comprehensive health insurance or alternate financial assistance (e.g., a spouse's income or health insurance) than is a married mother (Ahmed, 1990; Bennett, 2002; Shi et al., 2004). Furthermore, younger mothers may be more prone to forgo regular prenatal care because of the cost and their belief that they are "invincible" to pregnancy complications. On the other hand, older mothers, particularly those who are parous, may believe that because of prior uneventful pregnancies they do not need to have regular visits for their current pregnancy. Married is coded 0 and unmarried 1, which creates a measure of "unmarriedness."

The fourth socioeconomic variable is race. In previous studies non-Caucasian females have been shown to experience higher rates of inadequate health care and might exhibit such risky behaviors as alcoholism and obesity at higher rates than those for Caucasian females (Baldwin et al., 2002; Lee et al., 2005; Reader, 2001). These conditions are thought to lead to increased incidence of LBW. The coding is Caucasian (0) and non-Caucasian (1). Thus our measure is one of non-Caucasian.

Finally, we use the gender of the infant as a control variable because previous research indicates that among all races, male (0) newborns are somewhat heavier than females (1), and we want to accent the effect of female gender. Such other factors as maternal level of cigarette smoking, diet, and degree of routine exercise were not measured in our study.

RESULTS

The first step is to determine the distribution of the categories for the variables to see if there is sufficient variability for a sophisticated analysis. Table 1 presents the relevant data for each variable and its categories. The dependent variable of birth weight has the largest value (3,276g) and SD (615g) of all of the variables. The low end of its range indicates that at least one mother among our subjects gave birth to an infant with a LBW of 439g. The mean age for the mothers is 22.5 years and the range is from just entering teenage status (13 years of age) to mothers in their early 40s. Over half the mothers are parous with up to 8 previous births, which reflect a propensity of mothers living in rural areas to have larger families.

Table 1

Summary Statistics for Variables, All Mothers

Variable	**Mean (SD)**	**Range**	**Variable**	**Pct**
Birth weight (g)	3276 (615)	439-5103	**Insurance Type**	
Gestational age (days)	276 (12.9)	173- 306	self-pay	1.3%
Age (yrs)	22.5 (5.4)	13-43	indemnity	30.6
Parity	**Pct**	**Range**	TennCare	68.1
nulliparous	44.1%		**Marital status**	
Parous	55.9	1-8	Married	54.4
Adequacy of Prenatal Care			unmarried	45.6
inadequate	10.0		**Race**	
Adequate	90.0		Caucasian	96.0
Gestational diabetes			Non-Caucasian	4.0
None	88.7		**Infant's gender**	
borderline diabetic	1.8		Male	55.5
Diabetic	9.5		Female	45.5
N=621				

The percentage of unmarried mothers is 46 percent. We did not expect the percentage of unmarried mothers to be so high because the tendency is for females living in rural areas to marry at a younger age than females living in urban areas. Race is nearly a non-issue in our study with only four percent of the mothers being non-Caucasian.

The percentage of mothers who rely on TennCare for health care coverage is 68 percent. Interestingly, the incidence of medical conditions would appear to be minor amongst the mothers, with only 11 percent experiencing gestational diabetes, and 10 percent having inadequate prenatal care. But the percentage of mothers with gestational diabetes is deceiving because the 11 percent is 1.5 times the national rate for diabetes. There is a small SD for gestational age at delivery (13 days). Furthermore, the fact that the range for gestational age starts at 173 days and the mean is 276 days suggests that the incidence of premature delivery may not be an important attribute of infants born to these females.

The next step is to estimate an equation predicting birth weight using all of the variables. This equation is:

Eq. 1: Birth Weight = a + b_1Gestational Age + b_2Age + b_3Parity + b_4Adequacy of Prenatal Care + b_5Gestational Diabetes + b_6TennCare + b_7Unmarried + b_8Race + b_9Female

where Birth Weight is the infant's weight at time of delivery, and the independent variables are those previously discussed. We believe that the variables of gestational age, adequacy of prenatal care, and parity will have a positive effect because increases in these variables should lead to heavier birth weights. TennCare, unmarried, race and female should have a negative effect because an increase in each of these should reduce birth weight.

Table 2 provides the initial results. The standard error for each measure is in parentheses, and the values in Table 2 provide a baseline for the subsequent equations. The nine variables explain 46 percent of the variance in infant birth weight, which is significant at $P<.01$. The variables of gestational age and parity are significantly positive, which supports the dominant conclusion in the literature and our earlier argument. Per our earlier proposition, each of the medical conditions has a positively signed β, suggesting that increases in them are associated with increased birth weight.

Table 2

Coefficients of Independent Variables Predicting All Birth Weights

	B	Beta	T
Gestational age	26.78 (1.24)	.65	21.57***
Parity	49.44 (20.23)	.09	2.44**
Adequacy of prenatal care	75.58 (61.52)	.04	1.23
Gestational diabetic	53.34 (30.99)	.05	1.72*
Age	- .56 (4.15)	-.01	- .38
TennCare	- 171.94 (38.74)	-.14	4.44***
Unmarried	- 87.48 (38.46)	-.07	-2.28**
non-Caucasian	- 178.84 (93.86)	-.06	-1.90*
Female	- 143.83 (36.98)	-.12	-3.89***
Intercept	-3531.06 (384.39)		-9.19***

N = 621 R=.68 R^2=.46 F=58.06***

* = P <.10, ** = P<.05, *** = P<.01 (all 2-tailed test)

positive, which supports the dominant conclusion in the literature and our earlier argument. Per our earlier proposition, each of the medical conditions has a positively signed β, suggesting that increases in them are associated with increases in birth weight.

The four socioeconomic variables also have significant impacts. Unmarried leads is associated with a modest (88g) decrease in birth weight (P<.05). The direction of the β for TennCare indicates that moving from self-pay to TennCare is associated with a 342g decrease in birth weight (the largest value for all of the variables) since the effect of TennCare is twice its stated value because how this variable is coded.

Our next step is to modify Eq. 1 to include only mothers whose infants have a birth weight of less than 2,500g. Table 3 displays the results of this new equation. The equation explains 74 percent of the variance in LBW.

This value is significant (P<.01) and is greater than the 46 percent of Table 2.

Only two of the variables (gestational age and gestational diabetic) in Table 3 are statistically significant versus seven variables in Table 2. While increases in all of

Table 3

Coefficients of Independent Variables Predicting LBW

	β	Beta	T
Gestational age	16.10 (1.50)	.85	10.76***
Parity	66.52 (44.57)	.14	1.49
Adequacy of prenatal care	64.27 (176.78)	.03	.36
Gestational diabetic	127.34 (64.49)	.17	1.97*
Age	- 4.39 (8.54)	-.05	- .51
TennCare	- 45.88 (102.64)	-.04	- .45
Unmarried	- 76.60 (79.11)	-.08	- .97
Non-Caucasian	57.86 (167.12)	.03	.35
Female	24.25 (80.86)	.02	.30
Intercept	-1945.70 (503.36)		-3.86***

N = 54 R=.86 R^2=.74 F=13.98***

*= P <.10, *** = P<.01 (all 2-tailed test)

the medical variables is associated with a greater birth weight for LBW infants, only gestational age is significant as compared to gestational age, parity, and gestational diabetic in Table 2. Age, TennCare, and unmarried have a negative effect on LBW; i.e., lesser birth weight for infants born with LBW, but none of these variables is significant. Indeed, except for age, the socioeconomic variables have smaller values in Table 3 compared to their respective values in Table 2. TennCare does lead all of the variables with a decrease of 91g.

We believe that the preceding analyses are only part of the story, however. Obstetricians regard 19 to 34 years of age to be the prime years for child bearing, and females beyond those years are more at risk for having pregnancy complications, including infants with LBW. Using the preceding analysis as a guideline, we extracted from the data two subsets: mothers 18 of age or younger and mothers 35 years of age or older. This allows us to determine if there are differences for the two age groups as compared to all of the mothers. Table 4 presents the initial results of this procedure.

The results indicate that at least one individual in each group gave birth to an infant with LBW (the actual numbers are 17 mothers in the youngest group and 1 mother in the oldest group). A comparison of the data in Table 4 against that in Table 1 suggests a number of matters worthy of further discussion. First, in each subset, the percent of mothers who are parous is different with the older mothers having the greatest value (92 percent) versus the teenagers (20 percent) and versus all the mothers (56 percent). Second, the mean for birth weight is slightly greater for the older mothers (3,344g) compared to the teenage mothers (3,219g) or all of the mothers (3,276g). Third, the older mothers have a lower incidence of inadequate prenatal care (8 percent) compared to the teenage mothers (19 percent) versus all the mothers (10 percent). Fourth, the percentage of older mothers with some level of gestational diabetes (12 percent) is slightly higher than the rate for teenage mothers (10 percent), and all mothers (11 percent). Again, the rate of gestational diabetes hovers about 1.5 times the national rate. Fifth, while TennCare has the highest utilization rate among the teenage mother (79 percent), it is also utilized by a majority of the older mothers (52 percent) and amongst all mothers (68 percent) in our study. Private insurance trails far behind the users of TennCare with only 31 percent of all mothers (Table 1) covered by private insurance. Sixth, a greater percentage of the teenage mothers are unmarried (66 percent) than are older women (40 percent) or all mothers (46 percent). Last, female infants are more common for

Table 4				
Summary Statistics for Mothers by Two Age Ranges				
	≤18 years of age		≥35 years of age	
Variable	**Mean (SD)**	**Range**	**Mean (SD)**	**Range**
Birth weight (g)	3219 (576.1)	1991-4550	3344 (549.6)	2453-4196
Gestational age (days)	276.0 (14.4)	219-305	272.5 (17.1)	219-296
Age (yrs)	17.1 (1.1)	13-18	37.7 (2.4)	35-42
Parity	**Percentage**	**Range**	**Percentage**	**Range**
nulliparous	80.5%		8.0%	
Parous	19.5	1-2	92.0	1-8
Adequacy of prenatal care				
inadequate	18.8		8.0	
Adequate	91.2		92.0	
Gestational diabetes				
None	89.9		88.0	
borderline diabetic	1.9		4.0	
Diabetic	.2		8.0	
Insurance category				
self-pay	.6%		4.0	
indemnity	20.8		44.0	
TennCare	78.6		52.0	
Marital status				
Married	34.0		60.0	
unmarried	66.0		40.0	
Race				
Caucasian	96.9		96.0	
non-Caucasian	3.1		4.0	
Infant's gender				
Male	55.3		52.0	
Female	44.7		48.0	
N	159		25	

older mothers than they are for the teenage mothers or for all mothers. Given these results, we believe that using a single regression equation without any differentiation for age, may mask situations peculiar to mothers in the age extremes.

The next step is to estimate another equation, using the same variables in Eq. 1 for all birth weights except that the subjects are only the two age ranges of Table 4. Table 5 displays the results for this equation. This equation explains a respectable 46 percent of the variance in birth weight and it is statistically significant (P<.01), but the R^2 is substantially less than the R^2 in Table 3, but equal to the R^2 in Table 2. Four of the variables in Table 5 have a significant effect versus seven of the variables in Table 2. In the case of gestational diabetic, unmarried, non-Caucasian, and female, a one unit change in each of them is associated with a 100g or greater change in birth weight. By comparison the baseline (Table 2) has only three variables whose effect is greater than 99g (TennCare, non-Caucasian and female).

The next step is to estimate another equation, using the same variables in Eq. 1 for all birth weights except that the subjects are only the two age ranges of Table 4. Table 5 displays the results for this equation. This equation explains

Table 5

Coefficients of Independent Variables Predicting the Birth Weight for Infants Born To Mothers ≤18 Years of Age or ≥35 Years of Age

	β	Beta	T
Gestational age	25.09 (2.29)	.62	10.94***
Parity	23.40 (46.03)	.05	.51
Adequacy of prenatal care	- 21.99 (116.79)	-.01	- .19
Gestational diabetic	111.04 (58.58)	.11	1.90**
Age	1.71 (7.08)	.02	.24
TennCare	- 87.54 (72.28)	-.07	-1.21
Unmarried	- 131.29 (68.48)	-.11	-1.92*
non-Caucasian	- 217.85 (181.20)	-.07	-1.20
Female	- 203.11 (65.83)	-.18	-3.09***
Intercept	-3047.96 (707.95)		-4.30***

N= 184 R=.68 R^2=.46 F= 16.63***

* = P <.10, ** = P <.05, *** = P <.01 (2-tailed test)

a respectable 46 percent of the variance in birth weight and it is statistically significant (P<.01), but the R^2 is substantially less than the R^2 in Table 3, but equal to the R^2 in Table 2. Four of the variables in Table 5 have a significant effect versus seven of the variables in Table 2. In the case of gestational diabetic, unmarried, non-Caucasian, and female, a one unit change in each of them is associated with a 100g or greater change in birth weight. By comparison the baseline (Table 2) has only three variables whose effect is greater than 99g (TennCare, non-Caucasian and female).

Our final equation duplicates Eq. 1 with three major changes. First, it is limited to only mothers ≤ 18 years of age and mothers ≥ 35 years of age. Second, the mothers had to deliver an infant with LBW. Third, we deleted gestational diabetic from the equation because none of the mothers in either subset had this medical condition. We continue to believe that the β for the variables will be signed in the same direction as in the previous equation.

Table 6 summarizes the results of this equation. The equation explains 86 percent of the variance in LBW and its F-value is significant (P<.01). Of all of the variables in the model, only gestational age has a significant effect. In general, the medical variables have greater values when compared to Table 2, but the sign for parity changes to negative in Table 6. We believe this is due to the preponderance of teenagers in the subset who are nulliparous. Being unmarried is associated with a reduced birth weight of 92g. At the same time, movement towards TennCare, non-Caucasian, female gender of the infant and an increase in the mother's age all are associated with greater birth weight. Indeed, TennCare not only switches direction, but actually is associated with an increase in birth weight by 19g.

Table 6

Coefficients of Independent Variables Predicting LBW for Infants Born to Mothers ≤18 Years of Age or ≥35 Years of Age

	β	Beta	T
Gestational age	21.07 (3.77)	.94	5.59***
Parity	- 122.16 (166.43)	-.18	- .73
Adequacy of prenatal care	104.83 (255.77)	.06	.41
Age	24.97 (19.21)	.28	1.30
TennCare	.64 (164.19)	.01	.06
Unmarried	- 91.60 (118.19)	-.12	- .78
non-Caucasian	112.35 (242.72)	.06	.46
Female	62.24 (117.67)	.08	.53
Intercept	-3779.99 (1076.94)		-3.51***
N= 18 R=.93 R^2=.86 F= 7.10***			

*** = P <.01 (2-tailed test)

Our explanations for the latter coefficients is that: 1) Physicians were able to "game" TennCare's rules and provide better care than what would be possible under strict adherence to the rules: 2) As more non-Caucasians entered the Perinatal Network, their prenatal care became closer to what Caucasians receive, and therefore improved their outcome; i.e., fewer infants born with LBW: 3) As stated earlier in this paper, increases in age beyond the teenage years are thought to improve birth weight.

In summary, we believe that our use of a more sophisticated methodology than in most previous studies has uncovered important relationships such as the role of age, which might have been hidden if we only used one equation to analyze the data. Given the overall results displayed in the tables, particularly when we cross-compare coefficients, we accept both of our initial hypotheses: 1) Socioeconomic factors and medical conditions are similarly important regarding differences in birth weight: 2) The variables that explain differences in infant birth weight may not be the same variables as those for LBW.

DISCUSSION

The results of our study have a number of implications for physicians and policy makers about how to further reduce the incidence of LBW among mothers residing in rural areas of the United States. First, it is clear that one variable to focus upon is increasing gestational age. Just a one-day increase in gestational age is associated with an increase in birth weight between 16g and 25g. Therefore, physicians and policy makers need to collaborate on developing health care policies that will help a female carry a fetus to term.

Second, the lack of statistical significance for adequacy of prenatal care suggests that Kessner's scale as currently configured may not be a very good measure of prenatal care. Obstetricians may need to consider a better method for assessing prenatal care. For instance, a revised Kessner's scale should account for the quality of care provided during a prenatal visit. The measure needs to take into account other methods that physicians now use to treat patients (e.g., telephone, fax, e-mail).

Third, focusing an analysis on age extremes uncover relationships that just one equation may hide. Our results suggest that as we parse the data into smaller subsets based on age and focus on LBW, the effect of the variables may be differ regarding the differences in birth weight and LBW. Physicians and policy analysts may want to consider this relationship when contemplating changes to state and federal programs dealing with prenatal care.

Fourth, it appears that the effect of TennCare is associated with a reduction in birth weight by as much as 342g but the effect is not uniform in every scenario. Our explanation for this situation is two-fold. First, obstetricians have long believed that a large number of known and unknown variables affect birth weight and while those usually equalize in a large sample, it weakened our argument when applied to the sub-sample of mothers 18 years of age or younger. Second, we believe these differences are due to physicians learning to work around TennCare's rules regarding prenatal care. But physicians may want to consider lobbying state policy makers for changes to TennCare so it will be a consistent force for improving birth weight and lessening LBW.

Lastly, the effects of the socioeconomic factors suggest that physicians should consider them as also being important. While it is true that physician cannot alter a mother's age, race, or marital status, these conditions may provide valuable clues regarding the likelihood for LBW and assist in designing a comprehensive treatment plan. Focusing just on medical conditions does not treat the whole person.

REFERENCES

Ahmed, F. (1990). Unmarried mothers as a high-risk group for adverse pregnancy outcomes. *Journal of Community Health 15*: 35-44.

Allen, G. (1990). Diabetes in pregnancy. *Mid-South Perinatal Perspectives 1*: 1-3.

Anderson, N. E., Smiley, D. V., Flick, L. H., & Lewis, C. Y. (2000). Missouri rural adolescent pregnancy project. *Public Health Nursing 17*: 355-62.

Baker, C. (1991). Baby deaths found high in rural areas. *New York Times* 2 August: A12.

Baldwin, L. M., Grossman, D. C., Casey, C., Hollow, H., Sugarman, J. R., Freeman, W. L., & Hart, L. G. (2002). Perinatal and infant health among rural and urban American Indians/Alaska Natives. *American Journal of Public Health 92*: 1491-97.

Bennett, T. (2002). Reproductive health care in the rural United States. *JAMA 287*: 112.

Bennett, T., Skatrud, J. D., Guild, P., Loda, F., & Kierman, L. V. (1997). Rural adolescent pregnancy: A view from the South. *Family Planning Perspectives 29*: 256-67.

Creatsas, G., Goumalatos, N., Deligeoroglou, E., Karagitsou, T., Calpaktsoglou, C., & Arefetz, N. (1991). Teenage pregnancy: Comparison with two groups of older pregnant women. *Journal of Adolescent Health Care 12*: 77-81.

Del Priore, G., Zandieh, P., & Lee, M. J. (1997). Treatment of continuous data as categoric variables in *Obstetrics and Gynecology*. *Obstetrics & Gynecology 89*: 351-54.

Fink, A., Yano, E., & Goya, D. (1992). Prenatal programs: What the literature reveals. *Obstetrics & Gynecology 80*: 867-72.

Fiscella, K. (1995). Does prenatal care improve birth outcomes? A critical review. *Obstetrics & Gynecology 85*: 468-79.

Goldenberg, R. L., & Culhane, J. F. (2007). Low birth weight in the United States. *American Journal of Clinical Nutrition 85*: 584S-590S.

Green, J. R., Schumacher, L. B., Pawson, I. G., Partridge, C., & Kretchmer, N. (1991). Influence of maternal body habitus and glucose tolerance on birth weight. *Obstetrics & Gynecology 78*: 235-39.

Heaphy, P. E., & Bernard, S. L. (2000). Maternal complications of normal deliveries: variation among rural hospitals. *Journal of Rural Health 16*: 139-47.

Homko, C. J., Hagay, Z. ., & Reece, E. A. (1992). Diabetes mellitus in pregnancy. In E. A. Reece, J. C. Hobbins, M. J. Mahoney, & R. H. Petrie (Eds.), *Medicine of the Fetus & Mother* Philadelphia: J. B. Lippincott Company.

Hueston, W. J., Gilbert, G. E., Davis, L., & Sturgill, V. (2003). Delayed prenatal care and the risk of low birth weight delivery. *Journal of Community Health 28*: 199-208.

Ketterlinus, R. D., Henderson, S. H., & Lamb, M. E. (1990). Maternal age, sociodemographics, prenatal health and behavior: Influences on Neonatal Risk status. *Journal of Adolescent Health Care 11*: 423-31.

Kotelchuck, M. (1994). An evaluation of the Kessner adequacy of prenatal care index and a proposed adequacy of prenatal care utilization index. *American Journal of Public Health 84*: 1414-20.

Lee, S. K., Sobal, J., Frongillo, E. A., Olson, C. ., & Wolfe, W. S. (2005). Parity and body weight in the United States: Differences by race and size of place of residence. *Obesity Research 13*: 1263-69.

Leonardson, G. R., Loudenburg, R., & Struck, J. (2007). Factors predictive of alcohol use during pregnancy in three rural states. *Behavioral and Brain Functions 3*: 3-8.

McCarton, C. M., Wallace, I. F., & Bennett. F. C. (1995). Preventive interventions with low birth weight premature infants: An evaluation of their success. *Seminars in Perinatology 19*: 330-40.

Meyer, B. A., & Palmer, S. M. (1990). Pregestational diabetes. *Seminars in Perinatology 14*: 12-23.

Mittendorf, R., Herschel, M. Williams, M. A., Hibbard, J. U., Moawad, A. H., & Lee, K. S. (1994). Reducing the frequency of low birth weight in the United States. *Obstetrics & Gynecology 83*: 1056-59.

Moawad, A. H., Lee, K. S., Fisher, D. E., Ferguson, R., & Phillippe, M.. (1990). A model for the prospective analysis of perinatal deaths in a perinatal network. *American Journal of Obstetrics and Gynecology 162*: 15-22.

Olausson, P. M., Cnattingius, S., & Goldenberg, R. L. (1997). Determinants of poor pregnancy outcomes among teenagers in Sweden. *Obstetrics & Gynecology 89*: 451-57.

Reader, S. (2001). Detecting and analyzing clusters of low-birth weight incidence using exploratory spatial data analysis. *GeoJournal 53*: 149-59.

Schwartz, R. M., Muri, J. H., Overpeck, M. D., Pezzullo, J. C., & Kogan, M. D. (2000). Use of high-technology care among women with high-risk pregnancies in the United States. *Maternal and Child Health Journal 4*: 7-18.

Serwint, J. R., Wilson, M. E. H., Vogelhut, J. W., Repke, J. T., & Seidel, H. J. (1996). A randomized controlled trial of prenatal pediatric visits for urban, low-income families. *Pediatrics 98*: 1069-75.

Shi, L., Macinko, J., Starfield, B., Xu, J., Regan, J., Politzer, R., & Wulu, J. (2004). Primary care, infant mortality, and low birth weight in the states of the USA. *Journal of Epidemiology and Community Health 58*: 374-80.

Skatrud, J. D., Bennett, T. A., & Loda, F. A. (1998). An overview of adolescent pregnancy in rural areas. *Journal of Rural Health 14*: 17-27.

Stevens, G. D., Seid, M., & Halfon, N. (2006). Enrolling vulnerable, uninsured but eligible children in public health insurance: Association with health status and primary care access. *Pediatrics 117*: e751-e759.

Stewart, P. J., & Nimrod, C. (1993). The need for a community-wide approach to promote healthy babies and prevent low birth weight. *Canadian Medical Association Journal 149*: 281-85.

Thompson, L. A., Goodman, D. C., Chang, C. H., & Stukel, T. A. (2005). Regional variation in rates of low birth weight. *Pediatrics 116*: 1114-21.

U.S. Department of Health and Human Services. (1991). *Healthy People 2000*. Washington, D.C.: U.S. Government Printing Office.

U.S. General Accounting Office. (1994). *Medical Prenatal Care: States Improve Access and Enhance Services, but Face New Challenges*. Washington, D.C.: U.S. General Accounting Office.

U.S. General Accounting Office. (1996). *Health Insurance for Children: Private Insurance Coverage Continues to Deteriorate*. Washington, D.C.: U.S. General Accounting Office.

U.S. General Accounting Office. (1997). *Medicaid Managed Care: Delays and Difficulties in Implementing California's New Mandatory Program*. Washington, D.C.: U.S. General Accounting Office.

Warner, G. (1998). Birthweight productivity of prenatal care. Southern Economic Journal 65: 42-63.

Yoder, B. A., & Young, M. K. (1997). Neonatal outcomes of teenage pregnancy in a military population. Obstetrics & Gynecology 90: 500-06.

York, R., Grant, C., Gibeau, A., Beecham J., & Kessler, J. (1996). A review of problems of universal access to prenatal care. *Nursing Clinics of North America 31*: 279-92.

Zavis, A. (1997). Infant deaths at lowest level. *Chattanooga Times* 2 December: 1A.

VARIATION IN INFANT BIRTH WEIGHT: SOCIOECONOMIC FACTORS VERSUS MEDICAL CONDITIONS

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ABSTRACT

This paper seeks to determine the relative effect of socioeconomic variables and medical conditions in explaining changes in infant birth weight, specifically, low birth weight (LBW). Using ordinary least squares regression, we first analyze the effects of these variables on the birth weight of 621 infants. Four of the independent variables – gestational age in number of days, sex, parity, and health insurance – are statistically significant ($P<.05$) and explain 64 percent of the variation in infant birth weight. But in a subset of 18 infants born with LBW to mothers ≤18 years of age or 35≥ years of age, only gestational age in number of days is statistically significant.

INTRODUCTION

Previous investigations often explained variations in infant birth weight, particularly low birth weight rate (LBW, <2,500g), through physiologic variables such as gestational age and the presence of complicating medical factors. These investigations ignored the fact that such socioeconomic factors as insurance coverage, race, and marital status may also be important. Unfortunately, few studies have simultaneously examined medical conditions and socioeconomic factors to determine their total effect on infant birth weight (e.g., see Hueston, Gilbert, Davis, & Sturgill, 2003; Lee, Sobal, Frongillo, Olson, & Wolfe, 2005).

Moreover, the pattern has been for studies to rely on a handful of variables and simple descriptive statistics (e.g., see McCarton, Wallace, & Bennett, 1995; Moawad, Lee, Fisher, Ferguson, & Phillippe, 1990; Stewart & Nimrod, 1993; United States [U.S.]. Department of Health and Human Services 1991; U.S. General Accounting Office 1994, Warner, 1998). Only in recent years have health care professionals begun to employ more elaborate research designs, but these studies remain the exception and not the rule (see Baldwin et al., 2002; Bennett, 2002; Goldenberg & Culhane, 2007; Heaphy & Bernard, 2000; Lee et al., 2005; Leonardson, Loudenburg, & Struck, 2007; Mittendorf et al., 1994; Serwint, Wilson, Vogelhut, Repke, & Seidel, 1996; Shi et al., 2004; Stevens, Seid, & Halfon, 2006). Furthermore, the vast majority of rural studies examine populations in South America, Africa, or the Far East, whose demographics are very dissimilar from the rural population of the United States. Consequently, the previous studies may have little value for developing policy solutions to deal with the LBW in rural America.

Why should policy makers be concerned with a medical issue such as LBW? First, among developed nations, the LBW rate for the United States historically has been high. Indeed, the rate of births at <2,500g increased between 1980 and 1995, and the proportion still exceeds that of most other industrialized societies (Baker, 1991; Goldenberg & Culhane, 2007; U.S. Department of Health and Human Services, 1991; Zavis, 1997). Second, despite Federal and state programs developed specifically for pregnant women; e.g., *Women, Infant and Children*, the *California Sweet Success Program* (Anderson, Smiley, Flick, & Lewis, 2000; Mittendorf et al., 1994; Stevens, Seid, & Halfon, 2006), the rate of LBW has not declined consistently and continuously across the United States (see Thompson, Goodman, Chang, & Stukel, 2005). Third, the rate of LBW in the United States remains abnormally high in rural versus urban locations and in comparison to such other demographic variables as race and level of education (Baldwin et al, 2002; Yoder & Young, 1997).

Our study is an effort to bridge the gap regarding what we know about the factors contributing to LBW in rural areas by analyzing *together* medical conditions and socioeconomic factors. Such an approach mirrors the practice of treating the whole patient, and it provides a better picture of what affects LBW, particularly for females living in rural areas. Pregnant females living in rural areas are more likely to encounter obstacles to prenatal care than their counterparts living in such major urban areas as Boston and Chicago, or even in such smaller communities such as Knoxville, Tennessee, or Sioux Falls, South Dakota. We believe that these obstacles include traveling further for medical care, lesser access to specialist care, inadequate diets and access to dietary supplements, diminished likelihood of private health care coverage, and bearing more children than their urban counterparts.

RESEARCH DESIGN

CONCEPTUAL FRAMEWORK

We used the data that was prospectively collected on clients of the South-East Tennessee Rural Perinatal Network Program to look for correlates of low birth weight among a mostly low-income rural population. The "Network" was designed to bring high-quality streamlined pregnancy and newborn care to women and infants in a historically under-served region. As a novel program, we incorporated rigorous data collection and ongoing analysis for quality assurance. This paper presents social and economic determinants of low birth weight among the clients of the "Network".

HYPOTHESES

This study tests two hypotheses:

1) Socioeconomic conditions and medical conditions are similarly important regarding differences in infant birth weight.
2) The variables that explain differences in infant birth weight are not the same variables as those for LBW.

Our hypotheses stem from the fact the role of medical variables in explaining LBW have been amply documented in the literature, and physicians have worked to reduce their detrimental role through early detection and treatment. But despite the best efforts of physicians, particularly obstetricians, LBW continues to be a problem, especially in rural areas of the United States. If we assume that physicians are using their accumulated knowledge about the role of medical variables and treating the problem to the best of their abilities why has LBW not yet been reduced to a negligible issue? *There must be other factors at work*. One possible group of factors is socioeconomic variables. While medicine may not deal directly with these variables, physicians should be cognizant of their effects on birth weight when dealing with females residing in rural areas, who are at potentially greater risk for LBW infants.

DATA AND METHODOLOGY

Our data consist of medical conditions and socioeconomic factors for 621 females receiving clinical prenatal care in rural Tennessee between 1989 and 2000 under the auspices of the Southeast Tennessee Perinatal Network. This provider network includes: 1) eight primary care clinics serving ten rural counties within a sixty-mile radius of Chattanooga, Tennessee; 2) obstetric and gynecology specialists in four regional towns; 3) maternal and fetal and pediatric sub-specialists at the University of Tennessee College of Medicine-Chattanooga Unit.

Providers were selected from existing private practitioners and quasi-government health care organizations who are interested in adding perinatal services to their practices. In this novel approach to rural prenatal care, a pregnant female would choose a participating rural primary care provider. Then she and her children would return to the rural primary care provider for routine and maintenance care. A nurse-educator liaison from the University also provided on-site education to the rural practices on contemporary and comprehensive prenatal care based on the guidelines of the American College of Obstetrics and Gynecology.

Patients were given a comprehensive health screening survey as part of their first prenatal visit, and then monitored for pregnancy complications until the end of their pregnancy. If a patient was diagnosed with maternal or fetal complications, she was referred to the University's tertiary care center. We excluded females from our analysis if they: 1) Miscarried prior to 20 weeks gestation: 2) Transferred out of the program: 3) Carried multiple fetuses: 4) Delivered an infant with a major birth defect such as cleft palate: 5) Did not deliver: 6) Did not live in a rural area as determined by their zip code.

Even though a number of our independent variables are dichotomous measures (e.g., marital status and the infant's gender), the dependent variable is a continuous measure. Therefore, the most appropriate methodology for this study is ordinary least squares (OLS) regression. As per standard social science procedure, we used all of the variables in a single equation for each of the analyses.

Variables.

We employ a series of medical conditions that physicians know from previous studies have a statistically significant correlation with birth weight. First is gestational age as days at birth since the mother's last menstrual period. As gestational age at birth increases, the likelihood of LBW decreases. Second, parity (parous), which is a mother's number of previous births. Parity is potentially a dual-edged sword regarding LBW. The trend is that more births increases birth weight. On the other hand, a greater number of births may contribute to LBW because mothers with previous births tend to deliver sooner.

Third, the degree of adequacy of prenatal care a mother receives throughout her pregnancy. We documented the date and frequency of each patient's prenatal visits using a modified Kessner's scale of adequacy of prenatal care, which is based on the number of visits per trimester. In general, obstetricians believe that a greater number of visits lead to timely detection of pregnancy complications and to an improved pregnancy outcome (e.g., see Hueston et al., 2003; Kotelchuck, 1994; Shi et al., 2004).

Fourth, whether or not gestational diabetes is present during the mother's current pregnancy. This is coded as non-diabetic (0), impaired carbohydrate tolerance (1), and frank diabetes (2). Gestational diabetes is a situation unique to pregnancy and it has links to a range of pregnancy complications, particularly birth weight (Allen. 1990; Homko, Hagay, & Reece, 1992).

Our first socioeconomic variable is the mother's age at the time of delivery. The previous research indicates that very young mothers and older mothers are more at risk for pregnancy complications because of the stress that pregnancy places on a female's anatomy (e.g., see Bennett et al., 1997; Creatsas et al., 1991; Leonardson, Loudenburg, & Struck, 2007; Skatrud, Bennett, & Loda, 1998). Indeed, this stress may be due to both medical and socioeconomic factors, including greater incidence of single-motherhood, inadequate diet, and a lack of comprehensive health insurance.

The second socioeconomic variable is the mother's health insurance status. This is coded as self-pay (0), indemnity (private insurance) (1), and TennCare (2). TennCare is the Tennessee state insurance program for indigent and uninsured persons, which in 1992 replaced the state's participation in Medicaid. We created a measure with TennCare at one end of the scale because we believe the program may contribute to LBW in similar ways to having no insurance. We also want to differentiate between paying for one's own health care costs or self-pay (some patients do have health care coverage but for various reasons elect to pay for certain procedures out of their own pocket) and having state coverage, which may not be as generous as private insurance. Thus it seems logical to put self-pay and TennCare at opposite ends of the scale in order to accent the effect of TennCare (for more discussion about the possible link between insurance coverage and LBW, see Bennett, 2002; Schwartz, Muri, Overpeck, Pezzullo, & Kogan, 2000; U.S. General Accounting Office, 1994, 1996, 1997). Therefore, our measure is in effect, one of "TennCareness".

The third socioeconomic variable is marital status. Single-females are more likely to lack access to comprehensive health insurance or alternate financial assistance (e.g., a spouse's income or health insurance) than is a married mother (Ahmed, 1990; Bennett, 2002; Shi et al., 2004). Furthermore, younger mothers may be more prone to forgo regular prenatal care because of the cost and their belief that they are "invincible" to pregnancy complications. On the other hand, older mothers, particularly those who are parous, may believe that because of prior uneventful pregnancies they do not need to have regular visits for their current pregnancy. Married is coded 0 and unmarried 1, which creates a measure of "unmarriedness."

The fourth socioeconomic variable is race. In previous studies non-Caucasian females have been shown to experience higher rates of inadequate health care and might exhibit such risky behaviors as alcoholism and obesity at higher rates than those for Caucasian females (Baldwin et al., 2002; Lee et al., 2005; Reader, 2001). These conditions are thought to lead to increased incidence of LBW. The coding is Caucasian (0) and non-Caucasian (1). Thus our measure is one of non-Caucasian.

Finally, we use the gender of the infant as a control variable because previous research indicates that among all races, male (0) newborns are somewhat heavier than females (1), and we want to accent the effect of female gender. Such other factors as maternal level of cigarette smoking, diet, and degree of routine exercise were not measured in our study.

RESULTS

The first step is to determine the distribution of the categories for the variables to see if there is sufficient variability for a sophisticated analysis. Table 1 presents the relevant data for each variable and its categories. The dependent variable of birth weight has the largest value (3,276g) and SD (615g) of all of the variables. The low end of its range indicates that at least one mother among our subjects gave birth to an infant with a LBW of 439g. The mean age for the mothers is 22.5 years and the range is from just entering teenage status (13 years of age) to mothers in their early 40s. Over half the mothers are parous with up to 8 previous births, which reflect a propensity of mothers living in rural areas to have larger families.

Table 1

Summary Statistics for Variables, All Mothers

Variable	**Mean (SD)**	**Range**	**Variable**	**Pct**
Birth weight (g)	3276 (615)	439-5103	**Insurance Type**	
Gestational age (days)	276 (12.9)	173- 306	self-pay	1.3%
Age (yrs)	22.5 (5.4)	13-43	indemnity	30.6

Parity	**Pct**	**Range**	TennCare	68.1
nulliparous	44.1%		**Marital status**	
Parous	55.9	1-8	Married	54.4
Adequacy of Prenatal Care			unmarried	45.6
inadequate	10.0		**Race**	
Adequate	90.0		Caucasian	96.0
Gestational diabetes			Non-Caucasian	4.0
None	88.7		**Infant's gender**	
borderline diabetic	1.8		Male	55.5
Diabetic	9.5		Female	45.5
N=621				

The percentage of unmarried mothers is 46 percent. We did not expect the percentage of unmarried mothers to be so high because the tendency is for females living in rural areas to marry at a younger age than females living in urban areas. Race is nearly a non-issue in our study with only four percent of the mothers being non-Caucasian.

The percentage of mothers who rely on TennCare for health care coverage is 68 percent. Interestingly, the incidence of medical conditions would appear to be minor amongst the mothers, with only 11 percent experiencing gestational diabetes, and 10 percent having inadequate prenatal care. But the percentage of mothers with gestational diabetes is deceiving because the 11 percent is 1.5 times the national rate for diabetes. There is a small SD for gestational age at delivery (13 days). Furthermore, the fact that the range for gestational age starts at 173 days and the mean is 276 days suggests that the incidence of premature delivery may not be an important attribute of infants born to these females.

The next step is to estimate an equation predicting birth weight using all of the variables. This equation is:

Eq. 1: Birth Weight = a + b_1Gestational Age + b_2Age + b_3Parity + b_4Adequacy of Prenatal Care + b_5Gestational Diabetes + b_6TennCare + b_7Unmarried + b_8Race + b_9Female

where Birth Weight is the infant's weight at time of delivery, and the independent variables are those previously discussed. We believe that the variables of gestational age, adequacy of prenatal care, and parity will have a positive effect because increases in these variables should lead to heavier birth weights. TennCare, unmarried, race and female should have a negative effect because an increase in each of these should reduce birth weight.

Table 2 provides the initial results. The standard error for each measure is in parentheses, and the values in Table 2 provide a baseline for the subsequent equations. The nine variables explain 46 percent of the variance in infant birth weight, which is significant at P<.01. The variables of gestational age and parity are significantly positive, which supports the dominant conclusion in the literature and our earlier argument. Per our earlier proposition, each of the medical conditions has a positively signed β, suggesting that increases in them are associated with increased birth weight.

Table 2

Coefficients of Independent Variables Predicting All Birth Weights

	B	Beta	T
Gestational age	26.78 (1.24)	.65	21.57***
Parity	49.44 (20.23)	.09	2.44**
Adequacy of prenatal care	75.58 (61.52)	.04	1.23
Gestational diabetic	53.34 (30.99)	.05	1.72*

Age	- .56 (4.15)	-.01	- .38
TennCare	- 171.94 (38.74)	-.14	4.44***
Unmarried	- 87.48 (38.46)	-.07	-2.28**
non-Caucasian	- 178.84 (93.86)	-.06	-1.90*
Female	- 143.83 (36.98)	-.12	-3.89***
Intercept	-3531.06 (384.39)		-9.19***
N = 621 R=.68 R^2=.46 F=58.06***			

* = P <.10, ** = P<.05, *** = P<.01 (all 2-tailed test)

positive, which supports the dominant conclusion in the literature and our earlier argument. Per our earlier proposition, each of the medical conditions has a positively signed ß, suggesting that increases in them are associated with increases in birth weight.

The four socioeconomic variables also have significant impacts. Unmarried leads is associated with a modest (88g) decrease in birth weight (P<.05). The direction of the ß for TennCare indicates that moving from self-pay to TennCare is associated with a 342g decrease in birth weight (the largest value for all of the variables) since the effect of TennCare is twice its stated value because how this variable is coded.

Our next step is to modify Eq. 1 to include only mothers whose infants have a birth weight of less than 2,500g. Table 3 displays the results of this new equation. The equation explains 74 percent of the variance in LBW. This value is significant (P<.01) and is greater than the 46 percent of Table 2.

Only two of the variables (gestational age and gestational diabetic) in Table 3 are statistically significant versus seven variables in Table 2. While increases in all of

Table 3

Coefficients of Independent Variables Predicting LBW

	ß	Beta	T
Gestational age	16.10 (1.50)	.85	10.76***

Parity	66.52 (44.57)	.14	1.49
Adequacy of prenatal care	64.27 (176.78)	.03	.36
Gestational diabetic	127.34 (64.49)	.17	1.97*
Age	- 4.39 (8.54)	-.05	- .51
TennCare	- 45.88 (102.64)	-.04	- .45
Unmarried	- 76.60 (79.11)	-.08	- .97
Non-Caucasian	57.86 (167.12)	.03	.35
Female	24.25 (80.86)	.02	.30
Intercept	-1945.70 (503.36)		-3.86***
N = 54 R=.86 R^2=.74 F=13.98***			

*= P <.10, *** = P<.01 (all 2-tailed test)

the medical variables is associated with a greater birth weight for LBW infants, only gestational age is significant as compared to gestational age, parity, and gestational diabetic in Table 2. Age, TennCare, and unmarried have a negative effect on LBW; i.e., lesser birth weight for infants born with LBW, but none of these variables is significant. Indeed, except for age, the socioeconomic variables have smaller values in Table 3 compared to their respective values in Table 2. TennCare does lead all of the variables with a decrease of 91g.

We believe that the preceding analyses are only part of the story, however. Obstetricians regard 19 to 34 years of age to be the prime years for child bearing, and females beyond those years are more at risk for having pregnancy complications, including infants with LBW. Using the preceding analysis as a guideline, we extracted from the data two subsets: mothers 18 of age or younger and mothers 35 years of age or older. This allows us to determine if there are differences for the two age groups as compared to all of the mothers. Table 4 presents the initial results of this procedure.

The results indicate that at least one individual in each group gave birth to an infant with LBW (the actual numbers are 17 mothers in the youngest group and 1 mother in the oldest group). A comparison of the data in Table 4 against that in Table 1 suggests a number of matters worthy of further discussion. First, in each subset, the percent of mothers who are parous is different with the older mothers having the greatest value (92 percent) versus the teenagers (20 percent) and versus all the mothers (56 percent). Second, the mean for birth weight is slightly greater for the older mothers (3,344g) compared to the teenage mothers (3,219g) or all of the mothers (3,276g). Third, the older mothers have a lower incidence of inadequate prenatal care (8 percent) compared to the teenage mothers (19 percent) versus all the mothers (10 percent). Fourth, the percentage of older mothers with some level of gestational diabetes (12 percent) is slightly higher than the rate for teenage mothers (10 percent), and all mothers (11 percent). Again, the rate of gestational diabetes hovers about 1.5 times the national rate. Fifth, while TennCare has the highest utilization rate among the teenage mother (79 percent), it is also utilized by a majority of the older mothers (52 percent) and amongst all mothers (68 percent) in our study. Private insurance trails far behind the users of TennCare with only 31 percent of all mothers (Table 1) covered by private insurance. Sixth, a greater percentage of the teenage mothers are unmarried (66 percent) than are older women (40 percent) or all mothers (46 percent). Last, female infants are more common for

Table 4

Summary Statistics for Mothers by Two Age Ranges

	≤18 years of age		≥35 years of age	
Variable	**Mean (SD)**	**Range**	**Mean (SD)**	**Range**
Birth weight (g)	3219 (576.1)	1991-4550	3344 (549.6)	2453-4196
Gestational age (days)	276.0 (14.4)	219-305	272.5 (17.1)	219-296
Age (yrs)	17.1 (1.1)	13-18	37.7 (2.4)	35-42

Parity	Percentage	Range	Percentage	Range
nulliparous	80.5%		8.0%	
Parous	19.5	1-2	92.0	1-8
Adequacy of prenatal care				
inadequate	18.8		8.0	
Adequate	91.2		92.0	
Gestational diabetes				
None	89.9		88.0	
borderline diabetic	1.9		4.0	
Diabetic	.2		8.0	
Insurance category				
self-pay	.6%		4.0	
indemnity	20.8		44.0	
TennCare	78.6		52.0	
Marital status				
Married	34.0		60.0	
unmarried	66.0		40.0	
Race				
Caucasian	96.9		96.0	
non-Caucasian	3.1		4.0	
Infant's gender				
Male	55.3		52.0	
Female	44.7		48.0	
N	159		25	

older mothers than they are for the teenage mothers or for all mothers. Given these results, we believe that using a single regression equation without any differentiation for age, may mask situations peculiar to mothers in the age extremes.

The next step is to estimate another equation, using the same variables in Eq. 1 for all birth weights except that the subjects are only the two age ranges of Table 4. Table 5 displays the results for this equation. This equation explains a respectable 46 percent of the variance in birth weight and it is statistically significant (P<.01), but the R^2 is substantially less than the R^2 in Table 3, but equal to the R^2 in Table 2. Four of the variables in Table 5 have a significant effect versus seven of the variables in Table 2. In the case of gestational diabetic, unmarried, non-Caucasian, and female, a one unit change in each of them is associated with a 100g or greater change in birth weight. By comparison the baseline (Table 2) has only three variables whose effect is greater than 99g (TennCare, non-Caucasian and female).

The next step is to estimate another equation, using the same variables in Eq. 1 for all birth weights except that the subjects are only the two age ranges of Table 4. Table 5 displays the results for this equation. This equation explains

Table 5

Coefficients of Independent Variables Predicting the Birth Weight for Infants Born To Mothers ≤18 Years of Age or ≥35 Years of Age

	ß	Beta	T
Gestational age	25.09 (2.29)	.62	10.94***
Parity	23.40 (46.03)	.05	.51
Adequacy of prenatal care	- 21.99 (116.79)	-.01	- .19
Gestational diabetic	111.04 (58.58)	.11	1.90**
Age	1.71 (7.08)	.02	.24
TennCare	- 87.54 (72.28)	-.07	-1.21
Unmarried	- 131.29 (68.48)	-.11	-1.92*
non-Caucasian	- 217.85 (181.20)	-.07	-1.20
Female	- 203.11 (65.83)	-.18	-3.09***
Intercept	-3047.96 (707.95)		-4.30***

N= 184 R=.68 R^2=.46 F= 16.63***

* = P <.10, ** = P <.05, *** = P <.01 (2-tailed test)

a respectable 46 percent of the variance in birth weight and it is statistically significant (P<.01), but the R^2 is substantially less than the R^2 in Table 3, but equal to the R^2 in Table 2. Four of the variables in Table 5 have a significant effect versus seven of the variables in Table 2. In the case of gestational

diabetic, unmarried, non-Caucasian, and female, a one unit change in each of them is associated with a 100g or greater change in birth weight. By comparison the baseline (Table 2) has only three variables whose effect is greater than 99g (TennCare, non-Caucasian and female).

Our final equation duplicates Eq. 1 with three major changes. First, it is limited to only mothers $\leq$ 18 years of age and mothers $\geq$ 35 years of age. Second, the mothers had to deliver an infant with LBW. Third, we deleted gestational diabetic from the equation because none of the mothers in either subset had this medical condition. We continue to believe that the ß for the variables will be signed in the same direction as in the previous equation.

Table 6 summarizes the results of this equation. The equation explains 86 percent of the variance in LBW and its F-value is significant (P<.01). Of all of the variables in the model, only gestational age has a significant effect. In general, the medical variables have greater values when compared to Table 2, but the sign for parity changes to negative in Table 6. We believe this is due to the preponderance of teenagers in the subset who are nulliparous. Being unmarried is associated with a reduced birth weight of 92g. At the same time, movement towards TennCare, non-Caucasian, female gender of the infant and an increase in the mother's age all are associated with greater birth weight. Indeed, TennCare not only switches direction, but actually is associated with an increase in birth weight by 19g.

Table 6

Coefficients of Independent Variables Predicting LBW for Infants Born to Mothers $\leq$18 Years of Age or $\geq$35 Years of Age

	ß	Beta	T
Gestational age	21.07 (3.77)	.94	5.59***
Parity	- 122.16 (166.43)	-.18	- .73

Adequacy of prenatal care	104.83 (255.77)	.06	.41
Age	24.97 (19.21)	.28	1.30
TennCare	.64 (164.19)	.01	.06
Unmarried	- 91.60 (118.19)	-.12	- .78
non-Caucasian	112.35 (242.72)	.06	.46
Female	62.24 (117.67)	.08	.53
Intercept	-3779.99 (1076.94)		-3.51***
N= 18 R=.93 R^2=.86 F= 7.10***			

*** = P <.01 (2-tailed test)

Our explanations for the latter coefficients is that: 1) Physicians were able to "game" TennCare's rules and provide better care than what would be possible under strict adherence to the rules: 2) As more non-Caucasians entered the Perinatal Network, their prenatal care became closer to what Caucasians receive, and therefore improved their outcome; i.e., fewer infants born with LBW: 3) As stated earlier in this paper, increases in age beyond the teenage years are thought to improve birth weight.

In summary, we believe that our use of a more sophisticated methodology than in most previous studies has uncovered important relationships such as the role of age, which might have been hidden if we only used one equation to analyze the data. Given the overall results displayed in the tables, particularly when we cross-compare coefficients, we accept both of our initial hypotheses: 1) Socioeconomic factors and medical conditions are similarly important regarding differences in birth weight: 2) The variables that explain differences in infant birth weight may not be the same variables as those for LBW.

DISCUSSION

The results of our study have a number of implications for physicians and policy makers about how to further reduce the incidence of LBW among mothers residing in rural areas of the United States. First, it is clear that one variable to focus upon is increasing gestational age. Just a one-day increase in gestational age is associated with an increase in birth weight between 16g and 25g. Therefore, physicians and policy makers need to collaborate on developing health care policies that will help a female carry a fetus to term.

Second, the lack of statistical significance for adequacy of prenatal care suggests that Kessner's scale as currently configured may not be a very good measure of prenatal care. Obstetricians may need to consider a better method for assessing prenatal care. For instance, a revised Kessner's scale should account for the quality of care provided during a prenatal visit. The measure needs to take into account other methods that physicians now use to treat patients (e.g., telephone, fax, e-mail).

Third, focusing an analysis on age extremes uncover relationships that just one equation may hide. Our results suggest that as we parse the data into smaller subsets based on age and focus on LBW, the effect of the variables may be differ regarding the differences in birth weight and LBW. Physicians and policy analysts may want to consider this relationship when contemplating changes to state and federal programs dealing with prenatal care.

Fourth, it appears that the effect of TennCare is associated with a reduction in birth weight by as much as 342g but the effect is not uniform in every scenario. Our explanation for this situation is two-fold. First, obstetricians have long believed that a large number of known and unknown variables affect birth weight and while those usually equalize in a large sample, it weakened our argument when applied to the sub-sample of mothers 18 years of age or younger. Second, we believe these differences are due to physicians learning to work around TennCare's rules regarding prenatal care. But physicians may want to consider lobbying state policy makers for changes to TennCare so it will be a consistent force for improving birth weight and lessening LBW.

Lastly, the effects of the socioeconomic factors suggest that physicians should consider them as also being important. While it is true that physician cannot alter a mother's age, race, or marital status, these conditions may provide valuable clues regarding the likelihood for LBW and assist in designing a comprehensive treatment plan. Focusing just on medical conditions does not treat the whole person.

REFERENCES

Ahmed, F. (1990). Unmarried mothers as a high-risk group for adverse pregnancy outcomes. *Journal of Community Health 15*: 35-44.

Allen, G. (1990). Diabetes in pregnancy. *Mid-South Perinatal Perspectives 1*: 1-3.

Anderson, N. E., Smiley, D. V., Flick, L. H., & Lewis, C. Y. (2000). Missouri rural adolescent pregnancy project. *Public Health Nursing 17*: 355-62.

Baker, C. (1991). Baby deaths found high in rural areas. *New York Times* 2 August: A12.

Baldwin, L. M., Grossman, D. C., Casey, C., Hollow, H., Sugarman, J. R., Freeman, W. L., & Hart, L. G. (2002). Perinatal and infant health among rural and urban American Indians/Alaska Natives. *American Journal of Public Health 92*: 1491-97.

Bennett, T. (2002). Reproductive health care in the rural United States. *JAMA 287*: 112.

Bennett, T., Skatrud, J. D., Guild, P., Loda, F., & Kierman, L. V. (1997). Rural adolescent pregnancy: A view from the South. *Family Planning Perspectives 29*: 256-67.

Creatsas, G., Goumalatos, N., Deligeoroglou, E., Karagitsou, T., Calpaktsoglou, C., & Arefetz, N. (1991). Teenage pregnancy: Comparison with two groups of older pregnant women. *Journal of Adolescent Health Care 12*: 77-81.

Del Priore, G., Zandieh, P., & Lee, M. J. (1997). Treatment of continuous data as categoric variables in *Obstetrics and Gynecology*. *Obstetrics & Gynecology 89*: 351-54.

Fink, A., Yano, E., & Goya, D. (1992). Prenatal programs: What the literature reveals. *Obstetrics & Gynecology 80*: 867-72.

Fiscella, K. (1995). Does prenatal care improve birth outcomes? A critical review. *Obstetrics & Gynecology 85*: 468-79.

Goldenberg, R. L., & Culhane, J. F. (2007). Low birth weight in the United States. *American Journal of Clinical Nutrition 85*: 584S-590S.

Green, J. R., Schumacher, L. B., Pawson, I. G., Partridge, C., & Kretchmer, N. (1991). Influence of maternal body habitus and glucose tolerance on birth weight. *Obstetrics & Gynecology 78*: 235-39.

Heaphy, P. E., & Bernard, S. L. (2000). Maternal complications of normal deliveries: variation among rural hospitals. *Journal of Rural Health 16*: 139-47.

Homko, C. J., Hagay, Z. ., & Reece, E. A. (1992). Diabetes mellitus in pregnancy. In E. A. Reece, J. C. Hobbins, M. J. Mahoney, & R. H. Petrie (Eds.), *Medicine of the Fetus & Mother* Philadelphia: J. B. Lippincott Company.

Hueston, W. J., Gilbert, G. E., Davis, L., & Sturgill, V. (2003). Delayed prenatal care and the risk of low birth weight delivery. *Journal of Community Health 28*: 199-208.

Ketterlinus, R. D., Henderson, S. H., & Lamb, M. E. (1990). Maternal age, sociodemographics, prenatal health and behavior: Influences on Neonatal Risk status. *Journal of Adolescent Health Care 11*: 423-31.

Kotelchuck, M. (1994). An evaluation of the Kessner adequacy of prenatal care index and a proposed adequacy of prenatal care utilization index. *American Journal of Public Health 84*: 1414-20.

Lee, S. K., Sobal, J., Frongillo, E. A., Olson, C. ., & Wolfe, W. S. (2005). Parity and body weight in the United States: Differences by race and size of place of residence. *Obesity Research 13*: 1263-69.

Leonardson, G. R., Loudenburg, R., & Struck, J. (2007). Factors predictive of alcohol use during pregnancy in three rural states. *Behavioral and Brain Functions 3*: 3-8.

McCarton, C. M., Wallace, I. F., & Bennett. F. C. (1995). Preventive interventions with low birth weight premature infants: An evaluation of their success. *Seminars in Perinatology 19*: 330-40.

Meyer, B. A., & Palmer, S. M. (1990). Pregestational diabetes. *Seminars in Perinatology 14*: 12-23.

Mittendorf, R., Herschel, M. Williams, M. A., Hibbard, J. U., Moawad, A. H., & Lee, K. S. (1994). Reducing the frequency of low birth weight in the United States. *Obstetrics & Gynecology 83*: 1056-59.

Moawad, A. H., Lee, K. S., Fisher, D. E., Ferguson, R., & Phillippe, M.. (1990). A model for the prospective analysis of perinatal deaths in a perinatal network. *American Journal of Obstetrics and Gynecology 162*: 15-22.

Olausson, P. M., Cnattingius, S., & Goldenberg, R. L. (1997). Determinants of poor pregnancy outcomes among teenagers in Sweden. *Obstetrics & Gynecology 89*: 451-57.

Reader, S. (2001). Detecting and analyzing clusters of low-birth weight incidence using exploratory spatial data analysis. *GeoJournal 53*: 149-59.

Schwartz, R. M., Muri, J. H., Overpeck, M. D., Pezzullo, J. C., & Kogan, M. D. (2000). Use of high-technology care among women with high-risk pregnancies in the United States. *Maternal and Child Health Journal 4*: 7-18.

Serwint, J. R., Wilson, M. E. H., Vogelhut, J. W., Repke, J. T., & Seidel, H. J. (1996). A randomized controlled trial of prenatal pediatric visits for urban, low-income families. *Pediatrics 98*: 1069-75.

Shi, L., Macinko, J., Starfield, B., Xu, J., Regan, J., Politzer, R., & Wulu, J. (2004). Primary care, infant mortality, and low birth weight in the states of the USA. *Journal of Epidemiology and Community Health 58*: 374-80.

Skatrud, J. D., Bennett, T. A., & Loda, F. A. (1998). An overview of adolescent pregnancy in rural areas. *Journal of Rural Health 14*: 17-27.

Stevens, G. D., Seid, M., & Halfon, N. (2006). Enrolling vulnerable, uninsured but eligible children in public health insurance: Association with health status and primary care access. *Pediatrics 117*: e751-e759.

Stewart, P. J., & Nimrod, C. (1993). The need for a community-wide approach to promote healthy babies and prevent low birth weight. *Canadian Medical Association Journal 149*: 281-85.

Thompson, L. A., Goodman, D. C., Chang, C. H., & Stukel, T. A. (2005). Regional variation in rates of low birth weight. *Pediatrics 116*: 1114-21.

U.S. Department of Health and Human Services. (1991). *Healthy People 2000*. Washington, D.C.: U.S. Government Printing Office.

U.S. General Accounting Office. (1994). *Medical Prenatal Care: States Improve Access and Enhance Services, but Face New Challenges*. Washington, D.C.: U.S. General Accounting Office.

U.S. General Accounting Office. (1996). *Health Insurance for Children: Private Insurance Coverage Continues to Deteriorate*. Washington, D.C.: U.S. General Accounting Office.

U.S. General Accounting Office. (1997). *Medicaid Managed Care: Delays and Difficulties in Implementing California's New Mandatory Program*. Washington, D.C.: U.S. General Accounting Office.

Warner, G. (1998). Birthweight productivity of prenatal care. Southern Economic Journal 65: 42-63.

Yoder, B. A., & Young, M. K. (1997). Neonatal outcomes of teenage pregnancy in a military population. Obstetrics & Gynecology 90: 500-06.

York, R., Grant, C., Gibeau, A., Beecham J., & Kessler, J. (1996). A review of problems of universal access to prenatal care. *Nursing Clinics of North America 31*: 279-92.

Zavis, A. (1997). Infant deaths at lowest level. *Chattanooga Times* 2 December: 1A.