

Reducing Low Birthweight by Resolving Risks: Results from Colorado's Prenatal Plus Program

Sue Austin Ricketts, PhD, Erin K. Murray, MSPH, RD, and Renee Schwalberg, MPH

Low birthweight (LBW)—weight of less than 2500 g—has long been recognized as a critical risk factor for infant mortality and neurologic and developmental disabilities.¹ For this reason, Healthy People 2010, the health objectives for the nation, includes as a goal the reduction of the low-birthweight rate to 5.0% of live births by 2010, from a baseline rate of 7.6% in 1998.²

Despite this ambitious goal, the reduction of low birthweight presents a vexing problem. Although the national low-birthweight rate reached a low of 6.8% in 1985, it has risen steadily since that time and reached 7.8% in 2002. Colorado has experienced this rise in low-birthweight rates as well, with 8.9% of women delivering low-birthweight babies in 2002. In addition, Colorado has had one of the highest low-birthweight rates in the nation for many years.

Much of the increase in low birthweight is attributable to an increase in the proportion of multiple births, because these infants face a much higher risk of low birthweight than do singleton infants. However, the rate of low birthweight among singleton births has risen as well, although not as rapidly as that of the population as a whole. The trend in low birthweight also varies by race and ethnicity. Although the LBW rate among non-Hispanic Whites has increased >20% since 1990, that for Hispanics has risen much less steeply, and that for non-Hispanic Blacks has declined slightly. Nonetheless, the LBW rate among Blacks remains nearly twice that of Whites.³

Low birthweight can be attributed to two major phenomena: intrauterine growth retardation and preterm delivery. The primary risk factor for intrauterine growth retardation is smoking, which accounts for 20% to 30% of all LBW births in the United States,⁴ followed by low maternal weight gain and low prepregnancy weight.⁵ Risk factors for preterm delivery include maternal or fetal stress, infections, and violence;^{6–8} however, a clear

Objectives. We examined low-birthweight (LBW) rates among participants in Colorado's Prenatal Plus program by prenatal risk factors (smoking, inadequate weight gain during pregnancy, and psychosocial problems) and the effect of successful resolution of these risks during pregnancy.

Methods. Data for 3569 Medicaid-eligible women who received care coordination, nutritional counseling, or psychosocial counseling through the Prenatal Plus Program in 2002 were analyzed to determine the prevalence of specific risks, the proportion of women who resolved each specific risk, and the low birthweight rates for births to women who did and did not resolve risk. LBW rates were analyzed with χ^2 tests of significance.

Results. Women who quit smoking had an LBW rate of 8.5%, compared with an LBW rate of 13.7% among women who did not. Women with adequate weight gain had an LBW rate of 6.7%, compared with 17.2% among women with inadequate weight gain. Women who resolved all of their risks had a low-birthweight rate of 7.0%, compared with a rate of 13.2% among women who resolved no risks. Women who had at least 10 Prenatal Plus visits were more likely to resolve their risks than were women who had fewer visits.

Conclusions. Multidisciplinary prenatal interventions targeted toward specific risks demonstrate success at significantly improving infant birthweight. (*Am J Public Health*. 2005;95:1952–1957. doi:10.2105/AJPH.2004.047068)

etiology or effective intervention for preterm delivery has not yet been identified.⁹ Low birthweight has also been associated with socioeconomic indicators such as education and income¹⁰ as well as with stress during pregnancy,¹¹ in addition, high-risk behaviors, such as smoking, may themselves be associated with psychosocial stress.¹²

Much research to date has focused on the effectiveness of early, consistent prenatal care in preventing low birthweight and preterm delivery; however, this research has not shown that standard prenatal care itself prevents low birthweight.¹³ To address the risk factors related to low birthweight that may be modifiable, many programs have been developed with the goal of reducing low-birthweight rates by providing psychosocial support services to high-risk women in the prenatal period. Evaluation results from these programs have found that low-birthweight rates for specific high-risk populations can be reduced with enhanced psychosocial prenatal care programs. Various programs have shown

reductions in low birthweight among HIV-infected women,¹⁴ medically high-risk women,¹⁵ low-income women,¹⁶ women pregnant with twins,¹⁷ and pregnant adolescents.¹⁸

Our study contributes to the literature on LBW by examining (1) prenatal interventions and their impact on specific risk factors associated with low birthweight, and (2) by examining the association of these risks with infant birthweight.

METHODS

The Prenatal Plus Program is a Medicaid-funded program that provides care coordination, mental health services, and nutrition services to high-risk pregnant women in Colorado. Local Prenatal Plus teams provided services to Medicaid-eligible women who were assessed at high risk of delivering low-birthweight infants. Multidisciplinary Prenatal Plus teams consist of a care coordinator, a registered dietitian, and a mental health professional. Prenatal Plus services complement

the medical component of prenatal care by addressing the lifestyle and behavioral characteristics that affect birth outcomes.

A full package of Prenatal Plus services consists of a minimum of 10 visits or contacts with a care coordinator, a registered dietitian, or a mental health professional throughout the course of pregnancy, beginning before 28 weeks of gestation. Two contacts must be home or off-site visits, and only one contact can be by telephone; most contacts are on-site visits that take place at the local health agency office. Prenatal Plus contacts are in addition to medical prenatal care visits, as the program is an adjunct to medical provider services and is billed separately. Prenatal Plus services are tailored to the unique risk factors and needs of high-risk pregnant woman through a client-centered model of care that addresses behavioral risk factors that may affect birth outcomes. On the basis of the client's risk factors, the care coordinator maintains frequent and consistent contact with Prenatal Plus clients, with psychosocial and nutritional contacts occurring as needed. Up to five dietitian (nutrition) and five mental health professional (psychosocial) contacts with clients may be counted toward the minimum of 10 contacts required.

The overall goal of Prenatal Plus is to improve the health of high-risk Medicaid-eligible pregnant women in Colorado to assure healthy birth outcomes. Specific program goals include reducing the incidence of low birthweight; improving the nutritional and psychosocial health status of high-risk Medicaid clients; assisting women in developing and maintaining healthy lifestyles during pregnancy and beyond, with particular attention to discouraging the use of tobacco, alcohol and other drugs; increasing appropriate use of medical and social services; and strengthening women's self-sufficiency so that they are better able to make appropriate use of existing resources.

Prenatal Plus services are provided through county health departments, community health centers, and other health care settings throughout the state. At each clinic site, a Prenatal Plus care coordinator (usually a registered nurse), a social worker, or other health care professional screens pregnant Medicaid-eligible women to determine whether they are eligible for Prenatal Plus services. A screening tool is used to determine Prenatal

Plus eligibility. The screening tool lists the risk factors for low birthweight that were shown in the literature to have an effect on birthweight. Medicaid-eligible women are also eligible for Prenatal Plus services if they have at least one of the LBW risk factors listed. LBW risk factors listed on the screening tool include a history of a previous low-birthweight infant; age at delivery of 17 years or younger; recent or current use of alcohol, tobacco, or other drugs; or prepregnancy Body Mass Index of 19.8 or less. In addition, women with at least three of the following risk factors are designated as high risk and thus are qualified for the program: delivery less than 12 months before the start of the current pregnancy; inadequate weight gain at any point during the current pregnancy; HIV-positive status; preexisting Type I or Type II diabetes; less than a high school education; homelessness; a history of domestic violence; high amount of life stress or a lack of support systems; a history of psychiatric diagnosis, including depression; a child currently in protective custody or termination of parental rights; not married; cognitive or developmental disability; or aged 18 or 19 years or >35 years of age at the time of delivery.

When Prenatal Plus eligibility was determined, participants were assessed for individual risks, grouped as appropriate into several specific risk categories, and assessed again at the end of their pregnancies to determine whether they were able to successfully resolve these risks during the course of program enrollment. The three categories of risk tracked during pregnancy and included in this analysis were smoking, psychosocial risk, and inability to gain the recommended amount of weight. Data collected on risk and change in risk status was done by the Prenatal Plus staff through assessment and client self-reported information. Successfully resolving risk is defined as quitting smoking; gaining the recommended amount of weight during pregnancy; or adequately addressing psychosocial problems such as homelessness, domestic violence, or depression. Assessment of adequacy of weight gain was done by weighing the participant during each trimester. Assessment of psychosocial risk was determined by the care coordinator, with consultation from the mental health professional

if needed. Assessment of smoking, alcohol, and illicit drug use was done by client self-report. Because of the close relationship that develops between the care coordinator and Prenatal Plus participant throughout the course of the pregnancy, the care coordinator was able to assess client self-reported information and decrease the possibility of prevarication.

We used data from women who participated in the Prenatal Plus Program, including both primiparas and multiparas, collected through the Integrated Registration and Information System (IRIS) computer system administered by the Colorado Department of Public Health and Environment. Data were gathered during 2002 on 3569 women who received Prenatal Plus services. A total of 2377 mothers remained in the program through delivery, delivering a total of 2403 live births (26 women had twins). Of the 2377 women who remained in the program through delivery, 40% (948) received a complete package of services. Of the 1192 women who left the program, 443 moved, 429 transferred care to other providers or withdrew for other reasons, and 104 could not be located after numerous attempts by providers. In addition, 87 women experienced miscarriages or fetal deaths; another 129 did not continue with Prenatal Plus services for reasons unknown.

We examined the major outcome of low birthweight and its relationship to three major risk factors: smoking, psychosocial problems, and weight gain. Low-birthweight rates were calculated for groups of clients on the basis of their success at resolving their risk factors, and these were compared using χ^2 tests.

RESULTS

The characteristics and risk factors of three groups of women are shown in Table 1: women who enrolled in Prenatal Plus but were unable to continue in the program and withdrew before delivery ($n=1192$), all Prenatal Plus participants who remained in the program through delivery ($n=2377$), and all women who delivered in Colorado in 2002. As this table shows, women in the Prenatal Plus population are more likely to be teenagers, to be unmarried, to have less

TABLE 1—Demographic Characteristics and Risk Factors of Mothers

	Prenatal Plus Withdrawals Before Delivery n (%)	Prenatal Plus Deliverers n (%)	All Births in Colorado, 2002	Prenatal Plus Withdrawals vs Prenatal Plus Deliverers P
Demographic characteristics				
Aged ≤ 19 y	346 (29)	727 (31)	11% ^a	NS
Not married	852 (75)	1740 (74)	25% ^a	NS
Education < 12 y	504 (56)	1281 (54)	22% ^a	NS
Race/ethnicity				
White non-Hispanic	519 (44)	1032 (43)	61% ^a	NS
Hispanic	546 (46)	1091 (46)	30% ^a	NS
Black	76 (6)	165 (7)	4% ^a	NS
Other/unknown	51 (5)	89 (4)	5% ^a	NS
Risk factors				
Smoking ^b	540 (45)	1025 (43)	20% ^c	NS
Inadequate prenatal weight gain ^d	539 (45)	1345 (57)	25% ^e	.001
Psychosocial problems ^f	789 (66)	1919 (81)	NA	.001
Inadequate weight gain and psychosocial problems ^g	431 (36)	1126 (47)	NA	.001
Smoking and inadequate weight gain ^g	261 (22)	567 (24)	NA	NS
Smoking and psychosocial problems	411 (34)	823 (35)	NA	NS
Smoking, inadequate weight gain, and psychosocial problems ^g	228 (19)	486 (20)	NA	NS
Total	1192 (100)	2377 (100)	68 420	

Note. NA = not available; NS = not significant at $P < .05$. Risk groups are not mutually exclusive. All women who were at risk for smoking were grouped under "Smoking." If they were also at risk for inadequate weight gain, they were grouped under the "Smoking and inadequate weight gain" group as well. Furthermore, if they were also at psychosocial risk they were included in the "Smoking, inadequate weight gain, and psychosocial" group.

^aBirth certificate data.

^bBased on self-report. Smoking risk was defined as the participant reporting smoking during pregnancy any time after conception, including before pregnancy confirmation.

^cDate from Pregnancy Risk Assessment Monitoring System (2002), 3 months before pregnancy.

^dInadequate prenatal weight gain was defined as weight gain during the current pregnancy that is below the appropriate weight gain grid line, any weight loss below pregravid weight, or weight loss ≥ 2 lb in the second or third trimester.

^eData from Pregnancy Risk Assessment Monitoring System (2002).

^fPsychosocial risk was defined as experiencing significant or severe stress as a result of personal/family safety needs, lack of support systems, or an inability to meet basic needs. Examples of psychosocial risk include, but are not limited to the following: domestic violence; sexual assault; child abuse/neglect; lack of food, clothing or shelter; lack of transportation; lack of family/biological father's support/involvement; or diagnosable mental illness.

^gThis combination of risks includes women who met the definition of all of the risk factors listed. Women may appear in more than one row of the table; categories are not mutually exclusive.

withdrew from Prenatal Plus may have been undocumented immigrants and thus were unable to continue with the program because of Medicaid ineligibility. This significant difference in initial risk factors suggests that the women who stay with the program through delivery may be at higher risk initially for a poor birth outcome.

The number and percentage of Prenatal Plus clients who successfully resolved one or more of the risks that they reported at intake is shown in Table 2; a complete definition of risk resolution is included in the table note. Among the women who were smokers when they started the Prenatal Plus Program in 2002, one half (51%) quit during pregnancy. Of the women who reported psychosocial or mental health problems, 55% resolved their risk during pregnancy. Among Prenatal Plus clients at nutritional risk—with inadequate weight gain at any point during pregnancy—62% resolved their risk and gained the recommended amount of weight.

Among women who had a combination of risks, many were able to resolve some or all of the risks assessed. Among women with psychosocial and weight gain risks, 37% were able to resolve both risks by the end of pregnancy. One third of those who reported both smoking and inadequate weight gain were able to resolve both risks, as were 30% of those who had psychosocial risks in addition to smoking. Of those with risks in all three areas—smoking, weight gain, and psychosocial risks—20% were able to resolve all of their risks before delivery.

The overall LBW rate among high-risk women who remained in the Prenatal Plus program through delivery was 9.7%. Table 3 shows the LBW rates for infants born to women with each risk factor, comparing rates for those who successfully resolved their risks with those for women who did not. For women who were smokers and were able to quit smoking during pregnancy, the low-birthweight rate was 8.5%. For women unable to quit smoking, the rate was 13.7%, a significant difference ($P < .01$). The low-birthweight rate for women at nutritional risk was 6.7% for those who gained weight adequately, compared with 17.2% for those women who did not gain enough weight during pregnancy. This difference in LBW was

education, and to have at least one risk factor for a poor pregnancy outcome than the overall population of women that delivers in Colorado. Also, a higher percentage of Prenatal Plus participants are Hispanic and Black than the overall population of women giving birth in Colorado.

When comparing Prenatal Plus participants who received services through delivery to those who were unable to continue in the program and withdrew before delivery, there

were no significant differences between the groups with regard to demographic characteristics and risk factors, with the exception of the percentage of women with inadequate weight gain and psychosocial problems. Prenatal Plus participants who dropped out of the program were less likely to have the initial risks of inadequate weight gain during pregnancy ($P < .001$) and psychosocial problems ($P < .001$) than women who were able to continue to delivery. Many women who

TABLE 2—Successful Resolution of Risk Factors Among Prenatal Plus Deliverers

	Total at Risk		Percentage Resolving Risk
	Prenatal Plus Deliverers, n ^a	Total Resolving Risk, n ^b	
Smoking ^c	980	503	51
Inadequate weight gain ^d	1287	799	62
Psychosocial problems ^e	1829	997	55
Inadequate weight gain and psychosocial problems	1056	387	37
Smoking and inadequate weight gain	533	173	33
Smoking and psychosocial problems	792	239	30
Smoking, inadequate weight gain, and psychosocial problems	455	92	20

^an = the total number of women at risk with known risk resolution. These numbers are slightly lower than the totals shown in Table 1 (Prenatal Plus Deliverers) by the number of women with unknown risk resolution.

^bn = the number of women at risk with known risk resolution who were able to successfully resolve the risk during pregnancy.

^cSmoking risk was defined as the participant reporting smoking during pregnancy any time after conception, including prior to pregnancy confirmation. Smoking risk was resolved if the client reported no smoking at the end of pregnancy. Smoking risk was not resolved if the client smoked any amount at the end of pregnancy.

^dInadequate prenatal weight gain risk was defined as weight gain during the current pregnancy that was below the appropriate weight gain grid line, any weight loss below pregravid weight, or weight loss ≥ 2 lb in the second or third trimester. Inadequate weight gain risk was resolved if the client gained within the recommended weight range according to prepregnancy BMI status and gained at or above the appropriate weight gain grid line on a prenatal weight gain grid. The risk was not resolved if the client's total weight gain was below the recommended total weight gain range, or if the client continued to gain at a rate below the appropriate weight gain grid line or had additional weight loss.

^ePsychosocial risk was defined as experiencing significant or severe stress as a result of personal/family safety needs, lack of support systems, or an inability to meet basic needs. Examples of psychosocial risk include, but are not limited to: domestic violence; sexual assault; child abuse/neglect; lack of food, clothing or shelter; lack of transportation; lack of family/biological father's support/involvement; or diagnosable mental illness. Psychosocial risk was resolved if the client had taken action (with the help of referrals from the Prenatal Plus staff) to address the problem and the problem has been resolved so that it was no longer causing severe stress or it no longer existed. Psychosocial risk was unresolved if the client had not taken action to address the problem or problems which were still causing severe stress.

significant ($P < .001$). Among women who resolved psychosocial risks, the LBW rate was 8.5%. Among women who were unable to resolve psychosocial risk, the LBW rate was 10.7%. However, this difference was not statistically significant.

Women experiencing both weight gain and psychosocial problems who were able to resolve both of these risks had a low-birthweight rate of 5.1%, whereas those who could not resolve both risks had a higher ($P < .001$) low-birthweight rate of 14.5%. Women who both were smokers and had inadequate weight gain experienced a low-birthweight rate of 9.0% if they resolved both risks and 20.8% if they did not ($P < .01$). For women who resolved smoking and psychosocial risks, the low-birthweight rate was 6.7% versus 18.5% among those who did not ($P < .001$). Women with all three risks (inadequate weight gain, psychosocial, and smoking) had a low-birthweight rate of 3.2% among those who resolved all risks and

18.5% among those who did not resolve all three risks ($P < .001$).

When all women who successfully resolved risks were grouped together, regardless of whether they had one, two, or three risks, we found a low-birthweight rate of 7.0%. This means that, among these women, who represented 42% of all the deliverers with known risk status at delivery, the risk of low birthweight was greatly reduced. By contrast, Prenatal Plus women who did not resolve any of their risks had a higher low-birthweight rate of 13.2% ($P < .001$), a significant difference.

As shown in Table 4, women who received Prenatal Plus services throughout their pregnancies and who received the full package of services (at least 10 visits), compared with women who received a partial package of services, were more likely to resolve all or some of their risk factors ($P < .001$). A total of 80% of women ($n = 679$) receiving the full package of services resolved some or all of their risks, com-

pared with 68% of women ($n = 789$) who did not receive the full package of services. Under the ideal circumstances of full package care, close to one half (47%) of women resolved all of their risks and more than one third (34%) resolved some of their risks. Only 20% resolved no risks.

DISCUSSION

The reduction of low-birthweight rates poses a challenge for public health programs, as standard prenatal interventions have not generally shown success at increasing birthweights among infants born to high-risk women. Our study shows the effectiveness of enhanced services for pregnant women when these services are targeted toward the resolution of specific risk factors that are known to be associated with low birthweight, such as smoking, inadequate weight gain, and psychosocial problems. Moreover, the greater success of women who received a full package of Prenatal Plus services in addressing their risk factors, and the increased likelihood of risk resolution, emphasizes the effectiveness of the program's interventions, particularly when women receive the recommended number of visits during pregnancy, to improve maternal health and birth outcomes.

Although encouraging, these findings present a challenge in themselves. Multidisciplinary support services are not universally available to pregnant women at risk, and not all enhanced prenatal care programs provide the intensive services of Prenatal Plus. As of 2000, 42 state Medicaid programs covered "case management" services for pregnant women, but only 37 covered home visiting services, 37 covered psychosocial counseling, and 34 provided nutrition counseling.¹⁹ Not all of these programs, however, share Prenatal Plus's focus on identifying and addressing specific risks. Simply conducting risk screening and providing referrals, as many case management programs do, may not be as effective as the services of a multidisciplinary team with expertise in nutrition and mental health and in addressing specific known risk factors. In addition, successfully resolving prenatal risks may be more difficult in an older population, for whom high-risk behaviors are

TABLE 3—Low Birthweight Rates Among Births to Prenatal Plus Deliverers

	Successful Resolvers of Risk		Nonresolvers of Risk		P
	n ^a	% LBW	n ^b	% LBW	
Smoking ^c	508	8.5	489	13.7	<.01
Inadequate weight gain ^d	809	6.7	495	17.2	<.001
Psychosocial problems ^e	1000	8.5	848	10.7	NS
Inadequate weight gain and psychosocial problems	389	5.1	248	14.5	<.001
Smoking and inadequate weight gain	177	9.0	125	20.8	<.01
Smoking and psychosocial problems	240	6.7	227	18.5	<.001
Smoking, inadequate weight gain, and psychosocial problems	93	3.2	81	18.5	<.001
Any ^f	848	7.0	545	13.2	<.001

Note. NS = not significant.

^an = the number of infants born to women with initial risks who successfully resolved those risks. The number is slightly higher than the n in the Total Resolving Risk column in Table 2 because a few women had twins.

^bn = the number of infants born to women with initial risks who did not reduce or eliminate those risks.

^cSmoking risk was defined as the participant reporting smoking during pregnancy at any time after conception, including prior to pregnancy confirmation. Smoking risk was considered resolved if the client reports no smoking at the end of pregnancy. Smoking risk was considered unresolved if the client smoked any amount at the end of pregnancy.

^dInadequate prenatal weight gain risk was defined as weight gain during the current pregnancy that was below the appropriate weight gain grid line, any weight loss below pregravid weight, or weight loss ≥ 2 pounds in the second or third trimester. Inadequate weight gain risk was resolved if the client gained within the recommended weight range according to prepregnancy Body Mass Index status and gained at or above the appropriate weight gain grid line on a prenatal weight gain grid. The risk was unresolved if the client's total weight gain was below the recommended total weight gain range, or if the client continued to gain at a rate below the appropriate weight gain grid line or had additional weight loss.

^ePsychosocial risk was defined as experiencing significant or severe stress as a result of personal/family safety needs, lack of support systems, or an inability to meet basic needs. Examples of psychosocial risk include, but are not limited to: domestic violence; sexual assault; child abuse/neglect; lack of food, clothing or shelter; lack of transportation; lack of family/biological father's support/involvement; or diagnosable mental illness. Psychosocial risk was resolved if the client had taken action (with the help of referrals from the Prenatal Plus staff) to address the problem and the problem had been resolved so that it was no longer causing severe stress or it no longer existed. Psychosocial risk was considered unresolved if the client had not taken action to address the problem or problems that were still causing severe stress.

^fInfants of mothers who either resolved or did not resolve any combination of risk factors. For example, if the infant's mother had all 3 risk factors, either all 3 were resolved or none were resolved.

TABLE 4—Risk Resolution by Level of Prenatal Plus Services Among Deliverers

	n ^a	Percentage	P
Full package of services:			<.001
Resolved all risks ^b	394	46.5%	
Resolved some risks ^c	285	33.7%	
Resolved no risks ^d	168	19.8%	
Total Full package clients	847	100.0%	
Partial package of services:			<.001
Resolved all risks ^b	451	38.7%	
Resolved some risks ^c	338	29.0%	
Resolved no risks ^d	377	32.3%	
Total Partial package clients	1166	100.0%	

^an = the number of deliverers with known risk resolution. The sum of the Full and Partial package clients differs from the total number of deliverers shown in Table 1 by the number of women whose risk resolution was unknown.

^bThe number and percentage of women who resolved any combination of risk factors. For example, if a woman had all 3 risk factors, all 3 were resolved.

^cThe number and percentage of women who resolved one or more risk factors, but did not resolve all of their risk factors. For example, if a woman had all 3 risk factors, 2 of the 3 were resolved by the end of the pregnancy.

^dThe number and percentage of women who resolved none of their risk factors by the end of pregnancy. For example, if a woman had all 3 risk factors, none of the 3 were resolved by the end of the pregnancy.

more entrenched; older smokers are less likely to be able to quit during pregnancy, for example.²⁰

Our study had several limitations. First, information on risk factors and their resolution is on the basis of self-reports and is therefore subject to underreporting of risks. In addition, attrition may influence the apparent effectiveness of the program; it is possible that those who dropped out of the program are those who are less likely to be able to resolve their risks successfully. However, as Table 1 shows, women who are seen through delivery are more likely to have the risks of inadequate weight gain and psychosocial problems; therefore, perhaps women who are not seen through delivery are lower-risk participants.

Nonetheless, our findings have significant implications for program planning and policymaking. Coverage for multidisciplinary support services through Medicaid and private-sector payers is critical for assuring access to these services. However, as these findings demonstrate, program design is equally important: interventions are more likely to influence birth outcomes if they are targeted to the resolution of specific risks. Although the effect of standard prenatal care on birth outcomes is still unclear, it is clear that concentrated efforts to address modifiable risk factors can succeed in improving the health of pregnant women and their infants. ■

About the Authors

Sue Ricketts is with the Colorado Department of Public Health and Environment, Prevention Services Division. At the time of the study, Erin K. Murray was with the Colorado Department of Public Health and Environment, Prevention Services Division. Renee Schwalberg is with the Maternal and Child Health Information Resource Center, Washington, DC.

Requests for reprints should be sent to Sue Ricketts, PSD-A4, Colorado Department of Public Health and Environment, 4300 Cherry Creek Drive South, Denver, CO 80246 (e-mail: sue.ricketts@state.co.us).

This article was accepted November 13, 2004.

Contributors

S. Ricketts designed the analyses and supervised the development of the article. E. K. Murray conducted the analyses and drafted the article. R. Schwalberg provided guidance in the design of the analyses and assistance in writing and editing the final results. All of the authors helped to conceptualize ideas, interpret findings, and review drafts of the article.

Acknowledgments

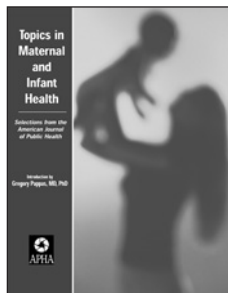
Renee Schwalberg's contributions to this article were supported by the Maternal and Child Health Bureau (Task Order No. 250-01-0003-0003[2]). The Colorado Prenatal Plus program is funded by the Medicaid program of the Colorado Department of Health Care Policy and Financing.

Human Participant Protection

No protocol approval was needed for this study.

References

- Hack M, Klein NK, Taylor HG. Long-term developmental outcomes of low birthweight infants. *Future Child*. 1995;5:176–196.
- Healthy People 2010: Understanding and Improving Health*. Washington, DC: US Department of Health and Human Services; 2000. Also available at: http://www.healthypeople.gov/Document/HTML/Volume2/16MICH.htm#_Toc494699665. Accessed August 17, 2005.
- Martin JA, Hamilton BE, Ventura SJ, et al. Births: final data for 2001. *Natl Vit Stat Rep*. 2002;51:1–102.
- Chomitz VR, Cheung LWY, Lieberman E. The role of lifestyle in preventing lowbirthweight. *Future Child*. 1995;5:121–138.
- Alexander GR, Korenbrot CC. The role of prenatal care in preventing lowbirthweight. *Future Child*. 1995;5:110–120.
- Wadhwa PD, Culhane JF, Rauh VA, et al. Stress, infection, and preterm birth: a biobehavioural perspective. *Paediatr Perinat Epidemiol*. 2001;15(suppl 2):17–29.
- Offenbacher S, Lief S, Boggess KA, et al. Maternal periodontitis and prematurity. *Ann Periodontol*. 2001;6:164–174.
- Covington D, Hage L, Hall T, Mathis M. Preterm delivery and the severity of violence during pregnancy. *J Reprod Med*. 2001;46:1031–1039.
- Goldenberg RL, Rouse DJ. Prevention of preterm birth. *N Eng J Med*. 1998;339:313–320.
- Parker JD, Schoendorf KC, Kiely JL. Associations between measures of socioeconomic status and low-birthweight, small for gestational age, and premature delivery in the United States. *Ann Epidemiol*. 1994;4:271–278.
- Sable MR, Wilkinson DS. Impact of perceived stress, major life events and pregnancy attitudes on lowbirthweight. *Fam Plann Perspect*. 2000;32:288–294.
- McCormick MC, Brooks-Gunn J, Shorter T, et al. Factors associated with smoking in low-income pregnant women in relationship to birthweight, stressful life events, social support, health behaviors and mental distress. *J Clin Epidemiol*. 1990;43:441–448.
- Lu MC, Tache V, Alexander GR, Kotelchuck M, Halfon N. Preventing lowbirthweight: is prenatal care the answer? *J Matern Fetal Neonatal Med*. 2003;13:362–380.
- Turner BJ, Newschaffer CJ, Cocroft J, et al. Improved birth outcomes among HIV-infected women with enhanced Medicaid prenatal care. *Am J Public Health*. 2000;90:85–91.
- Baldwin LM, Larson EH, Connell FA, et al. The effect of expanding Medicaid prenatal services on birth outcomes. *Am J Public Health*. 1998;88:1623–1629.
- Zimmer-Gembeck MJ, Helfand M. Low birthweight in a public prenatal care program: behavioral and psychosocial risk factors and psychosocial intervention. *Soc Sci Med*. 1996;43:187–197.
- Luke B, Brown MB, Misunias R, et al. Specialized prenatal care and maternal and infant outcomes in twin pregnancy. *Am J Obstet Gynecol*. 2003;189:934–938.
- Barnet B, Duggan AK, Devoe M. Reduced low birthweight for teenagers receiving prenatal care at a school-based health center: effect of access and comprehensive care. *J Adolesc Health*. 2003;33:349–358.
- Schwalberg R, Mathis SA, Giffin M, et al. *Medicaid Coverage of Perinatal Services: Results of a National Survey*. Washington, DC: The Henry J. Kaiser Family Foundation; 2001.
- Yu SM, Park CH, Schwalberg RH. Factors associated with smoking cessation among US pregnant women. *Matern Child Health J*. 2002;6:89–97.



ISBN 0-87553-026-5
2002 ■ 288 pages ■ softcover
\$19.95 APHA Members
\$26.95 Nonmembers
Plus shipping and handling

Topics in Maternal and Infant Health: Selections from the American Journal of Public Health

This volume demonstrates the great diversity in the types of problems being faced around the world and the kinds of solutions being evaluated in the area of maternal and infant health. An excellent resource for classroom use!

ORDER TODAY!

American Public Health Association

Publication Sales

Web: www.apha.org

E-mail: APHA@pbd.com

Tel: 888-320-APHA

FAX: 888-361-APHA



MCH05J6