A Randomized Trial of Nurse Specialist Home Care for Women with High-Risk Pregnancies: Outcomes and Costs

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Objective: To examine prenatal, maternal, and infant outcomes and costs through 1 year after delivery using a model of prenatal care for women at high risk of delivering low-birth-weight infants in which half of the prenatal care was provided in women's homes by nurse specialists with master's degrees.

Study Design: Randomized clinical trial.

Patients and Methods: A sample of 173 women (and 194 infants) with high-risk pregnancies (gestational or pregestational diabetes mellitus, chronic hypertension, preterm labor, or high risk of preterm labor) were randomly assigned to the intervention group (85 women and 94 infants) or the control group (88 women and 100 infants). Control women received usual prenatal care. Intervention women received half of their prenatal care in their homes, with teaching, counseling, telephone outreach, daily telephone availability, and a postpartum home visit by nurse specialists with physician backup.

Results: For the full sample, mean maternal age was 27 years; 85.5% of women were single mothers, 36.4% had less than a high school education, 93.6% were African American, and 93.6% had public health insurance, with no differences between groups on these variables. The intervention group had lower fetal/infant mortality vs the control group (2 vs 9), 11 fewer preterm infants, more twin pregnancies carried to term (77.7% vs 33.3%), fewer prenatal hospitalizations (41 vs 49), fewer infant rehospitalizations (18 vs 24), and a savings of more than 750 total hospital days and $2,880,000.

Conclusion: This model of care provides a reasoned solution to improving pregnancy and infant outcomes while reducing healthcare costs.

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The high rate of low-birth-weight (LBW) (preterm and small-for-gestational-age) infants born in the United States is costly in human and economic terms. Compared with normal-birth-weight infants (≥2500 g), LBW infants have greater rates of mental retardation, deafness, blindness, cerebral palsy or chronic lung problems, neurologic sequelae, and mortality.[1,2] They also have greater rehospitalization rates and more physician visits compared with normal-birth-weight infants,[3,4] as well as increased medical and educational costs for many years.

Maternal conditions (eg, infection, hypertension, diabetes mellitus, and previous preterm birth) and behaviors (eg, smoking, inadequate nutrition, and substance abuse) are highly associated with LBW. With adequate prenatal care, high-risk physiologic conditions and health behaviors can be monitored and treated. Unfortunately, many women receive inadequate prenatal care because of problems with transportation, lack of child care, long waiting periods in the office, and anxiety over medical procedures, as well as other personal, structural, and financial reasons.[5-11] Women at high risk for LBW infants often are scheduled for weekly or more frequent prenatal visits, increasing these barriers. Delivering prenatal care at home can reduce barriers and potentially improve pregnancy outcomes.

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Prenatal home care programs have differed in services provided and in levels and types of providers; have often focused on women at low risk for delivering LBW infants; and have reported mixed results.[12-19] Watson et al[12] found that risk of preterm birth was significantly reduced in a group receiving daily home uterine activity monitoring and perinatal nursing support (47%) compared with a group receiving standard care (84%).

Dyson et al[13] reported that women with preterm labor receiving weekly contact with a nurse, daily contact with a nurse, or daily contact with a nurse and home monitoring of uterine activity did not significantly differ in incidence of births at less than 35 weeks' gestation or in numbers of LBW births. York et al,[14] in a randomized trial of prenatal and postpartum home care of women with diabetes mellitus, reported fewer prenatal hospitalizations, fewer LBW infants, and a reduction of 44% in hospital charges for patients who received nurse specialist care compared with those who received standard care. Olds et al[17] reported positive outcomes of prenatal nurse home visitation, including earlier return to complete high school, longer maternal employment, 43% fewer subsequent pregnancies, and greater spacing of subsequent births.

In a randomized trial[15] of prenatal home visits to women with high-risk pregnancies in Latin America, interventions were insufficient to overcome the lifetime disadvantages and poor health of the women studied. However, Chapman et al,[16] analyzing numerous home visitation programs, concluded that such programs can improve prenatal care, the incidence of LBW infants, and maternal-infant interaction.

For women at high risk who need frequent prenatal care and monitoring, prenatal care delivered at home as a substitute for routine physician visits can eliminate transportation problems, the need for child care, long waits, and interruption of bed rest. Such care provided by nurses with master's degrees who specialize in caring for high-risk pregnant women and infants, and who have physician backup, might improve pregnancy and infant outcomes and reduce healthcare costs. The purpose of this study was to test such an approach, examining outcomes and costs prenatally through 1 year after birth.

··· METHODS ···

After receiving study approval from the University of Pennsylvania institutional review board, women with pregestational or gestational diabetes mellitus, chronic hypertension, or diagnosed preterm labor or at high risk of preterm labor receiving prenatal care between January 1, 1992, and January 1, 1996, at a large urban tertiary care hospital (Hospital of the University of Pennsylvania, Philadelphia, PA) were eligible for the study. Women at high risk for preterm labor included those with uterine fibroids, previous preterm labor, multiple pregnancy, or a score of 10 or greater on a modified Creasy screening tool.[20] Women with pregestational diabetes mellitus, chronic hypertension, or high risk for preterm labor were solicited at their first prenatal visit. Women with gestational diabetes mellitus or their first episode of preterm labor were solicited at diagnosis. All women spoke English and had access to a telephone. Women were randomly assigned to a control or intervention group using a sequence of sealed envelopes, prepared in advance by a statistician using a list of random numbers. After receiving informed consent from each patient, a research assistant opened each envelope in turn and assigned women to groups.

Maternal affect was measured using the Multiple Affect Adjective Checklist–state form,[21] which consists of 132 affect-connoting adjectives and provides self-report measures of anxiety, depression, and hostility. The median internal reliability estimate of 5 samples was 0.73, and test-retest reliabilities indicated the instrument's sensitivity to change in mood.[21] The checklist was collected by nurses at the first, second, and third trimesters and 3, 6, 9, and 12 months postpartum in both groups.

Patient satisfaction with care was measured using the LaMonica-Oberst Patient Satisfaction Scale.[22] Construct validity was demonstrated in the inverse relation of satisfaction scores to negative mood states. Reliability coefficients for the total instrument in successive testing were 0.92 and 0.95. In both groups, patient satisfaction was measured 1 month after hospital delivery discharge.

Control Group

Women in the control group received standard prenatal and postpartum care for high-risk patients at the hospital clinic (Clinic at the Hospital of the University of Pennsylvania, Philadelphia, PA) from residents and staff physicians. Women with pregestational diabetes mellitus were seen weekly (every other week if diabetes mellitus was less severe) until 33 completed weeks of gestation and then twice a week until delivery. Women with gestational dia-

betes mellitus were seen every other week until 35 completed weeks of gestation and then weekly until delivery. During prenatal visits, assessment included blood glucose levels, weight gain, vital signs, fetal well-being (nonstress tests beginning at 28 weeks), and dietary adequacy. Women routinely performed home glucose monitoring. Women with chronic hypertension were seen every other week until 28 weeks' gestation and then weekly for evaluation of blood pressure, signs and symptoms of preeclampsia, and fetal well-being. Women screened as being at very high risk for preterm labor (≥10 on a modified Creasy screening tool) at their initial prenatal visit were seen every other week until 23 weeks' gestation and then weekly. Women with documented preterm labor were seen weekly from diagnosis until delivery. During visits, assessments included signs of preterm labor, cervical dilation and effacement, adequacy of tocolytic medication, and fetal well-being. For all women, teaching was provided by the nursing staff.

Routine postpartum care consisted of assessment for involution, nutrition and elimination, comfort, respiratory status, and mobility. Teaching of maternal and infant care, contraceptive counseling, and follow-up care were provided by the nursing staff. Routine length of hospital stay after delivery was 48 hours, with a follow-up visit at 4 to 6 weeks in the clinic or the physician's office. No routine home visits were provided.

Intervention Group

Women in the intervention group received standard prenatal and postpartum care for high-risk patients at the hospital clinic from resident and staff physicians. However, half of the prenatal physician clinic care was substituted with care delivered in the woman's home by nurse specialists with master's degrees. These advanced practice nurses (APNs) specialized in caring for high-risk pregnant women and infants. The intervention group schedule was based on the routine times (weeks of gestation) and number of prenatal visits provided to the control group. Physician visits were alternated weekly with APN home visits (eg, 1 week of APN home visits followed by 1 week of physician clinic visits, etc). Control and intervention groups were scheduled to receive the same total number of prenatal visits.

Prenatal home visits included assessment of vital signs and fetal heart rate, electronic monitoring of uterine and fetal activity, and nonstress testing. Maternal health/risk behaviors (nutrition, smoking, and substance abuse), activity level, emotional status and coping, support systems, and basic environmental supports were part of the APN's clinical assessment, and interventions were conducted as needed. Medication regimens were monitored for effectiveness and adjusted after physician consultation. Individualized teaching and counseling were provided, referrals to community resources were made, follow-up medical care was reviewed, and appointments were scheduled.

Women in the intervention group received one postpartum APN home visit within the first week of hospital discharge. Those who delivered prematurely received an additional APN visit within 48 hours of the infant's hospital discharge. Postpartum home visits included assessment of maternal involution, complications, medication, diet, activity level, coping, emotional status, adequacy of support systems, infant sleep patterns and nutritional status, and parenting skills. Newborn physical examinations were performed. The APNs provided teaching and counseling, confirmed appointments for medical follow-up, and made referrals to community resources as needed.

During the postpartum period, women in the intervention group were contacted weekly by telephone for 8 weeks by the APNs to monitor coping and physical status. Throughout the study intervention, patients were able to telephone APNs daily from 8 AM to 10 PM Monday through Friday and from 8 AM to noon on weekends with concerns. At all other times women telephoned the physician or the hospital labor floor.

··· RESULTS ···

Of 188 eligible women, 15 were excluded because of either psychiatric history (n = 1), exclusionary criteria (n = 8), and refusal to participate (n = 6). The sample included 173 women and 194 infants: 85 women and 94 infants in the intervention group and 88 women and 100 infants in the control group (**Table 1**). There were no statistically significant differences between the groups in maternal age, race, educational level, marital status, annual income, and type of health insurance. In addition, there were no significant differences between groups in maternal diagnoses and gestational age at enrollment in the study for each diagnosis (Table 1).

Infant Outcomes

There was a significant difference in fetal/infant mortality between groups (**Table 2**). Both pregnancy losses occurred in the control group. Six of 7 infant deaths in the control group were due to

immaturity, and the other was due to pneumonia associated with HIV infection. In the intervention group, the 2 infant deaths were caused by a severe congenital anomaly (tetralogy of Fallot) and extreme prematurity.

The intervention group had 11 fewer preterm infants and 6 fewer infants born at less than 29 weeks' gestation compared with the control group (Table 2). In the intervention group, the mean birth weight of preterm infants was more than 300 g greater than that of controls, and fewer infants weighed less than 1250 g. Seven (77.7%) of 9 twin pregnancies were carried to term in the intervention group compared with 4 (33.3%) of 12 in the control

Table 1. Characteristics of 173 Women With High-Risk Pregnancies by Group

Characteristic	Control Group (n = 88)	Intervention Group (n = 85)	Statistic
Maternal age, mean ± SD (range), y	26.7 ± 6.5 (15.0-38.0)	26.6 ± 6.34 (15.0-40.0)	$t = 0.16$
Education, No. (%)			
< High school	32 (36.4)	31 (36.5)	$\chi^2 = 0.52$
High school graduate	32 (36.4)	25 (29.4)	
> High school	24 (27.2)	29 (34.1)	
Marital status, No. (%)			
Never married	63 (71.6)	67 (78.8)	$\chi^2 = 0.52$
Married	15 (17.0)	10 (11.8)	
Divorced/separated	10 (11.4)	8 (9.4)	
Race, No. (%)			
African American	82 (93.2)	80 (94.1)	$\chi^2 = 0.32$
White	5 (5.7)	2 (2.4)	
Other	1 (1.1)	3 (3.5)	
Type of health insurance, No. (%)			
Public	84 (95.5)	78 (91.8)	$\chi^2 = 0.78$
Private	4 (4.5)	7 (8.2)	
Income, No. (%)*			
<$5000	29 (33.0)	32 (37.6)	$\chi^2 = 0.59$
$5000-$12,499	30 (34.1)	22 (25.9)	
$12,500-$19,999	17 (19.3)	13 (15.3)	
≥$20,000	7 (8.0)	16 (18.8)	
Maternal diagnosis at enrollment, No. (%)			
Gestational diabetes mellitus	12 (13.6)	10 (11.8)	$\chi^2 = 0.98$
Pregestational diabetes mellitus	11 (12.5)	9 (10.6)	
Diagnosed preterm labor	26 (29.5)	27 (31.8)	
Risk for preterm labor	22 (25.0)	21 (24.7)	
Chronic hypertension	17 (19.3)	18 (21.2)	
Gestational age at enrollment, mean ± SD (range), wk			
Total group	23.3 ± 7.1 (8.9-33.6)	24.1 ± 6.4 (1.9-33.1)	$t = 0.69$
Diagnosis			
Gestational diabetes mellitus	26.5 ± 8.1	30.2 ± 1.9	$t = 1.51$
Pregestational diabetes mellitus	19.3 ± 7.1	18.3 ± 5.7	$t = 0.34$
Diagnosed preterm labor	27.6 ± 4.1	27.5 ± 4.3	$t = 0.05$
Risk for preterm labor	21.2 ± 5.6	21.3 ± 5.4	$t = 0.06$
Chronic hypertension	19.4 ± 7.5	21.6 ± 7.0	$t = 0.88$
Type of delivery, No. (%)†			
Spontaneous	48 (54.5)	50 (58.8)	$\chi^2 = 0.81$
Surgical	36 (40.9)	34 (40.0)	
Twin (surgical and spontaneous)	2 (2.3)	1 (1.2)	

*Percentages reflect missing data.
†Does not include 2 women with spontaneous abortions.

Table 2. Infant Outcomes

	Control Group (n = 98)*	Intervention Group (n = 94)	Statistic
Mortality, No.			
Pregnancy loss	2†	0	$\chi^2 = 4.28$‡
Neonatal deaths	4	0	
Infant deaths	3	2	
Total Mortality	**9**	**2**	
Preterm infants			
No.	40*	29	$\chi^2 = 2.07$
Gestational age, mean ± SD, wk	32.6 ± 4.1	33.8 ± 2.8	$t = 1.37$
Birth weight, mean ± SD, g	1960.4 ± 748.0	2263.5 ± 711.0	$t = 1.70$§
Term infants			
No.	58	65	
Gestational age, mean ± SD, wk	38.7 ± 1.2	38.7 ± 1.0	$t = 0.23$
Birth weight, mean ± SD, g	3139.0 ± 526.4	3094.5 ± 591.4	$t = 0.24$
Gestational age, No.			
<26.0 wk	5*	0	$\chi^2 = 6.89$
≤26.1-28.9 wk	3	2	
29.0-32.9 wk	5	7	
33.0-36.9 wk	27	20	
≥37.0 wk	58	65	
Birth weight, No.			
≤1000 g	8*	1	$\chi^2 = 12.97$§
1001-1250 g	2	1	
1251-1500 g	0	4	
1501-1750 g	2	0	
1751-2000 g	5	4	
2001-2250 g	9	8	
2251-2499 g	9	14	
≥2500 g	63	62	
Delivery hospitalizations			
Days, mean ± SD, No.	8.1 ± 17.77	7.2 ± 8.93	$t = 0.46$
Days, total No.	796	675	
Rehospitalizations			
Infants, total No.	24	18	$\chi^2 = 0.67$
Hospitalizations, total No.	36	19	
Days, total No.	887	522	
Days, mean ± SD, No.	8.9 ± 42.3	5.6 ± 38.2	$t = 0.57$
Acute care visits			
Infants, total No.	53	59	$\chi^2 = 1.89$
Visits, total No.	163	152	
Visits, mean ± SD, No.	1.6 ± 2.6	1.6 ± 2.5	$t = 0.04$
Twin infants	(n = 24)	(n = 18)	
Preterm, No.	16	4	$\chi^2 = 8.15$‡
Birth weight, mean ± SD, g	2034.8 ± 584.38	2351.1 ± 484.26	$t = 1.87$§
Gestational age, mean ± SD, wk	34.3 ± 3.82	36.9 ± 2.05	$t = 2.65$‡

*Does not include 2 spontaneous abortions.
†Includes 2 spontaneous abortions.
‡$P < .01$.
§$P < .05$.

group. Twins in the intervention group had a 300 g greater mean birth weight and a 2-week greater mean gestational age compared with controls.

In the intervention group, infants were hospitalized for more than 100 fewer days after birth, and fewer were rehospitalized (18 vs 24) during the first year of life, saving more than 350 hospitalization days compared with controls. Both groups of infants had similar numbers of acute care visits.

Maternal Outcomes

Fewer women in the intervention group vs the control group were hospitalized during pregnancy (41 vs 49), resulting in a savings of more than 200 hospital days (**Table 3**). Mean length of prenatal hospital stay was significantly lower for the intervention group. Considering only those hospitalized, however, intervention women had significantly longer hospital stays than control women (6.1 ± 5.1 vs 5.7 ± 3.5; $t = 1.72$; $P < .05$). There was a significant difference in the total number of prenatal visits between the control (n = 1239; mean ± SD, 14.6 ± 5.9) and intervention (n = 1522; mean ± SD, 18.3 ± 5.9) groups, with the intervention group receiving the greater number of visits ($P < .001$) (data not shown). This can be explained in part by the longer gestation in the intervention group. In addition, significantly fewer women in the intervention group vs the control group required acute care visits (64 vs 75), and women in the intervention group had fewer total acute care visits (230 vs 261) and tests for biophysical profiles (256 vs 309).

At delivery, women in both groups were hospitalized for a similar number of days. Average lengths of stay for postpartum rehospitalizations were also similar (data not shown). However, when only those hospitalized were considered, intervention women had shorter lengths of stay than controls (1.2 ± 1.3 vs 5.7 ± 7.7; $t = 1.88$; $P < .05$). This resulted in a savings of 42 hospital days for the intervention group even though more intervention women required rehospitalization during the postpartum period than did controls. The major reason for postpartum hospitalizations in both groups was subsequent preg-

Table 3. Maternal Outcomes

	Control Group (n = 88)	Intervention Group (n = 85)	Statistic
Prenatal hospitalizations			
Women, No.	49	41	$\chi^2 = 1.31$
Hospitalizations, No.	80	59	
Days hospitalized, total No.	493	285	
Length of stay, mean ± SD (range), d	5.7 ± 3.5 (0-83.0)	6.1 ± 5.1 (0-29.0)	$t = 1.72$*
Delivery hospitalizations			
Length of stay, mean ± SD (range), d	3.2 ± 3.0 (1.0-22.0)	3.0 ± 2.5 (1.0-17.0)	$t = .49$
Days hospitalized, total No.	279	258	
Postpartum rehospitalizations			
Women, No.	11	17	$\chi^2 = 1.62$
Rehospitalizations, No.	13	20	
Days hospitalized, total No.	63	21	
Length of stay, mean ± SD, d	5.7 ± 7.7	1.2 ± 1.3	$t = 1.88$*
Maternal prenatal acute care visits			
Women, No.	75	64	$\chi^2 = 3.30$*
Visits, total No.	261	230	
Visits, mean ± SD No.	3.0 ± 2.6	2.7 ± 3.0	$t = 0.69$
Maternal postpartum acute care visits			
Women, No.	30	31	$\chi^2 = 0.05$
Visits, total No.	70	71	
Visits, mean ± SD No.	0.81 ± 1.55	0.84 ± 1.66	$t = 0.09$
Biophysical profile tests			
Total No.	309	256	
Mean ± SD No.	3.6 ± 5.3	3.0 ± 4.0	$t = 0.81$

*$P < .05$.

nancy (3 in the control group and 5 in the intervention group), followed by tubal ligation in the intervention group (n = 5). Two hospitalizations in the control group and one in the intervention group were for chronic illness. In addition, one woman in each group was rehospitalized for an abdominal wound infection.

Both groups had similar numbers of women with postpartum acute care visits, total numbers of visits, and mean number of visits. There were no differences in maternal affect (anxiety, depression, and hostility) between groups. Women in the intervention group were significantly more satisfied with care than were controls ($P < .001$).

Cost of Care

Table 4 illustrates the intervention effects on hospital and APN charges. We recognize that charges are not necessarily an accurate measure of true costs. Even use of the ratio of cost to charges would give only crude approximations of true cost, without a full microcosting. The expense of microcosting was prohibitive and beyond the scope of this study. Our goal was to determine not the true costs for any patient but whether the intervention group had lower charges and, if so, how much lower relative to the control group. We believe that data on charges were adequate for making such proportional estimates. Cost analysis assumed the same standard physician charge for prenatal, delivery, and postpartum care for both control and intervention groups. Costs for APN services were assumed to be additive. Because no charges were available for APN services, the actual cost of providing this care was converted to a charge and used for the analysis.

Charges for APN services included time for direct care of mothers, infants, and families; telephone time; home visit time; administrative time; and telephone and travel charges. Advanced practice nurse time was calculated to cost $39.06 per hour, the average of hourly wages and benefits for midpoint APNs working in the geographic area in 1995. The total mean charge for APN services for the intervention group was $2039 per maternal-infant dyad.

In the intervention group, mean prenatal hospital charges were less than those for controls ($6213 vs $10,196). The difference ($3983), nearly a 39% charge savings, was statistically significant ($P<.05$).

Because of the high risk for prematurity, twins represent a significant subgroup, despite being a small proportion of the sample (13.6% in the intervention group and 10.6% in the control group)

Table 4. Hospital and Nurse Specialist Charges

	Control Group	Intervention Group	Group Differences	*t*
Prenatal hospitalization charges, $				
Mean ± SD (range)	10,196 ± 19,487 (0-116,726)	6213 ± 9913 (0-50,349)	3983	1.70*
Total	876,866	515,657	361,209	
Delivery hospitalization charges, $				
Mother				
Mean ± SD (range)	11,351 ± 8439 (3213-48,271)	10,399 ± 6451 (2036-38,121)	952	0.84
Total	998,905	863,156	135,749	
Infant				
Mean ± SD (range)	29,372 ± 94,290 (541-809,800)	16,820 ± 30,759 (541-207,826)	12,552	1.25
Total	2,790,345	1,530,585	1,259,760	
Postdelivery rehospitalization charges, $				
Mother				
Mean ± SD (range)	2191 ± 9788 (0-73,252)	564 ± 1907 (0-10,813)	1627	1.53
Total	184,035	45,663	138,372	
Infant				
Mean ± SD (range)	9030 ± 55,617 (0-412,012)	241 ± 1385 (0-10,999)	8789	1.56
Total	821,753	21,706	800,047	

*$P < .05$.

(**Table 5**). The intervention group had cost savings on all measures, with the greatest differences being for delivery hospitalizations (savings exceeding $345,000) and subsequent infant rehospitalizations in the 1 year after delivery (savings exceeding $196,000). Differences resulted from the greater gestational age at birth of infants in the intervention group.

Because of the high cost of prematurity, a subgroup analysis was done by preterm cohort. Total intervention group charges were considerably lower in the less than 26 week group and the 26.1 to 28.9 group (**Table 6**). Total charges (including APN charges for the intervention group) were $1,685,823 for the intervention group and $4,181,968 for the control group, representing a saving of $2,496,145. Differences were largely due to prolonged gestation for intervention infants.

··· DISCUSSION ···

Study results in prolonging pregnancy and improving infant mortality and morbidity are consistent with those of Olds,[17] Watson,[12] York,[14] and Chapman[16] and colleagues. Our intervention, however, differs from most reported programs of prenatal care in scope of services, educational preparation of nurse provider, and its focus on women at greater risk of delivering LBW infants. Our sample of mostly Medicaid recipients also differs from many reported studies.

Most reported prenatal home care programs focus on monitoring uterine activity to intervene early in preterm labor.[12,13,18,19] Nurses might provide patient teaching regarding preterm labor but most often review uterine activity with the woman by telephone and report results to the physician. Nurses' educational specialty preparation is seldom noted. In addition, study samples might not consist of women at high risk of delivering LBW infants.

For high-risk women who need frequent prenatal care and monitoring, prenatal care delivered at home that substitutes for routine physician clinic visits following study protocols has many advantages. It reduces transportation problems, the need for child care, long waits to be seen, and interruption of medical regimens such as bed rest. This

Table 5. Mother and Twin Infant Charges*

	Control Group	Intervention Group	Group Differences	*t*
Prenatal hospitalization charges, $				
Mean ± SD (range)	19,596 ± 21,120 (0-62,570)	8852 ± 11,404 (0-29,455)	10,744	1.50
Total	235,156	79,666	155,490	
Delivery hospitalization charges, $				
Mother				
Mean ± SD (range)	19,210 ± 12,544 (9278-48,271)	18,637 ± 7892 (9220-38,121)	573	0.13
Total	230,516	167,731	62,731	
Infant				
Mean ± SD (range)	24,318 ± 45,505 (659-168,712)	13,211 ± 20,907 (1599-70,304)	11,107	1.06
Total	583,624	237,806	345,818	
Postdelivery rehospitalization charges, $				
Mother				
Mean ± SD (range)	0	710 ± 2009 (0-6393)	(710)	1.06
Total	0	6393	(6393)	
Infant				
Mean ± SD (range)	9008 ± 59,559 (0-207,177)	687 ± 3637 (0-10,999)	8321	0.68
Total	207,177	10,999	196,178	
Advanced practice nurse charges, mean ± SD, $	NA	1891 ± 1080	NA	NA

*NA indicates not applicable.

approach provides continuity of care by having an APN that specializes in caring for women with high-risk pregnancies provide direct care, with physician backup, and by making services of the APN available to the woman and family 7 days a week through a telephone service. For example, intervention women had an average of 50 telephone contacts with APNs from enrollment in the prenatal period to 6 weeks postpartum. Continuity of care, monitoring of the woman's physical status, coping, and adherence to the medical plan, allows for early detection and earlier intervention when problems

Table 6. Total Mother and Preterm Infant Hospitalization Charges*

Gestational Age and Category of Charges	Control Group	Intervention Group	Group Differences
<26 wk	(n = 5)*†	(n = 0)	
Prenatal hospitalization charges—mother, $	4300	0	
Delivery hospitalization charges, $			
Mother	66,270	0	
Infant	467,012	0	
Postdelivery hospitalization charges, $			
Mother	0	0	
Infant	412,012	0	
Subtotal, $	**949,594**	**0**	**949,594**
26.0-28.9 wk	(n = 3)	(n = 2)	
Prenatal hospitalization charges—mother, $	19,371	32,046	
Delivery hospitalization charges, $			
Mother	38,985	51,358	
Infant	1,328,472	299,445	
Postdelivery hospitalization charges, $			
Mother	7448	0	
Infant	200,576	0	
Advanced practice nurse charges, $	NA	3932	
Subtotal, $	**1,594,852**	**386,781**	**1,208,071**
29.0-32.9 wk	(n = 5)	(n = 7)	
Prenatal hospitalization charges—mother, $	97,667	56,249	
Delivery hospitalization charges, $			
Mother	32,956	83,032	
Infant	441,513	500,489	
Postdelivery hospitalization charges, $			
Mother	0	6393	
Infant	207,177	0	
Advanced practice nurse charges, $	NA	11,599	
Subtotal, $	**779,313**	**657,762**	**121,551**
33.0-36.9 wk	(n = 27)	(n = 20)	
Prenatal hospitalization charges—mother, $	277,475	135,176	
Delivery hospitalization charges, $			
Mother	277,896	199,744	
Infant	256,883	263,467	
Postdelivery hospitalization charges, $			
Mother	43,967	10,813	
Infant	1988	0	
Advanced practice nurse charges, $	NA	32,080	
Subtotal, $	**858,209**	**641,280**	**216,929**
Total, $	**4,181,968**	**1,685,823**	**2,496,145**

*NA indicates not applicable.
†Does not include 2 spontaneous abortions.

arise. Overall, physicians were receptive to the APN model of care. There were disagreements, however. As the study progressed, physicians approached the APNs with a patient they believed needed the program and the APN expertise; the APNs had to remind them that this was a randomized controlled trial.

The safety and efficacy of the study intervention were demonstrated by lower fetal/infant mortality (2 vs 9); hospital days saved (>750 total days); fewer women being hospitalized prenatally (41 vs 49); and fewer infants being rehospitalized (18 vs 24) in the intervention group compared with the control group. Although more women in the intervention group vs the control group had a postpartum hospitalization (17 vs 11), the intervention group had 42 fewer hospitalized days. These outcomes were achieved in a sample of mothers in which 36.5% had less than a high school education, 78.8% were unmarried, 91.8% were receiving Medicaid, and 60.7% had a reported annual income of less than $12,499. Acceptability of the study approach was demonstrated by significantly greater satisfaction with care in the intervention group, the low refusal rate (n = 6, 3.2%), and the low attrition rate of enrolled women (n = 11, 6.4%). Nine of the 11 dropouts (5.2% of all participants) occurred after pregnancy loss or infant death.

Some of the greatest improvements in outcomes were in infants born at 32.9 weeks' gestation or earlier (9 in the intervention group vs 13 in the control group) and in those weighing 1750 g or less at birth (6 in the intervention group vs 12 in the control group). Success in prolonging gestation to term was especially evident in women with twin pregnancies (77.7% vs 33.3%). The intervention, in addition to providing support, teaching, and counseling, allowed women to remain on bed rest rather than traveling to the physician's office or clinic, which often required women to make several bus transfers with small children. For some women, attending prenatal care involved 10 hours from door to door.[23] For women at risk or stabilized with preterm labor, such visits were especially stressful and were relieved by APN prenatal care delivered at home.

The intervention's success in prolonging gestation resulted in reduced hospital charges for newborns. Healthcare charges greatly favored the intervention for infants born at <26 weeks' gestation ($0 vs $949,594), and 26.1 to 28.9 weeks' gestation ($386,781 vs $1,594,852. Differences in healthcare charges were far less for infants born at 29.0 to 32.9 weeks gestation ($657,762 vs $779,313) and 33.0 to 36.9 weeks' gestation ($641,280 vs $858,209). Intervention group costs were consistently lower in all infant groupings and often reached statistical significance. In addition, the APN intervention cost is small relative to the magnitude of the savings. Similar results have been demonstrated using the APN model of care in other patient groups.[14,23-26]

A major study limitation was that the sample was African American and poor, thus limiting generalizability to other racial or economic groups. In addition, the longitudinal design of the study, with multiple data points, resulted in missing data after pregnancy loss and infant death. However, study results that demonstrate improved maternal and infant outcomes and reduction of healthcare charges are important in systems of capitated payment. Study results demonstrate improved pregnancy and infant outcomes and overall cost savings for a group of women who were predominantly Medicaid recipients, similar to those enrolled in managed care organizations.

The study approach also has long-term health and economic benefits for infants, families, and society. Healthier infants require fewer healthcare services, fewer educational services, and reduced caregiver and financial burden for families. Healthier infants also have a greater probability of becoming independent, productive members of the nation's workforce and society. We conclude that models of care such as that used in this study provide a reasoned solution to improving pregnancy and infant outcomes while reducing healthcare costs.

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··· REFERENCES ···

1. Kramer MS, Demissie K, Yang H, Platt RW, Sauve R, Liston R. The contribution of mild and moderate preterm birth to infant mortality: Fetal and Infant Health Study Group of the Canadian Perinatal Surveillance System. *JAMA* 2000;284:843-849.

2. Wood NS, Marlow N, Costeloe K, Gibson AT, Wilkinson AR. Neurologic and developmental disability after extremely preterm birth. *N Engl J Med* 2000;343:378-384.

3. Mutch L, Newdick M, Lodwick A, Chalmers I. Secular changes in rehospitalization of very low birth weight infants. *Pediatrics* 1986;78:164-171.

4. Termini L, Brooten D, Brown L, Gennaro S, York R. Reasons for acute care visits and rehospitalizations in very low-birthweight infants. *Neonatal Netw* 1990;8:23-26.

5. Moore ML, Zaccaro DJ. Cigarette smoking, low birth weight, and preterm births in low-income African American women. *J Perinatol* 2000;20:176-180.

6. Ancel PY, Saurel-Cubizolles MJ, Di Renzo GC, Papiernik E, Breart G. Very and moderate preterm births: Are the risk factors different? *Br J Obstet Gynaecol* 1999;106:1162-1170.

7. Institute of Medicine. *Prenatal Care: Reaching Mothers, Reaching Infants.* Washington, DC: National Academy Press; 1988.

8. Samadi AR, Mayberry RM. Maternal hypertension and spontaneous preterm births among black women. *Obstet Gynecol* 1998;91:899-904.

9. Klerman LV, Cliver SP, Goldenberg RL. The impact of short interpregnancy intervals on pregnancy outcomes in a low-income population. *Am J Public Health* 1998;88:1182-1185.

10. Moss NE, Carver K. The effect of WIC and Medicaid on infant mortality in the United States. *Am J Public Health* 1998;88:1354-1361.

11. Baldwin L-M, Larson EH, Connell FA, et al. The effect of expanding Medicaid prenatal services on birth outcomes. *Am J Public Health* 1998;88:1623-1629.

12. Watson DL, Welch RA, Mariona FG, et al. Management of preterm labor patients at home: Does daily uterine activity monitoring and nursing support make a difference? *Obstet Gynecol* 1990;76(suppl 1):32S-35S.

13. Dyson DC, Danbe KH, Bamber JA, et al. Monitoring women at risk for preterm labor. *N Engl J Med* 1998;338:15-18.

14. York R, Brown LP, Samuels P, et al. A randomized trial of early discharge and nurse specialist transitional follow-up care of high-risk childbearing women. *Nurs Res* 1997;46:254-261.

15. Villar J, Farnot U, Barros F, Victora C, Langer A, Belizan JM. A randomized trial of psychosocial support during high-risk pregnancies. *N Engl J Med* 1992;327:1266-1271.

16. Chapman J, Siegel E, Cross A. Home visitors and child health: Analysis of selected programs. *Pediatrics* 1990;85:1059-1068.

17. Olds DL, Henderson CR, Tatelbaum R, Chamberlin R. Improving the life-course of socially disadvantaged mothers: A randomized trial of nurse home visitation. *Am J Public Health* 1988;78:1436-1445.

18. The Collaborative Home Uterine Monitoring Study (CHUMS) Group. A multicenter randomized controlled trial of home uterine monitoring: Active versus sham device. *Am J Obstet Gynecol* 1995;173:1120-1127.

19. Wapner RJ, Cotton DB, Artal R, Librizzi RJ, Ross MG. A randomized multicenter trial assessing a home uterine activity monitoring device used in the absence of daily nursing contact. *Am J Obstet Gynecol* 1995;172:1026-1034.

20. Creasy RK, Gummer BA, Liggins GC. A system for predicting spontaneous preterm birth. *Obstet Gynecol* 1980;55:692-695.

21. Zuckerman M, Lubin B, Rinck C. Construction of new scales for the multiple adjective checklist. *J Behav Assess* 1983;5:119-129.

22. LaMonica E, Oberst M, Madea A, Wolf R. Development of a patient satisfaction scale. *Res Nurs Health* 1986;9:43-50.

23. Stringer M. *Personal Costs of Attending Prenatal Care* [dissertation]. University of Pennsylvania, Philadelphia, PA; 1995.

24. Brooten D, Kumar S, Brown LP, et al. A randomized clinical trial of early hospital discharge and home follow-up of very-low-birth-weight infants. *N Engl J Med* 1986;315:934-939.

25. Brooten D, Roncoli M, Finkler S, Arnold L, Cohen A, Mennuti M. A randomized trial of early hospital discharge and home follow-up of women having cesarean birth. *Obstet Gynecol* 1994;84:832-838.

26. Naylor M, Brooten D, Campbell R, et al. Comprehensive discharge planning and home follow-up of hospitalized elders: A randomized controlled trial. *JAMA* 1999;287:613-620.