Assessing the Role and Effectiveness of Prenatal Care: History, Challenges, and Directions for Future Research

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SYNOPSIS

Despite the widespread use of prenatal care, the evidence for its effectiveness remains equivocal and its primary purpose and effects continue to be a subject of debate. To provide some perspective on why the effectiveness and organization of prenatal care continue to be debated, the authors (*a*) briefly review the history of the development of prenatal care in the US; (*b*) attempt to conceptually define prenatal care in terms of its utilization, content, and quality; and, (*c*) highlight some of the research controversies and challenges facing investigators and advocates who seek to establish the value of prenatal care. In addition, the authors recommend directions for future research to address persistent questions regarding the function, structure, and significance of prenatal care in improving US perinatal outcomes.

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Prenatal care is one of the most widely used preventive health care services in the United States.[1] Nearly four million live births are delivered to women each year in the US, and the vast majority of these women receive some form of prenatal care.[1] Nevertheless, the evidence for the effectiveness of prenatal care remains equivocal, and health care and public health professionals are not in single accord regarding its primary purpose and effects.[2] The ongoing controversy over the intended role and benefits of prenatal care is surprising, given the extent to which its early and ongoing use has been touted as a health care service that is fundamental for improving pregnancy outcomes in the US.

To provide some perspective on why the effectiveness and organization of prenatal care continue to be debated, this article (*a*) briefly reviews the history of the development of prenatal care in the US; (*b*) attempts to conceptually define prenatal care in terms of its utilization, content, and quality; and (*c*) highlights some of the research controversies and challenges facing investigators and advocates who seek to establish the value of prenatal care. Last, we turn our attention to suggested directions for future research that we feel will be essential to resolving persistent questions regarding the function, structure, and significance of prenatal care in improving US perinatal outcomes over the next decade.

HISTORY

The idea of organized prenatal care has been attributed to proposals made by Ballantyne before the turn of the last century.[3–5] Ballantyne's initial interest in prenatal care was focused on the prevention of fetal abnormalities. He later recognized that prenatal care might also reduce maternal, fetal, and neonatal deaths.[6]

Maternal morbidity and mortality were among the earliest outcomes targeted in terms of benefits of prenatal care.[7–9] Concerns about eclampsia and complications of toxemia shaped the content of prenatal care from the start and played an important role in establishing the timing and frequency of visits. The observed association of eclampsia with albumin in the urine and high blood pressure led to tests of urine and serial blood pressure readings being incorporated into prenatal care protocols.

During the 1900s, support grew for the hypothesis that prenatal care could reduce the risk of low birthweight and preterm births and resulting mortality. In 1915, J. Whitridge Williams of The Johns Hopkins Hospital, in championing the potential benefits of prenatal care, asserted that "prenatal care and instruction offer great possibilities for the diminution in the number of deaths [due to prematurity]."[10] At mid-century, Eastman described a marked reduction in risk for low birthweight among mothers who received "adequate prenatal care," as defined by having three or more visits.[11] Subsequent studies also found a relationship between prenatal care and low birthweight, but nonsignificant and conflicting findings were reported as well.[12–14] In 1962, Shwartz suggested that the association between low birthweight and the trimester in which care began or the number of prenatal care visits may well be confounded by gestational age.[14] Compared to mothers who initiated care early, mothers who delayed initiation of care until the third trimester are likely to have a lower risk of very low birthweight births, as they are approaching full term before their care begins.

The observation that women who start prenatal care late have the lowest rate of very low birthweight births is evident in recent US data drawn from the National Center for Health Statistics' 1995 linked live birth–infant death cohort file (Table 1). Conversely, increased birthweight may be expected to coincide with more visits because the total number of scheduled visits increases with gestational age, as does birthweight. Noting a higher proportion of low birthweight deliveries to women with no prenatal care than to women receiving care, Terris and Glasser concluded in 1974 that "early birth prevents the initiation of prenatal care instead of vice versa."[15]

The next major development in prenatal care re-

Table 1. Trimester in which prenatal care began and very low birthweight births: 1995 single live births to US resident mothers

	Trimester prenatal care began			
Outcome	*First*	*Second*	*Third*	*No care*
Percent of very low birthweight (<1,500 g) births	0.94	1.02	0.32	6.14

SOURCE OF DATA: National Center for Health Statistics (US). 1995 birth cohort linked birth/infant death data set. NCHS CD-ROM Series 20, No.12a.

Table 2. Relationship between adequacy of prenatal care use as defined by the IOM/Kessner Index[16] and low birthweight births: 1995 single live births to US resident mothers

	Prenatal care use				
Outcome	*Adequate*	*Intermediate*	*Inadequate*	*No care*	*Missing data*
Percent of low birthweight (<2,500 g) births	5.06	7.24	8.81	21.06	9.05

SOURCE OF DATA: National Center for Health Statistics (US). 1995 birth cohort linked birth/infant death data set. NCHS CD-ROM Series 20, No.12a.

search came in the mid-1970s with an Institute of Medicine (IOM) report by Kessner et al.[16] This report proposed an index of adequate prenatal care utilization, which was among the first measures to demonstrate a systematic relationship between categories of adequate prenatal care utilization and low birthweight, using a large population database. When this index is used, the relationship between adequate use of care and low birthweight in the US is still evident using 1995 data, as indicated in Table 2, which shows that the percentage of low birthweight births decreases with increasing adequacy of prenatal care use.

The three-factor health services utilization index proposed by Kessner et al. takes into account the month of pregnancy in which prenatal care begins, the number of visits adjusted for the gestational age at delivery, and the site of care (private vs. public clinic).[16] While the site of care parameter was intended as a measure of quality of care, this variable was typically excluded by subsequent investigators employing this index due to either not having this information or not agreeing with its use as a measure of quality.

In 1980, Gortmaker reported the results of an investigation using a modification of the Kessner/IOM index, suggesting that the relationship between prenatal care and infant mortality was restricted to the impact of prenatal care on low birthweight.[17] Gortmaker's work, along with a 1985 IOM report on low birthweight,[18] shaped the direction of future prenatal care research and policy. The enrollment of all pregnant women into a system of prenatal care was promoted by the 1985 IOM report as a national policy to reduce the risk of low birthweight.[18] Soon thereafter, in the mid- and late 1980s, the US Congress enacted a series of legislative initiatives that incrementally expanded Medicaid eligibility to low income pregnant women and children independent of their welfare status. Reportedly, these policy actions were motivated in part by the expectation that increases in early initiation and adequate utilization of prenatal care would lower the risk of low birthweight and preterm birth and, as a result, lower infant mortality rates.[19,20]

The work of Kessner et al.[16] and Gortmaker[17] and the 1985 IOM report[18] established a research and policy paradigm in suggesting that the role of prenatal care in reducing infant mortality in a population was through improving the population's birthweight distribution and not through reducing birthweight-specific mortality. Based on this perspective, prenatal care became established as the key population-wide public health intervention for preventing low birthweight and preterm births, with the notion that by averting the occurrence of these adverse birth outcomes, infant morbidity and mortality and related neonatal intensive care costs would be reduced because fewer high-risk infants would be delivered. In turn, reducing infant mortality rates by improving the birthweight-specific survival rates of high-risk infants (i.e., reducing the risk of infant death associated with low birthweight, preterm, and other high risk deliveries) came to be viewed as the result of improvements in medical technology and clinical practice.[21–23] Consequently, even though the traditional core component of prenatal care remains the obstetric visit, prenatal care was viewed as a preventive public health intervention, due in part to its link to other public health ancillary services, such as WIC nutrition services and social support services.

The prevailing characterization of prenatal care as a public health intervention focused on reducing low birthweight and preterm births has far reaching policy implications. Nearly all of the decline in infant mortality rates in the US during the last several decades has been attributed to decreases in birthweight-specific mortality and not to improvements in the birthweight distribution.[23,24] These findings must be considered in evaluations of the success of national policy initiatives aimed at increasing access to and use of prenatal care, reducing the incidence of low birthweight, and, ultimately, reducing infant mortality in the US. Indeed, based on the paradigm of prenatal care as a preven-

Table 3. Annual trends in low birthweight, preterm delivery, inadequate use of prenatal care as defined by the R-GINDEX,[30] and infant mortality: 1981–1995 single live births to US resident mothers

Year	*Percent of low birthweight (<2,500 g) births*	*Percent of preterm deliveries (<37 weeks)*	*Percent with inadequate prenatal care use*	*Infant mortality rate*
1981	6.8	9.4	13.5	11.9
1982	6.8	9.5	13.6	11.5
1983	6.8	9.6	12.9	11.2
1984	6.7	9.4	12.7	10.8
1985	6.8	10.0	12.4	10.6
1986	6.8	10.2	12.1	10.4
1987	6.9	10.2	11.8	10.1
1988	6.9	10.6	11.9	10.0
1989	7.0	10.6	12.5	9.8
1990	7.0	10.8	12.1	9.2
1991	7.1	10.7	11.6	8.9
1992	7.1	11.0	10.9	8.5
1993	7.2	11.0	10.0	8.5
1994	7.3	11.0	9.4	8.0
1995	7.3	11.0	9.0	7.6

SOURCE OF DATA: National Center for Health Statistics (US). 1981–1995 natality data sets. Additional analysis by Michael Kogan, PhD, NCHS

tive public health intervention, it could be argued that in the US the decrease in infant mortality rates that has occurred in spite of rises in the rates of low birthweight and preterm births reflects the failure of public health approaches and, conversely, the success of high tech medical advances. Not surprisingly, while prenatal care continues to be widely touted as an effective approach to reducing rates of low birthweight births and preterm delivery, growing concerns have been raised regarding the validity of the evidence used to support these claims.[2,25–29] As evident in Table 3, which shows US natality and infant mortality data for the years 1981 through 1995, rates of inadequate use of prenatal care have decreased while rates of low birthweight and preterm births have risen, although infant mortality rates have declined.

While nonrandomized trials of prenatal care interventions have yielded promising findings to support claims of the benefits of prenatal care, randomized clinical trials of interventions to prevent preterm birth have generated equivocal results.[2,28] Several reviews of the literature on prevention of preterm births, including our own, have concluded that our current prenatal care approaches are not particularly effective and cannot be given wholehearted endorsement.[2,25–29] Addressing fetal growth restriction of term infants through nutrition and antismoking interventions may well have been the mechanism by which past interventions achieved a reduction in low birthweight rates. In essence, these reviews suggest that without a better understanding of the multiple etiologies of low birthweight, which include the various pathways that lead to preterm birth, it is not surprising that prenatal care, as currently constituted, is having little impact on low birthweight rates.[28,29] Only when more effective prenatal interventions are developed to address specific underlying mechanisms that lead to preterm birth—e.g., establishing the effectiveness of targeting antibiotics to women who have bacterial vaginosis or a spontaneous preterm birth—will prenatal care, as a vehicle for the delivery of these interventions, be likely to facilitate a marked reduction in the incidence of low birthweight or preterm delivery.

RESEARCH CHALLENGES

A fundamental problem facing researchers is that prenatal care, like many other medical practices and interventions, became an established standard of practice without randomized clinical trials having been conducted to demonstrate the efficacy of its many components. Since randomizing women into no-care or inadequate-care groups would now be considered unethical, researchers struggle with how to control for selection bias on the part of women who choose to utilize prenatal care adequately.[2] Health-conscious women may be more likely than other women to initiate prenatal care early, maintain a regular schedule

of visits, and demonstrate other health care-seeking and health-promoting behaviors, including planning their pregnancies, obtaining inter-conception care, maintaining a proper diet, and abstaining from the use of tobacco, alcohol, and illicit substances. Women may influence the content of their care through their selection of prenatal care providers and through their requests for and adherence to provider advice on positive pregnancy-related behaviors. Because the advantageous health care-seeking and health-promoting behaviors of these women may contribute to reducing their risk of low birthweight deliveries, their adequacy of prenatal care use and even the content and quality of the care they receive could be conceptualized as a proxy indicator of myriad health-enhancing maternal attitudes and behaviors in addition to being a measure of the prenatal care received.

Adding to the difficulty of interpreting the available research on the impact of prenatal care utilization are the now apparent flaws in the measures of prenatal care utilization used initially to establish a link between prenatal care participation and low birthweight.[30] Current concerns about the Kessner/IOM index[30,31] include its failure to accurately reflect American College of Obstetrics and Gynecology (ACOG) recommendations regarding the number of visits for "adequate" care,[32] resulting in a pronounced gestational age bias.

In an earlier publication,[30] we described a prenatal care utilization index based on the full ACOG recommendations and compared that index with the Kessner/IOM index and other indices discussed below.[30] When the Kessner/IOM index is changed to accurately reflect the ACOG criteria, the incremental relationship between less adequate use of care and low birthweight, which is traditionally observed when using the IOM/Kessner index, is no longer evident in US data (see Table 4). Also apparent in Table 4 is the lack of a clear relationship between very low birthweight and adequacy of prenatal care use as measured by either the Kessner/IOM index or the ACOG-based revision of the Kessner/IOM index. This is why we recommended abandoning use of the Kessner/IOM index—because it gives a biased, exaggerated view of any positive relationship between prenatal care use and low birthweight or preterm birth.[30]

In an effort to correct some of the perceived deficiencies with the Kessner/IOM index, two separate indices of prenatal care utilization have been proposed: the R-GINDEX and the APNCU.[30,31,33] While these indices more faithfully conform to ACOG visit recommendations than the Kessner/IOM index,[31] the two provide conflicting results regarding both the adequacy of prenatal care use and the impact of prenatal care use on selected birth outcomes (Table 5). The differences evident in Table 5 between the R-GINDEX and the APNCU reflect the distinct strategies used by each index to define adequate and intensive utilization of prenatal care, to define adequate use of care by the month care began, and to control for gestational age.[30] A discussion of the limitations of each of these indices, with recommendations for their appropriate use in specific situations, can be found in an earlier article by the present authors.[30] Much more work is needed to refine the definition of adequate utilization of prenatal care and to establish its precise relationship with birth outcomes.[30]

Concerns about the validity of the research that

Table 4. Comparison of the IOM/Kessner index[16] and the ACOG-based index:[30] 1995 single live births to US resident mothers

	Prenatal care use				
Outcome	*Adequate*	*Intermediate*	*Inadequate*	*No care*	*Missing data*
Distribution					
ACOG-based index	43.00	41.13	8.53	1.20	6.14
Kessner/IOM index	69.62	18.73	4.31	1.20	6.14
Percent of low birthweight (<2,500 g) births					
ACOG-based index	7.16	4.01	6.19	21.06	9.05
Kessner/IOM index	5.06	7.24	8.81	21.06	9.05
Percent of very low birthweight (<1,500 g) births					
ACOG-based index	1.42	0.52	0.51	6.14	2.48
Kessner/IOM index	0.88	1.13	0.90	6.14	2.48

SOURCE OF DATA: National Center for Health Statistics (US). 1995 birth cohort linked birth/infant death data set. NCHS CD-ROM Series 20, No.12a.

Table 5. Comparison of R-GINDEX and APNCU:[30] 1995 single live births to US resident mothers

	Prenatal care use					
Selected Outcomes	*Intensive*	*Adequate*	*Intermediate*	*Inadequate*	*No care*	*Missing data*
Distribution						
R-GINDEX	5.91	37.83	40.47	8.46	1.20	6.14
APNCU	26.08	42.20	13.68	10.70	1.20	6.14
Percent small for gestational age						
R-GINDEX	9.73	8.22	9.51	13.49	18.59	12.25
APNCU	9.09	8.35	10.43	12.65	18.59	12.25
Infant mortality rate of infants born 34–35 weeks of gestational age						
R-GINDEX	14.39	14.08	14.57	18.35	22.25	23.55
APNCU	13.59	17.61	19.36	14.74	22.25	23.55

SOURCE OF DATA: National Center for Health Statistics (US). 1995 birth cohort linked birth/infant death data set. NCHS CD-ROM Series 20, No.12a.

linked the adequate utilization of prenatal care to low birthweight grew during the 1990s and presented a challenge to policy makers, advocates, and public health professionals who had touted prenatal care as the solution to the steadily increasing rates of low birthweight deliveries in the US. In an effort to deflect some of the controversy about the benefits of prenatal care on low birthweight, the role of adequate utilization of prenatal care has more recently been downplayed and greater credence has been given to the importance of the content, comprehensiveness, and quality of prenatal care.[34] The controversy over the effectiveness of the adequate use of prenatal care in preventing low birthweight has broadened to embrace the difficulties in defining, operationally and conceptually, what constitutes not only adequate use of prenatal care but also adequate content and quality. This task is made even more difficult as the purpose and content of prenatal care have changed over time and continue to do so. Reflecting dramatic developments in clinical care technology, prenatal care has evolved to encompass the detection, treatment, or prevention of adverse maternal, fetal, and infant outcomes as well as interventions to address psychosocial stress, detrimental health behaviors such as substance abuse, and adverse socioeconomic conditions.

Unfortunately, as noted above, the efficacy of many of the traditional aspects of the content of prenatal care has never been established with any scientific rigor. Furthermore, periodic assessments of the scientific evidence for prenatal care practice standards have not been accompanied by progressive changes in prenatal care content and practice, even though it has been suggested that clinical practice guidelines should be reassessed for validity every three years.[35] Reviews need to be undertaken on an ongoing basis as more refined definitions of what constitutes the content and use of "adequate" prenatal care emerge.

While still evolving, prenatal care, broadly conceptualized, can be assessed in terms of:

- the timing of initiation of care, i.e., month or trimester care begins;
- adherence to a prescribed visit schedule, e.g., number and spacing of visits;
- the content of medical care, including assessment of risk status; medical tests to screen for and diagnosis disease conditions; medical procedures for the treatment of diseases; assessment of the need for and referral to ancillary services; provision of health education; and so on;
- the type, training, and organization of provider(s) of care;
- the setting of care, e.g., private vs. public; medical clinic or provider office vs. home visit;
- the content of ancillary services, including educational, nutritional, and psychosocial services; case management; tobacco, alcohol, and substance abuse counseling; social support intervention services; outreach and follow-up services; and so on;
- the quality, availability, accessibility, organization, and functioning of the prenatal care provider system, including patient/provider/system interactions.

DIRECTIONS FOR FUTURE RESEARCH

In 1962, Samuel Shwartz noted that "the role of prenatal care in the incidence of prematurity and perinatal mortality is neither well defined nor well established."[14] Unfortunately, this observation continues to apply today. What many policy makers, health care professionals, and members of the public know about the benefits of prenatal care is still too often based on personal opinion, advocacy position statements, and a multitude of research studies with overly optimistic findings that are, in fact, nebulous if not misleading due to weak study designs and flawed and biased measures of adequate care. There continues to be a pressing need for systematic research into the relative effectiveness of each of the many, diverse components of prenatal care, using outcomes that can plausibly be modified by the provided services. If we are to better understand the benefits of the use of prenatal care, future research must at the least attend to better defining "adequate prenatal care" and its role, delineating its individual intervention components, and specifying the modifiable adverse outcomes that each component is to ameliorate.

EXPLORING THE BENEFITS OF PRENATAL CARE

While much of the research attention in recent years has focused on the relationship between prenatal care use and low birthweight, there are several other perinatal outcomes that may be modified by prenatal care and are in need of thorough investigation. First, attention should return to its earlier focus on mortality, including maternal, fetal, perinatal, and infant death. Prevention of maternal mortality and morbidity should remain a primary consideration. While maternal death is a rare occurrence in the US, the importance of prenatal care's role in preventing maternal death should not be forgotten during periods when modifications to the content of prenatal care are being suggested in order to focus attention on other outcomes. Further, an understanding of the role of prenatal care in preventing maternal complications has been hindered by the limited available measures of maternal morbidity.

The impact of prenatal care on fetal mortality has been given scant attention in comparison to its role in improving the outcomes of live births. However, developments in obstetric and neonatal care have allowed for the earlier detection of a fetus that is failing to thrive and, in some cases, have lead to the earlier therapeutic interruption of pregnancy in order to reduce the risk of fetal death, particularly in twins.[23,36,37] Gestational age-specific investigations of perinatal mortality (fetal and neonatal deaths) will be needed to explore whether these developments have resulted in decreases in fetal death rates.

The assumption that prenatal care mainly influences infant mortality by improving the birthweight distribution, e.g., reducing rates of low birthweight and preterm birth, needs to be reexamined. Prenatal care may well play an important role in assuring transfer to and delivery in a facility providing a risk-appropriate level of delivery care (e.g., a Level III regional perinatal center), which would directly affect infant mortality rates by reducing birthweight-specific mortality. Moreover, better monitoring of the fetus, leading to a timely intervention for a postterm fetus or a preterm, failure-to-thrive fetus, may improve infant survival rates while reducing the rates of postmaturity syndrome, fetal growth restriction, and other related infant morbidities, e.g., meconium aspiration and respiratory distress. Prenatal care may reduce the risk of fetal growth restriction in term births, i.e., term small-for-gestational age births, and thereby alter rates of moderately low birthweight births.[38] Smoking cessation and nutrition counseling and support, leading to more adequate weight gain, have been proposed as a possible pathway for this impact.[2,38] However, more information is needed on the effectiveness of the specific components of prenatal care and of the prenatal care system that may lead to reductions in infant morbidity and mortality.

The benefits of prenatal care may not be equivalent for all population subgroups. Many researchers have observed that the use and impact of prenatal care varies across socioeconomic, demographic, cultural, and medical risk groups, suggesting that these characteristics, including pre-existing health status, age, education, poverty, and environmental conditions, may modify the effects of prenatal care.[39–41] There is still little definitive information on the extent to which individual components or combination of components of "standard" or comprehensive prenatal care may be effective in reducing or preventing adverse pregnancy outcomes for different groups of women with specific medical conditions and socioeconomic situations. Even the roles of the content and use of prenatal care in improving birth, infant, and maternal outcomes for women with diabetes, hypertension, and other medical conditions have yet to be fully explored. For example, to what extent does adequate use of prenatal care reduce the risk of macrosomia in diabetic pregnancies or the risk of fetal growth restriction in hypertensive mothers? For these conditions, too little is

known about whether the impact of prenatal care varies among women based on age, socioeconomic status, or ethnicity. Moreover, it remains unclear to what extent augmenting prenatal care with targeted ancillary services will more fully benefit subgroups of women who are under- or overweight or who smoke, abuse alcohol, or use illicit substances. Finally, the cost-effectiveness of particular prenatal care interventions for women with specific conditions and risk factors needs to be explored. Until the actual cost-effectiveness of prenatal care ancillary services and core components is solidly established, it is doubtful that managed care organizations will fully incorporate these services into their standard service packages, even for higher risk Medicaid populations.[38]

Prenatal care may have an impact on other health outcomes than those typically investigated. In particular, prenatal care experiences may have a positive influence on the postnatal health status of both the mother and infant and on postnatal health related behaviors and health care use. Through educational messages and related support services, prenatal care may help lower infant injury rates and other potentially preventable causes of infant morbidity and mortality, e.g., SIDS. For example, lower incidences of infant injury and disease may result from the prenatal provision of education that addresses home and vehicle safety, cleanliness, stress management, and infant care and feeding. Finally, more research is needed on the extent to which prenatal care may influence postpartum depression and, in the case of a perinatal death, the process of bereavement.

The relationship between prenatal care and the adoption of healthy behaviors has received relatively scant investigation. Our knowledge is incomplete about the degree to which the content and delivery of prenatal care are associated with other preconception and prenatal behaviors, including pregnancy planning, contraceptive use prior to pregnancy, preconception use of medical care, nutrition and exercise habits, and smoking and other substance use. Similarly, more needs to be known about the relationship of prenatal care with postpartum behaviors, e.g., choice of infant feeding method, appropriate use of car seats, and family planning.

A paucity of research also exists about the relationship between prenatal care and the utilization of other preventive and curative health services. A few studies have explored the association between prenatal care and pediatric health care use, including use of well-baby care and timely vaccinations.[42,43] Far less is known about how prenatal care might improve the use of needed maternal dental and mental health services and future use of inter-conception and prenatal care. For many primipara women, prenatal care may be their first adult contact with the medical system. The nature of that experience may well influence their future use of preventive services, as well as influence the use of those services by their children and partners.

MEASUREMENT OF PRENATAL CARE USE, CONTENT, AND QUALITY

Adequacy of prenatal care utilization indices have been in use for nearly three decades. Nevertheless, much needs to be done to improve their measurement validity. The current measures all establish "adequacy" by relying on ACOG recommendations for low risk mothers.[30] What is adequate for women with specific high risk conditions has not been operationalized, although for women of differing parity a separate set of recommendations has been suggested by the Expert Panel on Prenatal Care.[44] The impact of these recommended visit schedules for different risk groups needs to be explored. Given that many European countries have very different visit and content recommendations and have enviable birth outcomes in comparison to the US it remains unclear if the ACOG standard is the best choice to define patterns of use.[45,46] Moreover, little research has looked at what is the "normal" number of prenatal care visits that women receive in the US, compared to the recommended number of visits, and whether this "normal" utilization pattern is related to more positive pregnancy outcomes than the recommended number. Finally, none of the current indices has completely overcome the problem of controlling for gestational age bias. Until this is accomplished, the relationship between these indices and pregnancy outcomes that are highly influenced by gestational age, e.g., birthweight and infant mortality, will remain in question. As part of this problem is due to inaccuracy in the measurement of gestational age, part of the solution lies in improving the valid ascertainment of the initiation and duration of pregnancy. In the meantime, the use of different analytical approaches to examine the relationship of prenatal care use and birth outcomes, e.g., gestational age-specific, life table, survival, and two stage least squares analyses, may help us better understand and control for the influence of gestational age bias.

The few studies that have focused on the content of prenatal care have mainly examined the receipt of specific medical procedures and health education messages.[47–50] The medical procedures addressed in these studies include blood pressure measurement,

urine test, blood analysis, weight measurement, pelvic exam, and obtaining a health history. The health education and behavior advice messages cover vitamin use, proper diet, breastfeeding, avoidance of tobacco, alcohol, and drugs, and proper weight gain. Kogan et al. found no association between the receipt of all medical procedures within the first two visits and low birthweight, but did uncover a weak association between low birthweight and receiving all health behavior messages.[48] However, the relatively rudimentary approach to classifying satisfactory receipt of recommended content of care (i.e., the receipt of all vs. not all of the recommended procedures or education messages) is just a first step. Much needs to be done to disentangle which specific content of care components may be beneficial for targeted outcomes. Moreover, we should press forward to establish which current prenatal care practices are evidence-based and whether some features of prenatal care content are ineffective, overly risky, or excessively costly for their overall benefit. Further work in this area will initially need to concentrate on the development of better indices of the content of prenatal care and on identifying or developing ongoing population-based data sources to support research efforts.

Comprehensive approaches to prenatal care have been increasingly touted, particularly for low income populations. Comprehensive prenatal care typically refers to routine prenatal care visits combined with ancillary services. Comprehensive prenatal care services (which may also be referred to as coordinated, augmented, enhanced, enabling, enriched, or "wraparound" services) may entail outreach efforts to improve enrollment in prenatal care, WIC, case management, social work, psychosocial counseling, social support, health promotion/education, transportation, home visiting, and follow-up services to facilitate the ongoing use of the prenatal services offered. Evaluations of the impact of comprehensive prenatal care programs have shown mixed results, in part stemming from methodologic limitations.[2,51] Further research is needed to help us target costly interventions to those populations for which the specific components will be most beneficial, and randomized controlled trials should be conducted to assess the efficacy of the individual components of comprehensive prenatal care packages. As Medicaid managed care plans increasingly become the primary source of prenatal care for low income pregnant women and displace many traditional public providers of prenatal care services to Medicaid-eligible women, it is unclear to what extent these plans will offer packages of ancillary prenatal care services to Medicaid populations in the absence of detailed and credible evidence of efficacy and cost-effectiveness.[38] Without better information on the impact of providing ancillary prenatal services on improving pregnancy outcomes, it is unlikely that substantial sums will be invested in developing and providing more comprehensive forms of prenatal care in a climate of controlling health care expenditures.

While much attention has been placed on the development of indices of the mother's utilization of prenatal care, less effort has been directed toward assessing the prenatal care provider and the provider system. Numerous provider and system characteristics influence the receipt of care. These attributes include availability; accessibility (e.g., hours of operation, location, availability of parking); affordability; the types, quality, and mix of providers; the organization of setting and services; continuity of care (e.g., linkages between providers, provision of follow-up care); comprehensiveness and scope of care; satisfaction with provider/setting; the cultural competency of providers and system; and the overall quality and functioning of the prenatal care system. While some of these attributes have been cited in the context of barriers to care,[52–55] further research is needed into how variations and changes in these system characteristics may influence both the use and impact of prenatal care. Moreover, little attention has been given to assessing the potential for prenatal care system failures.

SUMMARY

From its origins a little more than 100 years ago, prenatal care is now one of the most frequently used preventive health care services in the US, and its use is increasing over time.[1] There is good reason to believe that prenatal care has played and can continue to play an important role in maintaining relatively low rates of maternal mortality, and there is much observational evidence that prenatal care provides numerous other maternal and infant health benefits. Nevertheless, the rigorous scientific evidence of its effects on health outcomes, health-related behaviors, health care utilization, and health care costs is meager and insufficient. As public health professionals at the local, state, and federal levels struggle to improve pregnancy outcomes and reverse the increasing trend in the rate of premature births, there is a critical need for information regarding the efficacy and cost-effectiveness of prenatal care programs and their specific components.

The following suggestions for further research are made to the research community, both funders and researchers:

1. Expand research on the impact of prenatal care on pre- and postnatal health status measures other than birthweight, e.g., maternal, perinatal, and child morbidity and mortality, maternal health behaviors such as substance abuse, and health care utilization.
2. Expand research on the adequacy of prenatal care utilization; improve the current definition and measurement of adequate use; define adequate use for high risk women; and improve the valid measurement of gestational age.
3. Expand research on the measurement of the content of prenatal care and on comprehensive prenatal care packages and use randomized controlled trials to assess their efficacy.
4. Expand research on the measurement and impact of quality of prenatal care.
5. Expand research on the measurement and impact of prenatal care provider characteristics.
6. Expand research on improving maternal risk assessments to better target ancillary services.
7. Expand research on the cost-effectiveness of all prenatal care components.
8. Explore the varying impact of prenatal care on diverse populations as defined by medical, demographic, cultural, and socioeconomic characteristics.
9. Periodically assess clinical prenatal care practice standards and guidelines in order to assure that practice is based on current rigorous scientific evidence and to establish needed new directions for future prenatal care-related research.

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