Telemedicine: Cost-Effective Management Of High-Risk Pregnancy

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ABSTRACT

Purpose: To evaluate the cost-effectiveness of telemedicine services in patients diagnosed with preterm labor (PTL).

Design: Women hospitalized with a diagnosis of PTL during a 3-year study period were identified within a health maintenance organization. Inclusion criteria: singleton gestation, stabilized after tocolysis and discharged from the hospital, and participation in the HMO's preterm-birth prevention program. After a PTL diagnosis, telemedicine services (home uterine activity monitoring with daily telephonic nursing contact) were authorized by the payer. The decision to prescribe telemedicine services was made by each patient's individual physician. Two groups of patients were identified: those who received telemedicine services (telemedicine group), and those who received standard care without the adjunctive outpatient service (control group).

Methods: Descriptive and statistical methods were used to compare maternal demographics, pregnancy outcome, antepartum hospitalization, delivery, nursery, and outpatient services.

Principal findings: One hundred women were identified: 60 in the telemedicine group and 40 in the control group. Gestational age at diagnosis of PTL was similar at 29.4±3.8 weeks, telemedicine group vs. 28.0±7.4 weeks, control group (P=0.252). The telemedicine group had a significantly later mean gestational age at delivery (38.2±1.4 vs. 35.3±3.8), higher mean birth weight (3224±588 vs. 2554±911), fewer mean total nursery days (2.4±1.8 vs. 14.9±26.4), and less frequent admission to the neonatal intensive care unit (6.7 percent vs. 40 percent) than the control group (all P<0.005). The total mean cost per pregnancy was $7,225 for the telemedicine group and $21,684 for the control group. This represented average savings of $14,459 per pregnancy using telemedicine services.

Conclusion: Following an episode of PTL, use of telemedicine services can be a cost-effective tool to improve pregnancy outcome.

Key terms: Telemedicine, preterm labor, preterm birth, home uterine activity monitoring, outcomes.

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INTRODUCTION

The neonatal and long-term health care costs of premature and/or low birth weight infants impose a considerable economic burden on families, third-party payers, and society as a whole.[1,2] In the United States, approximately $23 billion to $28 billion is spent annually for maternal and infant health care.[3] Of the annual $10.2 billion spent on newborn care alone, 57 percent is disproportionately consumed by the 10 percent of infants who are born preterm.[1] Private insurance is responsible for approximately 63 percent of total payments for this population.[3] An infant born at 35 weeks incurs expenses that are greater than ten times that of an infant born at 38 weeks ($4,733 vs. $441). Furthermore, an infant born at 29 weeks incurs 10 times the expense of the infant born at 35 weeks ($49,540 vs. $4,733).[1] In addition, first-year health care charges for infants of even moderately low birth weight (1,500 to 2,499 grams) are 46 percent higher than infants of normal birth weight.[2] Therefore, there is great financial incentive to third-party payers to support and/or provide measures that may help to prolong pregnancy in women experiencing preterm labor (PTL).

Accordingly, HMO-sponsored prematurity prevention programs frequently include one or more of the following interventions: risk assessment, patient education, increased prenatal visits, case management, home nursing visits, and/or home uterine activity monitoring (HUAM).[4,5] Nearly all approaches to prematurity prevention increase prenatal expenditures, though the increased maternal cost is often justified through savings in neonatal care expenses. The success in reducing the preterm-birth rate, and/or the incidence of low birth

weight, reported with use of various prevention programs, has been variable.[4–8] These inconsistent reports may be related to differences in study design, patient populations, specific treatments and individual practice patterns following a diagnosis of preterm labor, as well as differences in the actual prevention programs themselves.[9] Programs consisting of patient education alone appear to have little benefit in reducing preterm birth,[8] while more comprehensive programs that add risk assessment and case management have reported improved perinatal outcomes.[4,10]

A goal of all preterm-birth prevention programs is early detection of signs or symptoms of preterm labor. Early detection of signs or symptoms of preterm labor may allow for patient assessment and treatment prior to advanced cervical dilation. Successful treatment of an acute episode of preterm labor may significantly prolong pregnancy and allow administration of corticosteroids to the mother to enhance fetal lung maturity, thus permitting in-utero transfer to a facility more equipped to care for very preterm neonates.

Preterm labor places a pregnancy at undeniable risk for preterm birth and often is recurrent. The long-term management of women with this condition remains a serious challenge for health care providers. Following stabilization of an acute episode of preterm labor, a treatment plan must be devised to provide close patient surveillance, as well as long-term control of uterine activity and preterm-labor symptoms. A physician's decision to prescribe various treatments and surveillance programs for women experiencing preterm labor may be influenced by third-party payer guidelines. The purpose of this study was to determine the cost benefit of using telemedicine services as part of a comprehensive preterm-birth prevention program for women who had experienced an acute episode of preterm labor.

METHODS

The study population consisted of patients enrolled in an IPA-model HMO from January 1992 to November 1994. In a metropolitan area with a population of approximately 2.5 million people, this was the largest and most profitable HMO during the study period, serving a population of over 180,000 members and providing for approximately 2,500 deliveries annually. The HMO patient population was representative of the socioeconomic and educational strata in the metropolitan area, which was predominantly Caucasian and of middle income status.

In 1992, the HMO implemented a comprehensive preterm-birth prevention program, the intent of which was to improve pregnancy outcomes, lessening both the emotional and financial burden associated with preterm birth. The program consisted of a pre-conception phase that focused on identifying behaviors, lifestyles, and/or risk factors that could impact the outcome of future pregnancies, and a prenatal phase where pregnant members were screened at approximately 12, 24, and 30 weeks' gestation for conditions placing their pregnancy at risk. Whenever patients were identified as high risk, the obstetric case manager would assist in appropriate referrals to a perinatologist and/or home health service per established guidelines.

All pregnant patients were encouraged to attend on-site educational classes free of charge. Classes were taught by registered nurses and qualified educators in coordination with the March of Dimes and Healthdyne Perinatal Services (now Matria Healthcare). Instruction was given to the mother and care-partner on topics including awareness of the symptoms of preterm labor, smoking cessation, nutrition and exercise in pregnancy, stress management, and newborn care. In addition, all expectant mothers received the book, "What to Expect When You're Expecting,"[11] as well as additional educational materials stressing the importance of good prenatal care and a healthy lifestyle. This comprehensive program also included an early discharge program following delivery with additional postpartum follow-up care. The goal of the comprehensive program was identification of women at risk and appropriate early intervention, combined with education and coordinated communication to improve perinatal outcomes.

In the screening process, when women were identified as high risk for preterm birth due to a history of previous preterm delivery or multiple gestation, HUAM and telephonic nursing services were recommended to the patient's physician and authorized for payment by the case manager. Home health care services were also recommended for patients diagnosed with preterm labor in the current pregnancy. The telemedicine component of the home health care program consisted of HUAM, in which uterine activity was transmitted through a standard telephone line to a patient service center and interpreted by obstetric nurses who, through this daily patient phone contact, made an assessment for symptoms of preterm labor. Though recommended and approved by case managers, the actual prescription of the telemedicine service in all cases was at the discretion of each patient's physician.

For this analysis, women were identified retrospectively from a database prospectively compiled on all HMO members. Women who had participated in the prenatal education and screening portions of the preterm-birth prevention program and who had been referred for case management due to a hospitalization and a diagnosis of preterm labor were identified. Although patient-specific preterm-labor treatment was not controlled for in women whose clinical data were used in this study, an

assumption may be made that preterm-labor treatment, in general, was similar between the two study groups. Both the control and telemedicine groups were cared for by the same physician groups within the same system of care, following similar community practice patterns. More than two thirds of women in each group had been hospitalized at one of three tertiary care facilities. Patients who were candidates for outpatient management (remained undelivered with intact membranes, had cervical dilation <5 cm and were medically stable for a minimum of 48 hours after hospitalization for preterm labor) and who had a singleton gestation were included. Data were divided into two study groups for analyses: 1) women prescribed telemedicine services after the diagnosis of preterm labor (telemedicine, n=60), and 2) women with a diagnosis of preterm labor and whose physician elected not to prescribe telemedicine services (control, n=40). Patients having preterm ruptured membranes, advanced cervical dilatation (≥5 cm), hypertension, and diabetes prior to/or at hospitalization for preterm labor were excluded from the study.

Maternal and neonatal data were collected on identified patients using the HMO's clinical database, risk assessment and pregnancy information forms completed by physicians, precertification forms, hospital face sheets, and hospital delivery-log books. Given that this was an IPA model and not a staff-model HMO, there were some limitations in data collection. These included the inability to consistently collect patient-specific data pertaining to the use of tocolysis, cervical status at diagnosis of preterm labor, and use of corticosteroids. Cost data on all patients were obtained from the HMO database. Actual paid amounts were collected for physician charges, antepartum hospitalizations, hospital labor and delivery stays, Level II (intermediate) nursery, neonatal intensive care unit (NICU) nursery days, and telemedicine services.

Data were analyzed using Student's t-test, Pearson's chi-square, and Fisher Exact Test statistics. The Mann-Whitney Rank test was also used when applicable for nonparametric variables. To test the potential of additional influences for differences in major outcome variables, multiple linear-regression models were tested. All tests were conducted as two-tailed, with *P*-values <0.05 considered statistically significant. Statistics were calculated using Systat and SPSS.

RESULTS

Maternal characteristics are presented in Table 1. A significantly higher proportion of women in the telemedicine group were Caucasian and married, though there were similarities in age and in employment status (employed vs. nonemployed) between study groups. Gestational ages at first prenatal visit and diagnosis of PTL were also similar between study groups.

Following the diagnosis of preterm labor, women in the telemedicine group achieved a mean of 99.0 percent of desired pregnancy prolongation (to 37 weeks), while those in the control group achieved a mean of 74.9 percent ($P<0.001$). More than twice as many women (88 percent) in the telemedicine group reached 37 weeks' gestation (term), compared with only 40 percent in the control group ($P<0.001$). Pregnancy and neonatal outcome data are summarized in Table 2.

The percentage of newborns admitted to the NICU was greater for the control group (40 percent in the control group vs. 7 percent in the telemedicine group, $P<0.001$). Of the four infants in the telemedicine group admitted to the NICU, the mean length of stay (LOS) was 4.0±2.2 days. These infants had a mean gestational age at delivery of 36.5±1.3 weeks and a mean birth weight of 2894±271 grams. In the control group, there were 16 infants admitted to the NICU having a mean gestational age at delivery of 32.4±3.8 weeks and a mean birth weight of 1809±800 grams; their average LOS was 17.9±29.5 days. Additionally, 14 infants in the control group and five infants in the telemedicine group were admitted to the Level II nursery. There were no reported congenital anomalies in infants born to either group.

Since statistically significant differences were found between the study groups for marital status and race (Table 1), it was possible that differences in pregnancy outcome could have been explained by these two characteristics rather than by group assignment. Therefore, we tested a

TABLE 1 Maternal characteristics

	Control n=40	Telemedicine n=60	*P*-value
Age at delivery (y)	27.7±6.0	29.6±4.8	NS
Caucasian	29 (73%)	54 (90%)	0.022
Married	28 (70%)	53 (88%)	0.022
Employed	25 (63%)	48 (80%)	NS
Gravidity	2.2±1.3	2.5±1.0	NS
GA at 1st prenatal visit (wk)	11.5±8.3	12.2±13.7	NS
GA at diagnosis of PTL (wk)	28.0±7.4	29.4±3.8	NS

Data presented as mean ± SD, or percentage as indicated.
GA=gestational age. PTL = preterm labor.

logistic-regression model for NICU admission and two separate linear-regression models for gestational age at delivery and birth weight. All three models jointly tested marital status, race, and study-group assignment as possible predictors for differences in the three outcomes (Table 3). Neither race nor marital status were significantly associated with any of the three major outcome variables. Overall, study group assignment is the only significant predictor for the differences that were seen in pregnancy outcome.

Twenty-one (35 percent) of the telemedicine patients experienced 43 antepartum hospital admissions after an initial diagnosis of preterm labor, with a mean LOS of 2.4 days per hospitalization. In the control group, 32 (80 percent) were hospitalized a total of 42 times, with a 3.4 day mean LOS per admission. The mean cost per antepartum hospital admission averaged $1,193 for those in the telemedicine group and $2,247 for those in the control group. Of the 43 hospital admissions in the telemedicine group, 26 (60.5 percent) were due to recurrent preterm labor, while 35 (83.3 percent) of the 42 hospital admissions in the control group were due to this indication (*P*=0.036). The remaining antepartum hospitalizations in the telemedicine group were due to placenta previa, bleeding, cerclage, infection and other obstetrical indications. In the control group, the remaining indications for admission were due to bleeding, infection, and other obstetrical indications.

Mean cost data (paid charges) per pregnancy are presented in Table 4. A sum of total costs is presented in Figure 1. Overall, more than $1.3 million were spent to care for these 100 high-risk singleton pregnancies. Fifty-three percent of this amount was used for neonatal intensive care. Each pregnancy in the telemedicine group cost an average of $7,225, or $14,459 less than the $21,684 that was paid for those who did not receive this outpatient service.

TABLE 2 Pregnancy and neonatal outcome

	Control n=40	Telemedicine n=60	*P*-value
GA at delivery (wk)	35.3±3.8	38.2±1.4	<0.001
<35 weeks	15 (37.5%)	1 (1.7%)	<0.001
<32 weeks	6 (15.0%)	0	0.003
Cesarean delivery	14 (35%)	17 (28%)	NS
Birth weight (g)	2554±911	3224±588	<0.001
<2500 g	16 (40%)	6 (10%)	0.001
<1500 g	7 (17.5%)	0	0.001
Regular nursery (d)	1.1±1.1	1.8±1.1	0.002
Level II nursery (d)	6.6±13.0	0.3±1.1	<0.001
NICU (d)	7.2±20.3	0.3±1.1	<0.001
Total nursery (d)	14.9±26.4	2.4±1.8	0.002

Data presented as mean ± SD, or percentage as indicated.
GA=gestational age. PTL = preterm labor.

TABLE 3 Regression-model results: *P*-values

	Pregnancy outcome		
Characteristic	NICU admission	GAD	BW
Study group (telemedicine)	<0.001	<0.001	<0.001
Race (nonwhite)	0.093	0.423	0.929
Marital status (single)	0.167	0.976	0.360
Overall model fit	0.608*	<0.001†	<0.001†

*Hosmer-Lemeshow test; †F-test.
GAD = Gestational age at delivery. BW = Birth weight.

DISCUSSION

Depending on the population, studies indicate that about 30 to 50

TABLE 4 Mean cost per pregnancy (U.S. dollars)

	Control n=40	Telemedicine n=60	Cost savings	(95% CI)
Prenatal care	$1,385	$1,320	$65	($–159–$289)
Antepartum hospitalization	$2,337	$815	$1,521	($100–$2,944)
Delivery	$1,838	$1,523	$315	($–63–$693)
Intensive care nursery	$16,124	$765	$15,359	($4,752–$25,966)
Telemedicine services	0	$2,802	$–2,802	($–3,191–$–2,413)
Total cost per pregnancy	$21,684	$7,225	$14,459	($3,342–$25,575)

Data presented as mean. CI = confidence interval.

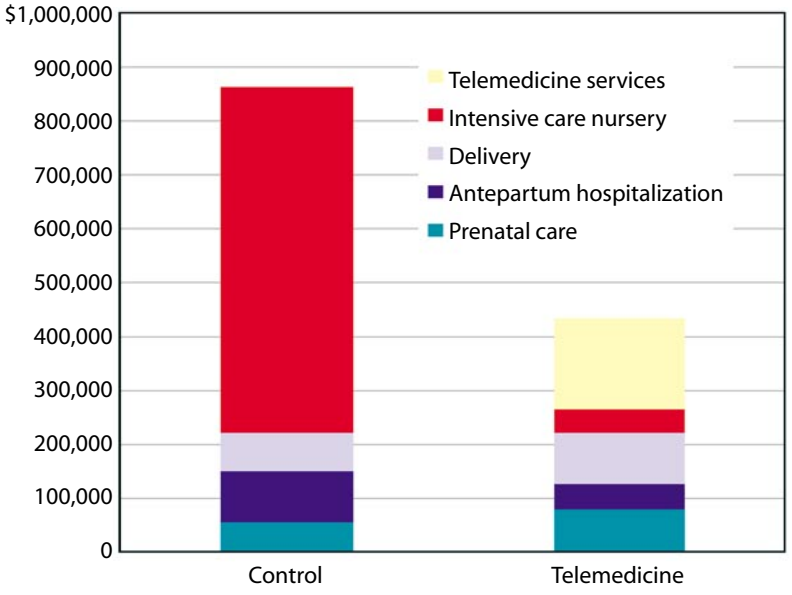
percent of preterm deliveries are due to spontaneous preterm labor. Another 30 to 40 percent are related to preterm premature rupture of the membranes, and 20 to 30 percent are indicated preterm births.[12] Early identification of preterm labor, prior to advanced cervical dilation, allows for more successful treatment of the condition and a continuation of the in-utero fetal maturation process. Often preterm labor is recurrent. Therefore, a patient who has already experienced preterm labor must be carefully followed. Comprehensive follow-up care is often achieved through case management, more frequent physician visits, and/or home nursing services with or without home uterine activity monitoring.

Subtle changes in a patient's uterine activity pattern may occur prior to the onset of preterm labor.[13,14] The home uterine activity monitor is a noninvasive, easy-to-use device that transmits data over existing telephone lines. It provides objective, trendable uterine contraction data that is assessed daily by an experienced, registered nurse. Using objective uterine data, as well as the patient's self-reported signs and symptoms of preterm labor, the nurse can determine if the patient's condition is stable, or if further assessment by the physician is warranted. Early intervention prior to advanced cervical dilation may allow for treatment of the condition with tocolytic medications and provide the window of opportunity to administer corticosteroids to the mother to enhance fetal lung maturation.

Previous studies also have suggested the cost-effectiveness of service models that now can be considered telemedicine. In a comparison of 34 women who received HUAM with daily nursing contact (monitored) vs. 33 women who had daily nursing contact but self-palpated for uterine activity (control), a cost model was used that illustrated a mean savings of $4,731 per monitored pregnancy.[15] In another analysis of 130 Medicaid recipients at risk for preterm delivery, there was an estimated average saving of $23,573 per monitored patient.[16] Both studies cite a reduction in neonatal intensive care as the primary basis for cost savings. Kosasa[17] estimated savings of $11,500 per pregnancy in 79 women monitored at high risk for preterm birth. In general, the patients who received monitoring in these studies represent a higher level of telemedicine surveillance by the addition of home uterine activity monitoring to telephonic nursing contact, much like the present study. Nevertheless, our study methodology is unique compared to these reports,[15–17] as we collected and analyzed actual cost data from a third-party pay reimbursement database. In addition, we analyzed only those patients with a diagnosis of preterm labor in the current pregnancy. We acknowledge that conclusions drawn from the results of this study are somewhat limited by its retrospective design and the lack of data regarding patient specific preterm-labor treatment(s). Nonetheless, we have demonstrated that the overall maternal/newborn costs were less for those women who received telemedicine services compared to those that received all other components of the program but not telemedicine.

In summary, the salutary effect demonstrated by the study outcome is indicative of the potential benefit derived from telemedicine services when applied to an appropriate high-risk patient population. Accordingly, the use of HUAM services as a tool in the outpatient management of women with preterm labor should be considered an integral part of a comprehensive preterm-birth prevention program, not just to reduce the rate of prematurity but to prolong gestation and reduce neonatal morbidity. When used in this manner, the cost of telemedicine services is readily justified by the resultant antenatal and neonatal cost reductions.

FIGURE 1 Comparison of total cost (U.S. dollars)



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