JAOA Original contribution

Adequacy of prenatal care and pregnancy outcome

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The objective of this study was to determine whether a relationship exists between adequacy of prenatal care and preterm delivery, low-birth-weight, and small-for-gestational-age infants. Data from 1771 patients enrolled in an ongoing study of maternal growth in young gravidas were studied. The indices of both Kessner and colleagues (the Kessner index) and Kotelchuck (the Kotelchuck index) were used to determine adequacy of prenatal care. Patients receiving adequate care were compared with those receiving intermediate or inadequate care and the incidence of preterm birth, low-birth-weight, and small-for-gestational-age infants was determined in each group. The study controlled for potential confounding variables, that is, black ethnicity, maternal age, pregravid body mass index, parity, adequate prenatal weight gain, smoking, and previous delivery of low-birth-weight or preterm infant.

The data were analyzed by logistic regression. When classified according to the Kessner index, 290 (16.4%) of the women received inadequate care, 961 (54.3%) received intermediate care, and 520 (29.4%) received adequate care. By the Kotelchuck index, 651 (36.8%) of the women received inadequate care, 201 (11.3%) received intermediate care, 604 (34.1%) received adequate care, and 315 (17.8%) received adequate-plus care. By use of the Kessner index and by estimating gestation from the last menstrual period, it was determined that women who received inadequate care had a 2.8 times greater risk (95% confidence interval [CI], 2.07-3.78), and by use of the Kotelchuck index, a 2.1 times greater risk (95% CI, 1.58-2.81) of having a preterm delivery. When the obstetric estimate of gestation was used, risk was 2.01 times greater (95% CI, 1.44-2.80) with the Kessner index and 1.4 times greater (95% CI, 1.0-1.94) with the Kotelchuck index. There was little effect of prenatal care on incidence of small-for-gestational-age infants.

The results of this study confirmed that inadequate prenatal care is associated with an increased risk of preterm delivery.

(Key words: prenatal care, preterm delivery, low-birth-weight infants, small-for-gestational-age infants)

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Preterm delivery and the low birth weight associated with it are among the leading causes of infant mortality in the United States. Care for surviving infants incurs a huge medical cost.[1] Prenatal care is seen as a clinically useful, cost-effective way of potentially decreasing the incidence of preterm birth; however, it remains unclear whether such is true.[2]

Prenatal care may be desirable for many reasons. It serves as an introduction to the healthcare system, allowing the physician to evaluate nonobstetric conditions such as immunizations and dental care.[3] It may be a cost-effective way of delivering long-term health benefits.[4] It may have a positive effect on the detection and treatment of obstetric conditions such as hypertension and diabetes.[5] Finally, prenatal care has well-documented benefits on maternal health.[5] However, the fact remains that its impact on preterm birth is poorly documented. We therefore examined the influence of two indices, the Kessner Adequacy of Prenatal Care Index (Kessner index)[6] and the more recent version, the Adequacy of Prenatal Care Utilization Index proposed by Kotelchuck,[7] to gauge adequacy of care on risk of delivering before term.

Materials and methods

Data from 1771 patients from the Camden Study, an ongoing study of nutrition and maternal growth in young (≤18 years) and older (19 to 29 years) gravidas, were used in this analysis. Women were enrolled from urban clinics (Camden, NJ) and followed up through delivery and the early postpartum period as previously described.[8] Approval of the Institutional Review Board was obtained before the project was initiated and updated yearly. Women with evidence of serious medical complications—lupus, chronic hypertension, congenital heart disease, insulin-dependent diabetes mellitus, hemoglobinopathies, cancer, seizures, drug abuse, heavy cigarette smoking (more than two packs per day), alcohol abuse (more than four drinks per day), or psychiatric disorders were not enrolled.

Length of gestation was estimated both from the mother's last menstrual period (LMP) and the obstetric (OB) estimate of gestation. To obtain the OB estimate, a combination of clinical findings and ultrasound was used. Before 12 weeks of gestation, crown-rump length was used sonographically. If the crown-rump length measurement was within 7 days of menstrual age for LMP, then the

Table 1
Study Group Characteristics and Kessner Adequacy of Prenatal Care Index[6] and Kotelchuck Adequacy of Prenatal Care Utilization Index[7]

	Kessner index		Kotelchuck index		
	Care characteristic		Care characteristic		
Variable	Inadequate	Adequate/ intermediate	Inadequate	Adequate/ intermediate	Adequate-plus
☐ Sample size, No.	290	1481	651	805	315
☐ Age, y (mean±SD)	17.3±3.3	18.0±3.5	17.5±3.4	18.0±3.4	18.5±3.7*
☐ Multipara, %	46.9*	30.2	40.5*	27.3	31.7
☐ Ethnicity, %					
— black	65.2†	56.5	65.0*	53.8	53.7
— Hispanic	27.2	34.2	27.5	36.7	35.2
— white	7.6	9.4	7.5	9.6	11.1
☐ Cigarettes per day, %					
— None	73.9	76.2	75.4	73.9	81.5
— 1 to 9	18.7	17.1	17.1	19.3	13.1
— 10 to 19	6.0	4.6	5.4	5.0	3.0
— 20 or more	1.4	2.1	2.0	1.9	2.2
☐ Alcohol use, drinks per day (%)					
— None	79.6	77.0	78.1	75.9	79.9
— 0 to 1	20.1	22.6	21.4	23.8	19.8
— 1 or more	0.4	0.4	0.5	0.4	0.3
☐ Inadequate weight gain, %					
— by last menstrual period estimate	28.0	22.8	24.7	22.5	24.4
— by obstetric estimate	29.7‡	22.4	25.6	22.0	23.2
☐ Medicaid, %	87.5	86.2	86.2	87.5	84.0
☐ Previous spontaneous abortion, %	10.0	8.9	7.2§	9.6	11.4
☐ Prior preterm delivery	6.6	4.1	7.4*	2.1	4.8

*$P<.05$.
†$P<.01$.
‡$P<.001$.
§$P<.1$

estimated date of delivery was based on LMP. Beyond the first trimester, biometry was used. If this calculation was within 10 days of menstrual age, then the estimated date of delivery was also based on LMP. If these limits were exceeded, then the OB estimate was based on the ultrasonographic findings.

Infant low birth weight was defined as birth weight less than 2500 g. Preterm delivery (<37 completed weeks) was calculated based on both LMP and the OB estimate as described previously. Small for gestational age (SGA) was defined as below the 10th percentile for gestational age using Brenner's standard.[9]

Prenatal care for these gravidas was calculated from both the Kessner[6] and the Kotelchuck[7] indices. Adequacy of care was then compared with regard to preterm delivery, low birth weight, and SGA as previously defined. When the Kessner index[6] was used, women who received inadequate care were compared

Table 2
Agreement Between Kessner Adequacy of Prenatal Care Index[6] and Kotelchuck Adequacy of Prenatal Care Utilization Index[7]

	Kotelchuk index			
Kessner index	Inadequate	Intermediate	Adequate	Adequate-plus
Adequate	0.0	9.0	58.5	32.4
Intermediate	38.2	15.4	31.2	15.2
Inadequate	97.9*	2.1	0.0	0.0

*$P < .001$.

Table 3
Outcomes in Patients With Adequate/Intermediate Care as Determined by Kessner Adequacy of Prenatal Care Index[6] and Kotelchuck Adequacy of Prenatal Care Utilization Index[7]

	Preterm labor, %		
Index*	Last menstrual period estimate	Obstetric estimate	Low birth weight, %
☐ Kessner	16.3	12.2	10.9
☐ Kotelchuck	13.0	9.9	9.6

with women receiving adequate or intermediate care. The Kotelchuck index[7] was used to compare women who received inadequate and adequate-plus care (>110% of expected visits) with women at the other levels of prenatal care.

Logistic regression was used to control for potential confounding variables, including preterm birth and low birth weight, black ethnicity, maternal age, pregravid body mass index (kilogram of body weight divided by height in meters squared), parity, inadequate weight gain for length of gestation,[10] smoking, and previous delivery of low-birth-weight or preterm infant. Adjusted odds ratios were computed from the logistic regression coefficient, and 95% confidence intervals (CI) were calculated from the covariance matrix.

Results

Characteristics of the 1171 women are shown in *Table 1*. According to the Kessner index, 290 (16.4%) of the women received inadequate care, 961 (54.3%) received intermediate care, and 520 (29.4%) received adequate care. Women who received inadequate care were less likely to be multiparous, to be black, and to have inadequate weight gain for length of gestation when calculated from the OB estimate. No differences existed in other characteristics (cigarette smoking, alcohol use, inadequate weight gain by LMP, previous spontaneous abortion, or previous preterm delivery).

By use of the Kotelchuck index, 651 (36.8%) of the women received inadequate care, 201 (11.3%) received intermediate care, 604 (34.1%) received adequate care, and 315 (17.8%) received adequate-plus care (*Table 1*). Women receiving inadequate care were again more likely to be multiparous and black. They were also more likely to have had a previous preterm delivery and somewhat less likely to have had a previous spontaneous abortion. There was no correlation with cigarette smoking, alcohol use, adequate weight gain by the OB estimate or LMP, or payer.

When the indices were cross-classified (*Table 2*), there was significant concordance ($P<.001$), but the best agreement was for inadequate care—97.9% of the women who had inadequate care on the Kessner index also had inadequate care according to the Kotelchuck index. Adequate care ranked second; 90.9% of women receiving adequate care by the Kessner index had either adequate (58.5%) or adequate-plus care (32.4%) when classified by the Kotelchuck index. The poorest agreement was for intermediate care where the concordance was only 15.4% (*Table 2*).

The rates of poor outcome were high even in the group receiving adequate/intermediate care (*Table 3*) when classified by the Kessner index: 16.3% had

Table 4
Preterm Delivery: Influence of Inadequate and Adequate-Plus Prenatal Care*

Quality of prenatal care	Kessner index[6] N†	%‡	AOR§	95% CI‖	Kotelchuck index[7] N†	%‡	AOR§	95% CI‖
■ **Last menstrual period estimate**								
☐ Inadequate	271	36.2	2.80	2.07 to 3.78	622	25.9	2.10	1.58 to 2.81
☐ Adequate-plus	...	...	...	...	313	22.7	1.93	1.37 to 2.72
☐ Adequate/ intermediate	1455	16.3	1.00	...	791	13.0	1.00	...
■ **Obstetric estimate**								
☐ Inadequate	289	22.5	2.01	1.44 to 2.80	650	14.8	1.40	1.00 to 1.94
☐ Adequate plus	...	...	...	...	313	22.0	2.61	1.82 to 3.73
☐ Adequate/ intermediate	1479	12.2	1.00	...	805	9.9	1.00	...

*Adjusted for age, parity, ethnicity, pregravid BMI, inadequate gain for gestation (last menstrual period or obstetric estimate as appropriate), cigarettes per day, prior preterm delivery.
†Sample size.
‡Unadjusted proportion preterm.
§Adjusted odds ratio.
‖Ninety-five percent confidence interval

Table 5
Low Birth Weight: Influence of Inadequate and Adequate-Plus Prenatal Care*

Quality of prenatal care	Kessner index[6] N†	%‡	AOR§	95% CI¶	Kotelchuck index[7] N†	%‡	AOR§	95% CI‖¶
☐ Inadequate	289	16.6	1.46	1.00 to 2.12	650	12.2	1.14	0.80 to 1.62
☐ Adequate-plus	...	...	...	...	315	16.8	1.96	1.32 to 2.89
☐ Adequate/ intermediate	1481	10.9	1.00	...	805	9.6	1.00	...

*Adjusted for age, parity, ethnicity, pregravid body mass index, inadequate gain for gestation (obstetric estimate), cigarettes per day, prior low birth weight.
†Sample size.
‡Unadjusted proportion low birth weight.
§Adjusted odds ratio.
‖Ninety-five percent confidence interval.

preterm delivery according to the LMP estimate, 12.2% according to the OB estimate, and 10.9% had a low-birth-weight infant. When the Kotelchuck index was used, 13.0% had preterm delivery by the LMP estimate, 9.9% by the OB estimate, and 9.6% had a low-birth-weight infant.

The relationship between the adequacy of prenatal care and preterm delivery as determined by LMP is shown in *Table 4*. By the Kessner index, the preterm delivery risk for women receiving inadequate care was increased nearly threefold when compared with that for women receiving adequate or intermediate care after controlling for potential confounding variables. By the Kotelchuck index, women who had inadequate care had a risk of preterm delivery that was twice that of women receiving adequate or intermediate care. Women receiving adequate-plus care (the Kotelchuck index) also had an increased

risk of preterm delivery in comparison to the reference group.

The relationship of prenatal care to preterm delivery by OB estimate also is shown in *Table 4*. When classified according to the Kessner index, women receiving inadequate care had a twofold increase in risk of preterm birth by OB estimate. When classified by the Kotelchuck index, women receiving inadequate care had a preterm delivery rate about 40% greater than those women receiving adequate or intermediate care. Women receiving adequate-plus care were also at increased risk. Their risk was increased more than 2.5 times after controlling for potential confounding variables.

Results relating adequacy of prenatal care to low birth weight are shown in *Table 5*. By the Kessner index, women who had inadequate care had a less-than-twofold increase in risk of infant low birth weight. With the Kotelchuck index, the risk was close to unity and was not statistically significant (the confidence limits included unity). However, women who received adequate plus-care (the Kotelchuck index) had a twofold increase in risk of infant low birth weight.

The risk of SGA infants by LMP and its relationship to inadequate care on the Kessner index also was close to unity (AOR=0.74; 95% CI, 0.48 to 1.40). The same was true for adequate plus care (AOR=1.21, 95% CI, 0.75 to 1.94). Results were similar when SGA derived from the OB estimate was used. Thus, the effects of prenatal care on this aspect of pregnancy outcome were small and not statistically significant.

Table 6
Kessner Adequacy of Prenatal Care Index[6]

Level of care/ week of gestation	No. of prenatal visits
■ **Inadequate*†**	
☐ 14 to 21	0 or unkown
☐ 22 to 29	<2 or unknown
☐ 30 to 31	<3 or unknown
☐ 32 to 33	<4 or unknown
☐ >33	<5 or unknown
■ **Adequate‡**	
☐ >14	>0 or unknown
☐ 14 to 17	>1
☐ 18 to 21	>2
☐ 22 to 25	>3
☐ 26 to 29	>4
☐ 30 to 31	>5
☐ 32 to 33	>6
☐ 34 to 35	>7
☐ >35	>8
■ **Intermediate**	
☐ All combinations other than specified above	

*Every woman who started her prenatal care during week 28 or later was considered to have inadequate care.
†Care was considered inadequate if the data of the first visit were unknown.
‡To be adequate care had to be initiated prior to 14 weeks gestation.

Discussion

In 1984 Kessel and colleagues[11] studied US natality statistics from 1970 to 1980 and showed a reduction in the incidence of infants weighing less than 2500 g, especially at term. The 1970s was a period of rapid growth of federal, state, and local health programs such as those sponsored by Women, Infants and Children (WIC), Department of Health and Human Services, regional perinatal centers, and others. Thus, Kessel and associates[11] concluded that these programs "may have had a more substantial direct effect on improving infant health than previously realized."

Kessel and coworkers' study and other work documented the possibility that prenatal care reduced the risk of infant low birth weight. Hulsey and colleagues[12] showed fewer low-birth-weight infants among the preterm infants delivered to mothers who received prenatal care. They suggested that significant improvements in pregnancy outcome are seen in women who use prenatal care. Coria-Soto and associates[13] in Mexico concluded from their case-control study, "an important reduction in the incidence of births with IUGR [intrauterine growth restriction] and preterm delivery could be expected if women attend an adequate number of antenatal visits." Barros and colleagues,[14] using a questionnaire to study the role of prenatal care on preterm birth in Portugal, found that free access to care had an independent effect on reducing preterm births and low-birth-weight infants.

The methodology and conclusions of these and many similar studies[15-28] have been criticized.[2] For example, most are retrospective, and data quality often is poor. Birth certificates or vital statistics or both were often used, both of which have notorious inaccuracies.[29,30] Studies using questionnaires and other cross-sectional methods are subject not only to inaccuracies, but they also have recall bias. Another major problem is selection bias. Prenatal care is both an indicator and an index of maternal behavior.[31] Finally, as verified in our study, women at risk for preterm delivery may receive more prenatal visits than women who do not.

The design of our study minimizes these biases. Data were collected prospectively. No birth certificate or vital statistics data were used. Confounding variables are reported and analyzed (*Table 1*). We do not believe that a randomized clinical trial, the only study design preferred to ours, is acceptable because it would deny prenatal care to a group of women.

It is difficult enough to document adequacy of prenatal care, let alone content and quality. The American College of Obstetricians and Gynecologists (ACOG) guidelines[32] do not form an effective research tool. Patients who deliver before term should, by definition, have fewer visits than women who do not, because guidelines call for the greatest number of visits in the third trimester.

Various indices have been developed to overcome this bias. Most widely used is Kessner's Adequacy of Prenatal Care Index.[6] As shown in *Table 6*, it combines the timing of the first prenatal visit and the total number of visits into three categories: *adequate, intermediate,* and *inadequate*. For care to be considered adequate, it must begin before 14 weeks gestation. Any woman who initiates pre-

Table 7
Kotelchuck Adequacy of Prenatal Care Utilization Index[7]

Variable	Prenatal care			
	Inadequate	Intermediate	Adequate	Adequate-plus
■ **Adequacy of received services, %**	<50*	50 to 79*	80 to 109*	⩾110*
■ **Adequacy of initiation of prenatal care (month begun)**	No prenatal care or ⩾7th mo	5th or 6th mo	3d or 4th mo	<3d mo
■ **Summary of Adequacy of Prenatal Care Utilization Index**				
□ Prenatal care started and/or □ Recommended visits attended, %	After the 4th mo or <50	By the 4th mo and 50 to 79	By the 4th mo and 80 to 109	By the 4th and >109

*Percentage of the number of visits recommended by the American College of Obstetrics and Gynecology received during pregnancy.

natal care during week 28 or later is considered to have inadequate care. Adequate care closely follows the ACOG guidelines.[32] This index has been criticized.[7] The index has been said to overemphasize the initiation of prenatal care; to be termed "adequate," care must begin in the first trimester.[7] It does not distinguish whether prenatal care was inadequate due to a delay in initiation or to an inadequate number of visits. Finally, the index is based on New York City birth certificates and is artificially designed to adapt to this basis. For example, the index stops at nine prenatal visits probably because only one digit was allocated by New York Vital Statistics.

Kotelchuck[7] redefined the Kessner index into the Adequacy of Prenatal Care Utilization Index (*Table7*). Several differences exist. Care initiated after the first trimester can at least be "intermediate" if an adequate number of visits is achieved. Small differences exist relating the number of visits to the "inadequate" and "adequate" categories. However, the major difference to the clinician is the addition of an *Adequate-plus* care category for patients who begin prenatal care by the fourth month and have 110% or more of the number of visits recommended by the ACOG. This classification effectively develops a category of women who are, for some reason, at high risk. Their obstetricians are recommending visits at more frequent intervals. This was shown in our study, whereby women who received adequate-plus care had a 22.7% chance of preterm delivery by LMP estimate and a 22% chance of preterm delivery by the OB estimate. More striking was their 16.8% risk of low-birth-weight infant, which was actually greater than that of those patients receiving inadequate care. It seems that our ability to identify women at risk for preterm labor and low-birth-weight infants is greater than our ability to treat it.

For our purposes, there exists neither a major difference nor a major advantage between indices. Both showed that prenatal care reduced the risk of preterm delivery. Care that was inadequate on the Kessner index was very likely to be inadequate on the Kotelchuck index (97.9%). Similarly, women who had adequate care according to the Kessner index were very likely to have care that was adequate or adequate-plus by the Kotelchuck index (90.9%). The major difference was that the Kotelchuck index classified many more women into the inadequate-care category (36.8% vs 16.4%). One advantage is that Kotelchuck's adequate-plus category identified many women at risk for low-birth-weight infants and preterm delivery from either the LMP or the OB estimate.

Both indices were designed using birth certificate data and a due date based on the LMP. We used both the LMP and the OB estimates. Although both show a clear association between adequacy of prenatal care and preterm delivery, this association was much stronger when the LMP estimate was used, perhaps because this was the basis for calculation in the original indices. This is true despite the possibility that the OB estimate overestimates the impact of prenatal care on preterm delivery because women with SGA infants may have their due date revised downward by ultrasound.

The effect of inadequate prenatal care on risk of SGA in this study was modest and not statistically significant. Intrauterine fetal growth restriction is frequently an undiagnosed event. When abnor-

malities of intrauterine growth are detected, labor is induced, often before the fetus is below the 10th percentile (the definition of SGA used in this study). The effectiveness of interventions to prevent SGA infants are limited and have been recently reviewed.[33] Antimalarial chemoprophylaxis is effective, but it is not of clinical importance in the United States. Effective nutritional supplementation for fetal growth restriction is modest. Smoking cessation is the most effective intervention; however, the addictive properties of cigarettes make most smoking- reduction programs of limited success.

Comment

We have demonstrated that in a large sample of young inner-city minorities, women who had inadequate prenatal care have an increased risk of preterm delivery and infant low birth weight. We have done this by use of a prospective study design that minimizes the design flaws of other major studies.

Of great concern is the high incidence of preterm and low-birth-weight infants, even in women who receive adequate care—between 9.6% and 16.3%, depending on which indicator and which index are used. Certainly, more research is needed to find out why this occurs and who is susceptible. There is also an unacceptably high rate of inadequate prenatal care (16.4% to 36.8%) in Camden and other areas afflicted by urban poverty. Our findings suggest that outreach programs and community efforts to enroll these women in care at an early gestational age and to ensure that they make an adequate number of prenatal visits will decrease the burden of preterm births in the inner cities of the United States.

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JAOA

Brief report

Clinical intra-amniotic infection with meconium-stained fluid at term: an analysis of Apgar scores

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A retrospective analysis of 1- and 5-minute Apgar scores of patients at term gestation (37 to 42 weeks) with evidence of clinical intra-amniotic infection and meconium-stained amniotic fluid was performed. The patients were selected from the labor and delivery records of two Detroit hospitals during the study period from January 1988 through May 1994. The author suggests that the presence of clinical intra-amniotic infection with meconium-stained fluid does not affect Apgar scores of term infants.

(Key words: Apgar scores, meconium, intra-amniotic infection)

Clinical intra-amniotic infection (IAI), which has an incidence of 1% to 4%, develops an ascending process after prolonged premature rupture of membranes, with other cases being hematogenous in origin. By definition, IAI is a presumptive clinical diagnosis made on the bases of maternal fever, uterine tenderness, fetal tachycardia, maternal leukocytosis (>10,000 WBC), and malodorous amniotic fluid.[1]

Maberry and colleagues[2] reported that using criteria used to define asphyxia (Apgar scores of 6 or less), significantly more infants in the infected group had low Apgar scores. However, 60% of these patients were preterm infants, and it is known that preterm infants have other influences on Apgar scores that make the use of Apgar scores less reliable.[3] Yoder and colleagues[4] investigated IAI and its effect on maternal and perinatal well-being and found no adverse outcomes. The combined influence of meconium and IAI in term patients has not specifically been studied.

A number of published studies have noted lower Apgar scores related to meconium-stained fluid (MSF).[5,6] Berkus and colleagues[7] reported that moderate or thick meconium placed an infant at three times the risk of an adverse neonatal outcome (including meconium aspiration syndrome and significantly more neurologic sequelae) regardless of other stress factors. The presence of thick meconium early in labor has been associated with fetal acidosis and lower 1- and 5-minute Apgar scores.[8] Meconium-stained fluid is a risk factor for IAI in preterm patients and is considered a sign of hypoxia.[9] Approximately 60% of term patients with chorioamnionitis have MSF.[10] In light of these reported findings, and as no studies to date have exclusively investigated this group of patients, the purpose of this study was to determine if Apgar scores were affected by the combination of IAI and MSF at term.

Methods

A review of labor and delivery records

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