

Original Article

Relationship between prenatal care and maternal complications in women with preeclampsia: Implications for continuity and discontinuity of prenatal care

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Abstract

Objective: Prenatal care is associated with better pregnancy outcome and may be a patient safety issue. However, no studies have investigated the types and quality of prenatal care provided in northern Taiwan. This retrospective study assessed whether the hospital-based continuous prenatal care model at tertiary hospitals reduced the risk of perinatal morbidity and maternal complications in pre-eclampsia patients.

Materials and Methods: Of 385 pre-eclampsia patients recruited from among 23,665 deliveries, 198 were classified as patients with little or no prenatal care who received traditional, individualized, and physician-based discontinuous prenatal care (community-based model), and 187 were classified as control patients who received tertiary hospital-based continuous prenatal care.

Results: The effects on perinatal outcome were significantly different between the two groups. The cases in the hospital-based care group were less likely to be associated with preterm delivery, low birth weight, very low birth weight, and intrauterine growth restriction. After adjustment of confounding factors, the factors associated with pregnant women who received little or no prenatal care by individualized physician groups were diastolic blood pressure ≥ 105 mmHg, serum aspartate transaminase level ≥ 150 IU/L, and low-birth-weight deliveries. This study also demonstrated the dose–response effect of inadequate, intermediate, adequate, and intensive prenatal care status on fetal birth weight and gestational periods (weeks to delivery).

Conclusion: The types of prenatal care may be associated with different pregnancy outcomes and neonatal morbidity. Factors associated with inadequate prenatal care may be predictors of pregnancy outcome in pregnant women with pre-eclampsia.

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Keywords: discontinuity of physician-based prenatal care; integrated prenatal care; pre-eclampsia; prenatal care; quality of obstetric care

Introduction

Adequate prenatal care has been associated with low risk of preterm delivery and low birth weight [1]. Inappropriate prenatal care may lead to a poor pregnancy outcome and low birth weight. Adequacy of prenatal care reflects not only the timing of initiation and number of visits but also the quality and types of care [2,3]. We have used the Kessner Index of

Adequacy of Prenatal Care, which ranks prenatal care as adequate, intermediate, or inadequate [4]. In fact, content of prenatal care might be a more important predictor of perinatal outcome than number of visits. Several studies have indicated that patient knowledge, health education, and behavioral modification may enhance the effect of prenatal care [5–7]. However, the number of prenatal visits is not a reliable indicator for the quality of prenatal care, and fewer routine visits of low-risk women do not necessarily put a pregnancy at increased risk [8]. Maternity services in Taiwan are provided by hospital-based and community-based independent physician models, which demonstrate fragmented methods and discontinuity of care. Discontinuity of community-based care

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means that the patient receives partial, uncoordinated, or discontinuous prenatal care at clinics and hospitals.

In terms of heterogeneous types of obstetric care, pregnant women consult different prenatal care providers, such as midwives, obstetricians, and general practitioners, throughout the duration of pregnancy at independent physician-based clinics. Pregnant women may receive partial and heterogeneous types of prenatal care at local medical clinics and may subsequently be transferred to a medical center to continue their prenatal care or delivery [9]. Herein, heterogeneous is defined as diverse types of prenatal care providers. The content of prenatal care provided in hospital-based care and a multidisciplinary consultation in terms of a homogeneous type of practice model may play a major role in the effectiveness and continuity of prenatal care. The term homogeneous indicates that an organization has a uniform structure, discipline, and training and educational processes in a competence-based program. In addition, few studies have reported the type of prenatal care provided during high-risk pregnancy, such as hypertensive disorder, or shown any effect of the absence of adequate prenatal care on Asian women with avoidable and preventable maternal complications. In our daily practice, we encounter many pregnant women with hypertensive disorders who have been referred to our hospital without adequate prenatal care prior to admission. Based on different patterns of medical practice, the hierarchical framework of the health care delivery system, patients' preferences and geographical access to prenatal care, there may be large differences in the outcomes of pregnancies. Differences in obstetric service models and physicians' practice styles between local medical clinics and tertiary hospitals are difficult to determine. The primary hypothesis is that the quality assessment and obstetric care of a patient who receives partial, heterogeneous prenatal care at an independent physician's group would not be inferior to complete, homogeneous, and tertiary hospital-based prenatal care. The purposes of this study were: (1) to examine the impact of tertiary hospital-based continuity of care versus individualized, community-based discontinuity of prenatal care at local medical clinics in our study cohort under the current national health policy, as accessed by birth weight; and (2) to evaluate the associated factors for maternal complications in pre-eclampsia patients. Continuity of care was defined and referred to care that is not fragmented, and is overseen by a responsible attending physician (usually an obstetrician) and his/her team and presence of good communication within the system and consistent policies [10].

Materials and methods

Patients

During the past decade from January 1, 1999 to December 31, 2003, there were 23,665 pregnant women who delivered at the Chang Gung Memorial Hospital, Linkou, Taiwan. Of these nonselected, consecutive patients, 187 women with pre-eclampsia who received only homogeneous types of prenatal care and delivered at our center were recruited to our study.

We also enrolled a matched cohort that consisted of 198 women with pre-eclampsia who lacked adequate prenatal care or only received traditional, physician-based heterogeneous types of prenatal care at local medical clinics [11]. Some members of the latter cohort had received prior prenatal care at another facility before transferring to our practice for the remainder of their care and subsequent delivery [12]. Patients who received almost all prenatal care at local medical clinics and then presented as walk-in patients for delivery at our clinic were also stratified into this latter cohort as an obstetric prenatal care group with discontinuous, fragmented, and heterogeneous care. This study was approved by the Institute Review Board of Chang Gung Memorial Hospital (97-0207B).

Study design and clinical practice

Prenatal care is defined as prenatal clinic registration, initial laboratory testing, and examination by a physician. These criteria also apply to women who delivered at our facility after receiving prenatal care elsewhere. Pregnant women who received prenatal care less than twice at this hospital, whether they were recruited from the emergency department or were just walk-in patients at the birth center were classified into the little or no prenatal care group [1,12]. We defined little or no prenatal care as fewer than two visits at our hospital as the intervention group of the community-based model [12]. Women who started their prenatal visits, carried their babies to term, and then delivered at our hospital were classified as the standard of adequate prenatal care. This study only recruited patients who delivered at our hospital or who were referred to this hospital during their pregnancy for any reasons, therefore, this study may not have been able to investigate whether patients received prenatal care entirely at local medical clinics. Pre-eclampsia is defined as hypertension [systolic blood pressure ≥ 140 mmHg or diastolic blood pressure (Korotkoff V) ≥ 90 mmHg, or both, on at least two occasions ≥ 4 hours apart] arising after 20 weeks gestation and one or more of the following symptoms: proteinuria ≥ 300 mg/24 h or $\geq 1+$ dipstick (minimum criteria), renal insufficiency, liver disease, neurological problems, hematological disturbances, or fetal growth restriction [13]. Increased certainty of pre-eclampsia is characterized by the following conditions: blood pressure $\geq 160/110$ mmHg, proteinuria ≥ 2.0 g/24 h or $\geq 2+$ dipstick, serum creatinine > 1.2 mg/dL, platelet count $< 100,000/\text{mm}^3$, microangiopathic hemolysis (increased lactate dehydrogenase), elevated aspartate transaminase (AST) or alanine transaminase (ALT), persistent headache or other cerebral or visual disturbance, and persistent epigastric pain [14]. In brief, mild and severe pre-eclampsia was defined as different level of blood pressure: $\geq 140/90$ mmHg versus $\geq 160/110$ mmHg. HELLP syndrome was defined by the presence of: hemolysis, elevated liver enzymes, and low platelets. Seizures not attributed to other causes in a gravida with pre-eclampsia were defined as eclampsia.

Patient assessment

The Taiwan National Health Insurance Program (NHIP) has recommended that pregnant women should have at least 10

visits during their pregnancy, including the initial physical examination and blood tests initiated at 9 weeks of gestation; Down's screening test at 15 weeks of gestation; ultrasound examination at 20–23 weeks; and amniocentesis to be performed if categorized as high-risk in the Down's screening test. However, in actual daily practice the prenatal visits often number more than 12 in the high-risk pregnancy patients. Pregnant women referred from other clinics may subsequently receive the same comprehensive, coordinated, continuous, and hospital-based prenatal examination in order to assess risk factors related to the delivery of a low-birth-weight infant, and then receive regular monitoring until the end of delivery. Chart records were reviewed critically in terms of maternal age, parity, referral status, history of abortion, number of prenatal visits, route of delivery, and pregnancy complications. Women with hypertensive disorders were recruited, and the severity of the disorder, gestational age, clinical management, and pregnancy outcome were recorded. The assessment of infants included factors such as birth weight, preterm status, Apgar scores, and neonatal morbidity. Our secondary hypothesis was that patients with hypertensive disorders who received homogeneous, tertiary hospital-based continuity of prenatal care, even if they were diagnosed with pregnancy hypertension in the first trimester because of the patient's preference or the awareness of disease severity, had more severe maternal complications and poorer fetal outcomes than patients who received heterogeneous care at local medical clinics initially, and were then subsequently referred to a tertiary hospital. Therefore, the latter was defined as discontinuity of prenatal care. We defined tertiary hospital-based care as care that is focused strictly on the population groups at highest risk, particularly in deprived areas. Tertiary-hospital-based care can provide homogeneous, continuous, and complete prenatal care, integrated health care, interprofessional consultation, and comprehensive, cross-disciplinary care as well as patient-centered care. In contrast, heterogeneous, independent physician-based care was defined as the collaboration between one doctor or a group practice with other health professionals such as family physicians and midwives in local medical clinics.

We obtained the majority of data from medical records. We measured prenatal care utilization with the Adequacy of Prenatal Care Utilization Index. We also defined inadequate prenatal care as less than five prenatal visits during the entire pregnancy period, adequate prenatal care as nine to 12 visits, intermediate prenatal care as five to eight visits, and intensive prenatal care as more than 12 visits.

Statistical analysis

Statistical evaluations were performed using χ^2 contingency table analysis and the Student *t* test. Binary logistic regression and multivariate logistic regression analysis were also performed. Analysis of variance, nonparametric analysis and post-hoc least significant difference tests were also performed.

Results

Study populations were selected from among 23,665 deliveries between 1999 and 2003 by a review of the medical charts. Of these, 385 patients who met the criteria of presence of an antenatal record and diagnosis of hypertensive disorder were selected. One hundred and ninety-eight patients were classified as having received little or no prenatal care from an independent, heterogeneous, and traditional physician-based care group, and 187 control women were classified as belonging to the tertiary hospital-based, homogeneous type of prenatal care group. The mean age of enrolled women was 30.56 years (range: 13–48 years); mean gestational age of delivery, 34.42 weeks (range: 14–42 weeks); mean parity, 1.75 pregnancies (range: 1–7 pregnancies); mean infant birth weight, 2.12 kg (range: 0.18–5.16 kg); and mean platelet count, 189,626/mm³ (range: 22,400–554,000/mm³).

The characteristics of patients with hospital-based continuous care versus independent physician-based care (discontinuous community-based care model) are presented in Table 1. We stratified the pre-eclampsia patients into four groups according to disease severity. No significant differences in baseline characteristics were found across the two groups. The perinatal outcomes resulting from different status of prenatal care are

Table 1

Basic characteristics of pre-eclampsia patients receiving hospital-based prenatal care and those receiving discontinuous community-based prenatal care.

	Hospital-based prenatal care Continuity of care <i>n</i> = 187	Discontinuity of community-based care ^a <i>n</i> = 198	<i>p</i> value
Age, (y)			
13–19	2 (1.1)	2 (1.0)	0.111
20–25	26 (13.9)	30 (15.2)	
26–30	59 (31.6)	75 (37.9)	
31–35	70 (37.4)	48 (24.2)	
36–40	28 (15.0)	30 (15.2)	
41–45	2 (1.1)	13 (6.6)	
Parity			
Nulliparity vs. multiparity	76 (40.6)	54 (27.3)	0.007
Referral vs. Non-referral	15 (8.0)	178 (89.9)	<0.001
History of abortion	77 (41.2)	100 (50.5)	0.042
No. of prenatal care visits			
0	0	124 (62.6)	<0.001
1 or 2	0	74 (37.4)	
3–7	90 (48.1)	0	
8–12	87 (46.5)	0	
>12	10 (5.35)	0	
Characteristics of pre-eclampsia			
Mild pre-eclampsia	124 (66.3)	85 (42.9)	0.135 ^b
Severe pre-eclampsia	46 (24.6)	75 (37.9)	
Eclampsia	7 (3.74)	12 (6.1)	
HELLP syndrome	10 (5.35)	26 (13.1)	

Numbers in parentheses indicate percentages of the total group.

HELLP = hemolysis, elevated liver enzymes, and low platelets.

^a Use of Kessner Adequacy of Prenatal Care Index.

^b Use of paired *t* test; discontinuity, heterogeneous, and community-based care that the patient received partial, uncoordinated, and discontinuous independent physician-based prenatal care at clinics and hospitals.

summarized in Table 2. Significant statistical differences were found in low birth weight categories and neonatal prognosis (Apgar score and neonatal death) between the two groups. Interestingly, there were no differences in the incidence of cesarean delivery between them. The risk factors, predisposing factors and outcome variables, calculated by univariate analysis, that were associated with contents of prenatal care are shown in Table 3. We found that advanced maternal age, hypertension, thrombocytopenia, and AST elevation were predisposing factors among the case and intervention groups. The factors derived by multiple logistic regression analysis, which were associated with independent physician-based care (community-based model), are shown in Table 4. We observe that the three key features of the case group were diastolic blood pressure, AST, and low birth weight after considering the confounding factors. Table 5 shows the features of stratification of our cohort with respect to the utilization index of prenatal care. By using the utilization index for the types of prenatal care, we observed the effect of prenatal care and neonatal outcomes in terms of fetal birth weight in women with pre-eclampsia.

Discussion

Our study revealed that fetal birth weight was significantly related to types of prenatal care. For women initially seeking prenatal care at Chang Gung Memorial Hospital, basic physical examinations and risk assessment prior to delivery were performed in the obstetric center by a hospital-based care group team. Women with complicated pregnancies were referred from other facilities, where their prenatal care may at times have been inadequate. The hospital-based prenatal care was defined as multidisciplinary, co-operative, co-ordinated, comprehensive, and continuous care. This care included relevant counseling in medical areas such as nutrition, pediatrics, internal medicine, surgical intervention, and traditional Chinese medicine. For specific medical or relevant surgical diseases, cross-disciplinary consultation was mandatory. The

Table 3

Univariate analysis of predisposing factors and outcome variables associated with discontinuous, heterogeneous, and community-based prenatal care.

	OR	95% CI	<i>p</i> value*
Age > 40 y	2.91	1.22–6.93	0.016
Parity > 3	1.74	1.02–2.96	0.042
SBP > 180 mmHg	7.58	4.23–13.6	<0.001
DBP > 105 mmHg	6.38	4.01–10.14	<0.001
Late onset HP (>37 wk)	2.60	1.17–5.78	0.019
AST > 150 (IU/L)	7.76	1.79–33.55	0.006
Multiple pregnancy	0.842	0.349–2.031	0.702
Education < 10 y	0.489	0.315–0.761	0.002
Platelets < 50,000/ μ L	20.56	1.73–154.84	0.003
Abortion history	1.52	1.01–2.28	0.042
Thrombocytopenia	2.62	1.63–4.21	<0.001
Gestational age at delivery (wk)	0.802	0.75–0.857	<0.001
Low birth weight (gm)	5.813	3.64–9.28	<0.001

AST = aspartate aminotransferase; CI = confidence interval; DBP = diastolic blood pressure; OR = odds ratio; HP = hypertension; SBP = systolic blood pressure.

* Determined by binary logistic regression and statistical significance.

antenatal, educational manuals based on hospital prenatal care, were specified on selected topics dealing with high-risk pregnancy. Antenatal maternal classroom-antenatal education [7] was also available for teaching and resolving prospective mothers' questions and any related problems. Furthermore, the continuity of prenatal care was defined as care given in the same facility, whether or not the group or team providing care also attended the delivery, and the presence of a mechanism to ensure an uninterrupted succession of events [15]. The attending physician in charge was responsible for the labor, delivery, and recovery issues over the whole period of the pregnancy. We stated earlier that independent physician-based prenatal care was defined as care provided by a solo practice, a traditional physician-based or community-based model, a specialized family physician, an obstetrician, or a certified nurse-midwife at a local medical clinic. Therefore, the characteristics of discontinuity of prenatal care or heterogeneous

Table 2

Perinatal outcome stratified by the status of prenatal care.

	Hospital-based prenatal care group Continuity of care <i>n</i> = 187	Discontinuous, community-based care group ^a <i>n</i> = 198	<i>p</i> value
Preterm			
Early (<27 wk)	5 (2.70)	15 (7.73)	0.029
Moderate (<30 wk)	13 (7.10)	36 (18.7)	0.001
Late (<37 wk)	96 (52.2)	167 (85.2)	<0.001
Birth weight (g)	2498.3 \pm 869.7	1777.2 \pm 813.4	<0.001
Low birth weight (<2.5 s)	81 (44.0)	159 (82.4)	<0.001
Very low birth weight (<1.5 kg)	28 (15.0)	83 (43.2)	<0.001
Extremely low birth weight (<1.0 kg)	16 (8.56)	38 (19.8)	0.002
IUGR	60 (32.6)	96 (51.6)	<0.001
Neonatal deaths	7 (3.74)	20 (10.3)	0.013
C/S	157 (84.0)	173 (87.8)	0.277
AS < 5' at 1 min	15 (8.02)	50 (25.9)	<0.001
AS < 7' at 5 min	13 (6.95)	36 (18.6)	0.001

Numbers in parentheses indicate percentages of the total group.

AS = Apgar score (Apgar score meant fetus prognostic score, 1 min and 5 min have different implications on neonatal assessment and evaluation); C/S = Cesarean section; IUGR = intrauterine growth restriction.

^a Includes little or no prenatal care and inadequate prenatal care patients.

Table 4

Multivariate logistic regression analysis of predisposing factors and outcome variables associated with discontinuous, heterogeneous, and community-based prenatal care in patients with hypertensive disorders.

Characteristics	Adjusted OR	95% CI	<i>p</i> value
DBP \geq 105 mmHg	6.21	3.24–11.89	<0.001
AST \geq 150 IU/L	9.28	1.06–81.2	0.044
Education < 10 y	0.443	0.224–0.876	0.019
Platelets < 50,000/ μ L	6.883	0.794–59.68	0.089
Low birth weight (g)	3.26	1.56–6.81	0.002

Values are adjusted for gestational age at delivery.

AST = aspartate aminotransferase; CI = confidence interval; DBP = diastolic blood pressure; OR = odds ratio.

care, such as a mixture of family physicians, general practitioners, and midwives as obstetric care providers, may result in different pregnancy outcomes.

The women in the two groups in our study were similar in age distribution and abortion history. In general, our study yielded three important findings. First, we found that pregnant women with hypertensive disorders who received hospital-based standard prenatal care had favorable outcomes in terms of maternal complications and fetal assessments, even though many referral cases were transferred from local medical clinics because of disease severity. Second, the significant factors associated with hypertensive women with independent physician-based or community-based prenatal care were diastolic blood pressure \geq 105 mmHg, AST \geq 150 IU/L, and low-birth-weight deliveries. Third, we also noted a dose–response effect of the different levels of prenatal care on the pregnancy outcome in terms of fetal birth weight and gestational age at delivery. The fetal birth weight in patients who received inadequate care was less than that of patients who received adequate care. Furthermore, the gestational week of delivery in the inadequate care group was earlier than that in the adequate care group. However, we should not rush to conclude or infer that women in the community-based, independent physician practice group received poor quality obstetric care based on these findings.

Much of the evidence indicating an association between insufficient prenatal care and poor pregnancy outcome, such as

low birth weight, stems from studies that use indices of prenatal care utilization [16]. As noted by Kogan et al [17], increased and early utilization of prenatal care is a benchmark of several national programs and health policies. In our study the relatively better outcomes with respect to fetal birth weight and gestational age at delivery were found in the intensive prenatal care group. Regarding the use of prenatal care in Taiwanese women, we found that inadequate use of prenatal care is a risk factor for low birth weight (adjusted odds ratio, 3.26; 95% confidence interval, 1.56–6.81; $p = 0.002$), which is consistent with Leveno's observation that women without adequate prenatal care had a threefold higher relative risk as compared to women receiving prenatal care [1]. We also demonstrated that a dose–response relationship might exist between the level of prenatal care (intensive, adequate, intermediate, or inadequate) and fetal birth weight. This conclusion is in contrast to the report of Mustard and Roos [18], in which a slight difference in birth weight in complicated pregnancies was observed between adequate and less than adequate care groups. In a randomized controlled trial, McDuffie noted that the effect of frequency of prenatal visits was not associated with pregnancy outcome, and that there was little evidence to determine whether a dose–response relationship exists between prenatal visits and perinatal outcome for low-risk women [2]. A maternal educational level of <10 years would not be a risk factor in an independent physician-based group and could be elucidated by the availability and access to prenatal services at the academic medical center, and patient's practical choices and preferences regarding their prenatal visits [19]. Nielsen et al [20] have pointed out that patients might benefit from the effect of team training and collaborative work in reducing maternal adverse events and improving neonatal outcome, which is consistent with our results.

Morestin et al [21,22] have developed the idea of Donabedian's Integrative Model and have offered a comprehensive conceptual framework for the quality of obstetric care that consists of many characteristics and components as potential criteria for evaluation. Our study focused on the following deficiencies of clinic-based or community-based prenatal care:

Table 5

Features of stratification of the utilization index of prenatal care.

Characteristics ^a	Inadequate ^b (<i>n</i> = 228)	Intermediate (<i>n</i> = 77)	Intensive (<i>n</i> = 35)	Adequate care (<i>n</i> = 40)
Maternal age (y)	30.65 \pm 5.62	32.04 \pm 4.52	29.23 \pm 4.56	31.08 \pm 4.76 ^c
GA at delivery (wk)	32.97 \pm 3.91	35.56 \pm 3.10	37.89 \pm 1.83	36.68 \pm 1.71 ^d
Fetal BW (g)	1791.8 \pm 837.8	2424.9 \pm 872.7	3001.8 \pm 621.6	2753.5 \pm 754.2 ^e
Detection of HT (wk)	31.1 \pm 5.5	25.1 \pm 8.3	22.3 \pm 10.4	20.9 \pm 9.9 ^f
Parity	1.8 \pm 1.0	1.6 \pm 0.9	1.6 \pm 0.9	1.5 \pm 1.0 ^g

Use of analysis of variance tests: 1 = inadequate; 2 = intermediate; 3 = intensive; 4 = adequate.

BW = birth weight; GA = gestational age; HT = hypertension.

^a Data for five patients were missing.

^b Inadequate group includes hospital-based prenatal care patients because of noncompliance and discontinuity of community-based prenatal care.

^c Post-hoc LSD test: 1–2, $p = 0.044$; 2–3, $p = 0.009$.

^d Post-hoc LSD test: 1–2, 1–3, 1–4, $p < 0.001$.

^e Post-hoc LSD test: 1–2, 1–3, 1–4, $p < 0.001$; 2–4, $p = 0.036$.

^f Post-hoc Tukey test: 1–2, 1–3, 1–4, $p < 0.001$; 2–4, $p = 0.002$.

^g Not significant.

(1) the lack of routine monitoring and control of mild and severe pre-eclampsia; (2) lack of anticipatory guidance for mild-to-severe pre-eclampsia during prenatal care; (3) lack of dietary guidelines and team assistance for nonpharmacological control of gestational hypertension or pre-eclampsia; (4) lack of cross-disciplinary consultation and management; and (5) lack of criteria for referral and of a well-established prenatal care plan for achieving collaborative and effective care.

Our study demonstrates the importance of access to prenatal care at medical centers for hypertensive and high-risk pregnant women. It highlights the significance of collaboration and co-operation in terms of the so-called Integrated Health Care Delivery System between medical centers and local medical facilities, and it should encourage decision makers to investigate disease severity, bi-directional referral patterns, the linkage between independent physician-based prenatal care and coordinated hospital-based obstetric care, health policies, as well as health planning and resource-allocation issues. In contrast, other researchers have argued that the quality of care is somewhat higher among independent physicians [23]. There are still many issues to be resolved. Our results do not allow us to conclude which type of practice provides a better quality of prenatal care; however, it is possible to identify the features of discontinuity versus continuity of standard prenatal care and heterogeneous or homogeneous types of obstetric care.

Our study had the following limitations. It was a retrospective study on data from a single center, and it focused on one specific disease (i.e., hypertension) during pregnancy. The selection and referral biases could not be avoided. The study may have missed frequencies of individual visits to local medical clinics. Furthermore, it is unethical to design a prospective randomized control trial that includes pregnant women who are given little or no care at a tertiary hospital, based on traditional independent physician-based care only at local medical facilities, or who are referred to an academic center during their pregnancy as subsequent obstetric management. Our community-based care model was defined by fewer than two prenatal care visits to the medical center, thus, we cannot conclude that the quality of independent physician-based prenatal care was inferior to its hospital-based counterpart using this indicator. In addition, our study included a relatively small sample size and lacked detailed socioeconomic information (e.g., detailed income, ethnic background, personal and family history, and previous medical histories) of the patients. Inevitably, we did not include data of patients whose outpatient visits were to our hospital but who delivered babies elsewhere. Other weaknesses were that the quality of prenatal care may not really have been identified quantitatively from statements of patient satisfaction levels, patient safety issues, as well as from the utilization of the prenatal care index, and that representative quality indicators in terms of adequate prenatal care may not specifically have been identified. Given the above limitations, this study can only reflect situations in actual practice and elements that would be influenced by two practice models, patients' perspectives, physicians' behavior in obstetric practice, and prenatal care decisions.

The strengths of this study were that it elucidated the degree and extent of prenatal care, discussed the contents of prenatal care, regarded prenatal care as a systematic way of thought, and conceived of prenatal care as a health care delivery system. We stratified our study population into two categories: a hospital-based care model versus an independent physician-based (community-based) prenatal care model. The hospital-based, standard prenatal care management model had three primary components: (1) a collaborative and multidisciplinary practice of obstetricians, certified nurse-midwives and specialists; (2) comprehensive perinatal services including standard procedures and guidelines of prenatal care of the NHIP, case management, health care management, health education (such as maternal and fetal issues), nutritional counseling, multidisciplinary counseling, effective treatment protocols for high-risk pregnancy, and social workers and their services for bio-psychosocial support; and (3) a team-based obstetric and labor care process, delivery, postpartum recovery services, and interprofessional consultation. These components have been integrated within the health care services and delivery system at the Chang Gung Medical Institution, which includes co-operation with private practice obstetricians, neighborhood Tao-Yuan Chang Gung Community Hospital, Children's Hospital and tertiary academic centers. Through the behavioral intervention and evidence-based guidelines, the institute can create an environment and culture where hospital-based physicians may achieve mutual cooperation and effective obstetric care [24].

This study delineated variables such as low birth weight, very low birth weight, extremely low birth weight, intrauterine growth restriction, and three-phase periods of preterm labor. The key feature of this study was the use of analysis of variance and post-hoc and nonparametric analysis to elucidate the different levels of prenatal care and their effects on pregnancy outcome. In summary, the hospital-based prenatal care model provides multidisciplinary, co-operative, co-ordinated, comprehensive and well-established prenatal care. However, from our evaluation of traditional independent physician-based prenatal care service and hospital-based care, we cannot conclude which is the better care model. In terms of discontinuity of prenatal care, the physician-based group may be inferred to have greater disease severity and relatively poorer pregnancy outcomes such as low birth weight. These poor outcomes result from discontinuity of obstetric care [25], the hierarchical system of medical service, emergency obstetric management strategies [26], the patient's awareness of prenatal care and her decision making, and customer-oriented care-seeker behavior. However, these factors were not related to the quality of obstetric care in physician-based practices.

Further studies are required to investigate and compare the quality of care that patients receive from continuous prenatal care provided at independent physician-based clinics. The present study was carried out at only a single data center; therefore, we draw no other conclusions than those relevant to the observations and findings in the institution of study.

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References

- [1] Leveno KJ, Cunningham FG, Roark ML, Nelson SD, William ML. Prenatal care and the low birth weight infants. *Obstet Gynecol* 1985;66:599–605.
- [2] McDuffie RS, Beck A, Bischoff K, Cross J, Orleans M. Effect of frequency of prenatal care visits on perinatal outcome among low-risk women. *JAMA* 1996;275:847–51.
- [3] Misra DP, Guyer B. Benefits and limitations of prenatal care from counting visits to measuring content. *JAMA* 1998;279:1661–2.
- [4] Alexander GR, Tompkins ME, Peterson DJ, Weiss J. Sources of bias in prenatal care utilization indices: implications for evaluating the medicaid expansion. *Am J Public Health* 1991;81:1013–6.
- [5] Zancanato G, Msolomba R, Guarenti Franchi M. Antenatal care in developing countries: the need for a tailored model. *Semin Fetal Neonatal Med* 2006;11:15–20.
- [6] Ickovics JR, Kershaw TS, Westdahl C, Rising SS, Klima C, Reynolds H, et al. Group prenatal care and preterm birth weight: results from a matched cohort study at public clinics. *Obstet Gynecol* 2003;102:1051–7.
- [7] Enkin M, Keirse MJNC, Neilson J, Crowther C, Duley L, Hodnett E, et al. A guide to effective care in pregnancy and childbirth. 3rd ed. New York: Oxford University Press; 2000. p. 18–28.
- [8] Ciceklioglu M, Turk Soyer M, Asli Ocek Z. Factors associated with the utilization and content of prenatal care in a western urban district of Turkey. *Int J Qual Health Care* 2005;17:533–9.
- [9] Homer CSE, Davis GK, Brodie PM, Sheehen A, Barclay LM, Willis J, et al. Collaboration in maternity care: a randomized control trial comparing community-based continuity of care with standard hospital care. *Br J Obstet Gynaecol* 2001;108:16–22.
- [10] Green JM, Renfrew MJ, Curtis PA. Continuity of carer: what matters to women? A review of the evidence. *Midwifery* 2000;16:186–96.
- [11] Jackson DJ, Lang JM, Swartz WH, Ganiats TG, Fullerton J, Echer J, et al. Outcomes, safety, and resource utilization in a collaborative care birth center program compared with traditional physician-based perinatal care. *Am J Public Health* 2003;93:999–1006.
- [12] Kathryn SJ, Gutierrez M, Fridman M, Gregory KD. Health care cost associated with changing clinics and “walk-in” deliveries: evidence supporting a regionalized health Information network. *Am J Obstet Gynecol* 2008;198:707.e1–8.
- [13] Rumbold AR, Crowther C, Haslam RR, Dekker GA, Robinson JSACTS Study Group. Vitamin C and E and the risks of preeclampsia and perinatal complications. *N Engl J Med* 2006;354:1796–806.
- [14] Cunningham FG, Leveno KJ, Bloom SL, Hauth JC, Giltrap III LC, Wenstrom KD, editors. *Williams obstetrics*. 22nd ed. New York: McGraw-Hill; 2005. p. 761–808.
- [15] Starfield B. Primary care. Balancing health needs, services, and technology. New York and Oxford: Oxford University Press; 1998. p. 226–7.
- [16] Kotelchuck M. Adequacy of prenatal care utilization index: its U.S. distribution and association with low birth weight. *Am J Public Health* 1994;84:1486–9.
- [17] Kogan MD, Martin JA, Alexander GR, Kotelchuck M, Venturs S, Frigoletto FD. The changing pattern of prenatal care utilization in the United States, 1981–1995, using different prenatal indices. *JAMA* 1998;279:1623–8.
- [18] Mustard CA, Roos NP. The relationship of prenatal care and pregnancy complications to birthweight in Winnipeg, Canada. *Am J Public Health* 1994;84:1450–7.
- [19] Fuentes-Afflick E, Hessol NA, Bauer T, O’Sullivan MJ, Gomez-Lobo V, Holman S, et al. Use of prenatal care by Hispanic women after welfare reform. *Obstet Gynecol* 2006;107:151–60.
- [20] Nielsen PE, Goldman MB, Mann S, Shapiro DE, Marcus RG, Pratt SD, et al. Effects of teamwork training on adverse outcomes and process of care in labor and delivery- a randomized controlled trial. *Obstet Gynecol* 2007;109:48–55.
- [21] Donabedian A, Wheeler JR, Wyszewianski L. Quality, cost, and health: an integrative model. *Med Care* 1982;20:975–92.
- [22] Morestin F, Bicaba A, de Dieu Serme J, Fournier P. Evaluating quality of obstetric care in low-resource settings: building on the literature to design tailor-made evaluation instruments – an illustration in Burkina Faso. *BMC Health Serv Res* 2010;10:20.
- [23] Issacs SL, Jellinek PS, Ray WL. The independent physician- going, going. *N Engl J Med* 2009;360:655–7.
- [24] Althabe F, Buekens P, Bergel E, Belizán JM, Campbell MK, Moss N, et al. A behavioral intervention to improve obstetrical care. *N Engl J Med* 2008;358:1929–40.
- [25] Homer CS, Davis GK, Brodie PM, Sheehan A, Barclay LM, Willis J, et al. Collaboration in maternity care: a randomized controlled trial comparing community-based continuity of care with standard hospital care. *BJOG* 2001;108:16–22.
- [26] Rana TG, Chataut BD, Shakya G, Nanda G, Pratt A, Sakai S. Strengthening emergency obstetric care in Nepal: the Women’s Right to Life and Health Project (WRLHP). *Int J Gynaecol Obstet* 2007;98:271–7.