Gravidity and Parity in Postmenopausal American Indian Women: The Strong Heart Study

KARI E. NORTH,[1,2] JEAN W. MACCLUER,[1] LINDA D. COWAN,[3] AND BARBARA V. HOWARD[4]

Abstract The fertility of a large sample of American Indian women participating in the Strong Heart Study was examined to determine which factors are associated with variation in completed fertility among women in this population. The Strong Heart Study (SHS) is a study of cardiovascular disease (CVD) and its risk factors in American Indians living in Arizona, Oklahoma, and the Dakotas. Data were derived from a baseline examination between 1989 and 1992 of approximately 1,500 men and women, aged 45–74, from each of the 3 SHS centers. A personal interview elicited demographic information, family health history, and information on several life-style variables. A total of 1,955 ever-married, postmenopausal women were considered in these analyses. Women were considered to be postmenopausal if their menstrual cycles had stopped completely for at least 12 months, either because of natural or surgical processes. The average number of pregnancies (gravidity) for all women was 5.9, whereas the mean number of live births (parity) was 5.3. Women living in Arizona (5.6) and the Dakotas (5.8) had higher parity than those in Oklahoma (4.6). Furthermore, there was lower completed fertility in younger women: When American Indian women from all 3 centers were considered together, women born between 1910 and 1919 had a mean parity of 5.3, whereas women born between 1940 and 1949 had a mean parity of 4.0. Although previous research has suggested a relationship between parity and CVD risk factors, no linear associations between CVD risk factors and fertility were indicated in this population. We also examined the relationship of contraception, level of education, and income to fertility. While no significant relationship between contraception and the level of fertility was identified, there was a significant inverse linear relationship of both education and income with fertility. In summary, fertility rates in American Indian women are high, but appear to

[1] Department of Genetics, Southwest Foundation for Biomedical Research, P.O. Box 760549, San Antonio, TX 78245-0549.

[2] Department of Anthropology, University of Kansas, Lawrence, KS.

[3] Department of Biostatics and Epidemiology, University of Oklahoma Health Sciences Center, Oklahoma City, OK.

[4] Medstar Research Institute, Washington, D.C.

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be decreasing in younger generations. Fertility is higher in those with less education and lower incomes.

The U.S. Bureau of the Census has designated American Indians as the fastest growing segment of our population (Bureau of the Census 1995b). As reported by the Bureau of the Census, the American Indian population increased from 380,000 in 1950 to almost 2 million in 1990, an increase of nearly 455% in 40 years (Bureau of the Census 1995a). Several factors have been suggested to account for this increase, including improved health care for Indians living on reservations, better census enumeration in rural and reservation areas, changes in overall census procedures for identifying Indian status (self-identification as of 1960), and a political and cultural milieu in which individuals are more likely to identify themselves as American Indians (Shumway and Jackson 1995).

Despite these estimates of rapid population growth, baseline data concerning the fertility of American Indians are lacking. The published data suggest extreme variation in achieved reproduction across tribes (Crawford 1998). According to 1990 Census data, the highest fertility was reported on reservations or other rural Indian governed lands (Bureau of the Census 1995b). However, other findings to the contrary have been published (e.g., the 1987 Montana American Indian Health Risk Assessment study reported similar levels of completed fertility both on and off the reservation) (Warren et al. 1990). Clearly, there is a great deal to be learned about the fertility of American Indians living both on and off the reservation, and about the factors associated with levels of fertility among different American Indian populations.

The data on American Indian fertility are not only limited, but also controversial. Recent studies by Hahn and colleagues have demonstrated a remarkable inconsistency in the coding of race and ethnicity of infants at birth and death (Hahn et al. 1992). Additionally, Sink (1997) has shown a lack of agreement between the racial and ethnic classification systems used by the Bureau of the Census and the National Center for Health Statistics (NCHS) for American Indians. Whereas the Bureau of the Census employs a policy of self-identification of racial and ethnic category, the NCHS categories may be assigned by an observer. The Bureau of the Census has acknowledged these problems and has implemented some proposed improvements for the 2000 Census (Bureau of the Census 1995a).

Until these problems are resolved, it is important to assess the reproductive health of American Indians using alternate methods. These methods include using data resources such as the Indian Health Service (IHS), or data obtained from field studies of these populations. One such field study is the Strong Heart Study (SHS), a collaborative study of cardiovascular disease (CVD) and its risk factors among 3 large groups of American Indian people

living in Arizona, Oklahoma, and the Dakotas. Previously, Cowan and colleagues examined the relationship among parity, postmenopausal estrogen use, and cardiovascular disease risk factors in postmenopausal women participating in the Strong Heart Study (Cowan et al. 1997). In that report, differences were found in the median number of offspring between American Indian women living in Oklahoma, Arizona, and the Dakotas, but the differences in fertility among these women were not explored.

The purpose of the present study was: (1) to examine the fertility of this large sample of American Indian women participating in the Strong Heart Study in order to determine whether fertility differs among localities; and (2) to determine which factors are associated with variation in the level of completed fertility among these populations.

Materials and Methods

Data for these analyses were derived from the baseline examination of the SHS. Details of the 3 field centers and of the methodology used in the SHS, published previously (e.g., Lee et al. 1990), are briefly described here. The Dakota center includes 3 Sioux Indian tribes, representing 2 linguistic dialects, Lakota and Dakota. The Lakota are represented by 2 tribes. The first, the Oglala Sioux, live on the Pine Ridge Reservation, located to the southeast of Rapid City, South Dakota (Figure 1). Of the 8 communities of the Pine Ridge Reservation, 5 were selected to participate in the SHS, about 50% of the entire population of that tribe. Also representing the Lakota dialect are people from the Cheyenne River Sioux Reservation, located in north-central South Dakota (Figure 1). The second linguistic dialect, the Dakota, is represented by 1 tribe from the Spirit Lake Community in the Fort Totten area of North Dakota. These communities were selected on the basis of 2 criteria. First, they were considered by the tribes to be similar to the total tribal populations in life-style, employment, education, and other sociodemographic variables. Second, facilities were available to conduct clinical examinations.

The Oklahoma center encompasses 7 different tribes, historically Plains and Southeastern American Indians living in the Lawton-Anadarko, Oklahoma area (Apache, Caddo, Comanche, Delaware, Fort Sill Apache, Kiowa, and Wichita tribes). The 7 Oklahoma tribes represented in the SHS live primarily in 23 counties of southwestern Oklahoma (Lee et al. 1995). Several commonalities exist among these groups (Howard et al. 1996). First, several of the tribes (Apache, Comanche, Fort Sill Apache, Kiowa, and Wichita) are Plains Indians. Although the Caddo Indians were Woodland Indians, they took on much of the culture of Plains Indians. Similarly, although the Delaware Indians originated in the Northeastern United States, they now reside with the Cherokee Nation and in close association with Plains Indians. Second, unlike the tribes in Arizona and the Dakotas, members of these 7 tribes

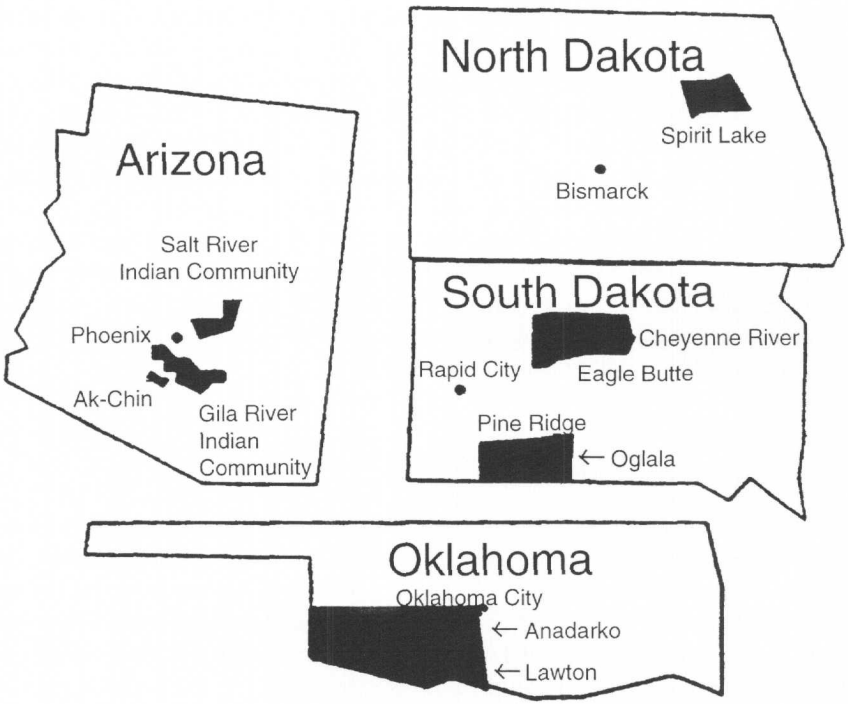

Figure 1. Approximate locations of Strong Heart Study communities (Lee et al. 1995).

do not live on reservations (there are no reservations in Oklahoma), but in the general community.

The Arizona field center is located in Phoenix. This center has enrolled primarily Pima Indians, but there are also representatives of the closely related Maricopa and Papago (Tohono O'odham) Indian tribes (Lee et al. 1990). The Indians live in 3 communities near Phoenix: the Gila River Reservation and the Salt River Reservation, which are Pima/Maricopa Indian communities, and the Ak-Chin Reservation, which is a Papago/Pima Indian community (Howard et al. 1992). The Gila River community is the largest of the 3, and consists of 7 districts. Approximately 76% of the Arizona SHS cohort resides in the Gila River Reservation. The Salt River Pima-Maricopa Indian Community is smaller and is located in Maricopa County, bordering several major cities (Figure 1). The Ak-Chin Indian community has the smallest population, numbering in total 500, of which 36 were within the cohort age range (45 to 74 years of age) at the beginning of the study (Lee et al. 1990). Their community is located on the border of the Gila River Indian Community (Figure 1).

The Strong Heart Study protocol was approved by the IHS Institutional Review Board, by the institutional review boards of the participating insti-

tutions, and by the 13 participating tribes. Clinical exams were offered to all age- and residence-eligible tribal members. Baseline examinations, conducted between July 1989 and January 1992, included at least 1,500 members from each center between the ages of 45 and 74. All tribal members who met the age criteria were invited to participate in the Strong Heart Study. Response rates were 71.8% in Arizona, 61.5% in Oklahoma, and 55.3% in the Dakotas (62% across all centers). These rates are comparable to those in other large epidemiological studies of CVD (Fabsitz et al. 1999). The lowest response rate, in the Dakotas, may reflect the greater distances between Strong Heart clinics and homes on the reservation (Fabsitz et al. 1999). The data used here were collected during a personal interview, which elicited demographic information, family health history, and several life-style variables.

A total of 4,549 individuals were recruited for the baseline Strong Heart Study. Of the 2,703 women, only ever-married, postmenopausal women were considered in these analyses (Cowan et al. 1997). Ever-married was used as an indirect measure of having had the opportunity to become pregnant. Women were considered to be postmenopausal if their menstrual cycles had stopped completely for at least 12 months (McKinlay 1996). Women whose menses had ceased were asked if their menopause were natural or had been surgically induced. If surgical, they were asked if only their uterus had been removed or if their ovaries had also been removed (oophorectomy). Women who reported hysterectomy without oophorectomy or who did not know whether their ovaries had been removed were classified as postmenopausal if their age was greater than or equal to 53, the age at which 90% of the women had had a natural menopause. There may be some error associated with self-reported oophorectomy, as women can be confused about the exact nature of their surgery. Nonetheless, using these criteria, 1,955 ever-married, postmenopausal women were identified.

Analysis of variance (ANOVA) was used to test for homogeneity of localities with respect to the sociodemographic and reproductive variables under consideration. Probabilities less than or equal to 0.05 were considered statistically significant. Scheffe's post hoc comparison of means was used to test for specific differences in means between different centers (Sokal and Rohlf 1981). The statistical significance of between-center differences in prevalence was determined using chi-square tests (Sokal and Rohlf 1981). Again, probabilities less than or equal to 0.05 were considered statistically significant. Simple linear regressions were used to determine whether relationships existed between a dependent variable (fertility measures) and any of the independent variables examined here (distal determinants of fertility) (Sokal and Rohlf 1981). Because of the correlation of several of the possible distal determinants of fertility in these data, multivariate regressions were not calculated. All computations were carried out using the PEDSYS data management software (Dyke 1994) and SYSTAT statistical software (SYSTAT 1997).

Table 1. Reproductive Characteristics of Ever-Married, Postmenopausal American Indian Women by Strong Heart Study Center

Characteristic	*Arizona*	*Oklahoma*	*Dakotas*	*Total*
N	660	670	625	1955
Menopausal Status				
Natural	468	365	480	1313
Surgical	192 (29%)	305 (46%)	145 (23%)	642[a]
(Complete)	98	179	65	342
(Uterus only)	36	96	68	200
(Unknown)	58	30	12	100
Mean age at surgical menopause	40.4 ± 6.8	39.3 ± 7.7	41.8 ± 5.8[b]	40.2 ± 7.1[a]
Mean age at natural menopause	45.6 ± 5.2[b,c]	47.7 ± 5.4	47.4 ± 4.7	46.9 ± 5.2[a]
Ever oral contraceptive use	199 (30%)	206 (31%)	148 (24%)	553[d]
Gravidity				
Mean	6.1 ± 3.5	5.1 ± 3.0[c,e]	6.4 ± 3.4	5.9 ± 3.3[a]
Median	6.0	5.0	6.0	6.0
Parity				
Mean	5.6 ± 3.4	4.6 ± 2.8[c,e]	5.8 ± 3.2	5.3 ± 3.2[a]
Median	5.0	4.0	5.0	5.0
Mean number of lost pregnancies	0.53 ± 0.90	0.57 ± 0.98	0.75 ± 1.3	0.61 ± 1.08[d]

a. Significant between center difference at $p \leq 0.001$.
b. Significantly different from Oklahoma Center.
c. Significantly different from Dakotas Center.
d. Significant between center difference at $p \leq 0.05$.
e. Significantly different from Arizona Center.

Results

The reproductive data for all 3 Strong Heart centers are presented in Table 1. The average number of pregnancies (gravidity) for all American Indian women considered together was 5.9, and the median number of live births (parity) was 5.0. Significant differences in gravidity and parity among these 3 centers were detected (Table 1). Post hoc comparisons of these fertility measures suggested that, in all cases, American Indian women from Oklahoma were significantly different from women from Arizona and the Dakotas (Table 1). Specifically, Oklahoma women had a significantly lower mean number of pregnancies and live births. Significant differences in the mean number of lost pregnancies were also detected (Table 1).

Trends in fertility through time were also examined by stratifying women into 4 cohorts, based on their decade of birth. Significant differences were found in gravidity and parity when all women were considered together (Table 2). The fertility of women born during the first 3 decades was significantly higher than the fertility of those born during the last decade examined (1940–1949).

Table 2. Reproductive Characteristics of Ever-Married, Postmenopausal American Indian Women by Strong Heart Study Center and by Decade of Birth

Characteristic	*Decade 1 1910–1919*	*Decade 2 1920–1929*	*Decade 3 1930–1939*	*Decade 4 1940–1949*	*F Statistic*
Total sample					
Gravidity	5.87 ± 3.65	6.12 ± 3.55	6.06 ± 3.12	4.47 ± 2.69[a,b,c]	18.989[d]
Parity	5.34 ± 3.58	5.59 ± 3.39	5.48 ± 2.98	4.00 ± 2.52[a,b,c]	18.753[d]
Sample size	149	633	900	273	1955
Arizona					
Gravidity	6.45 ± 3.71	6.88 ± 3.65[c]	6.02 ± 3.38	4.49 ± 2.86[a,b,c]	11.513[d]
Parity	6.18 ± 3.67	6.31 ± 3.52[c]	5.51 ± 3.26	3.98 ± 2.68[a,b,c]	11.955[d]
Sample size	40	208	309	103	660
Oklahoma					
Gravidity	4.86 ± 3.27	5.10 ± 3.13	5.50 ± 2.68	3.74 ± 2.38[a,b,c]	10.152[d]
Parity	4.33 ± 2.93	4.68 ± 2.97	4.89 ± 2.50	3.40 ± 2.16[b,c]	7.992[d]
Sample size	58	236	290	86	670
Dakotas					
Gravidity	6.43 ± 3.81	6.46 ± 3.62	6.64 ± 3.14	5.20 ± 2.60[b,c]	4.298[e]
Parity	5.71 ± 3.92	5.88 ± 3.41	5.98 ± 2.96	4.64 ± 2.53[b,c]	4.130[e]
Sample size	51	189	301	84	625

a. Significantly different from 1st decade.
b. Significantly different from 2nd decade.
c. Significantly different from 3rd decade.
d. Significant between decade difference at $p \leq 0.001$.
e. Significant between decade difference at $p \leq 0.01$.

This trend of fertility reduction in the most recent cohort was also examined independently in each study center (Table 2 and Figure 2). Although each center followed the trend of fertility reduction across time, there was variation in the pattern of fertility decline among the 3 Strong Heart centers. Fertility did not steadily decline across time in all cases, but in some instances increased slightly, followed by a dramatic drop-off in the last birth cohort (Figure 2).

Age at Menopause. The age at natural menopause varied significantly among population centers (Table 1). Post hoc comparisons suggested that women from Arizona had significantly earlier natural menopause than women from the Dakotas and Oklahoma. Indeed, women from Arizona reported a mean age of natural menopause approximately 2 years earlier than that of the other two groups. The age at surgical menopause also varied across populations (Table 3). American Indian women from the Dakotas were significantly different from women in Oklahoma, who reported the earliest mean age of surgical menopause.

The prevalence of surgically induced menopause varied across population centers, with 44% of women in the Oklahoma sample having had a

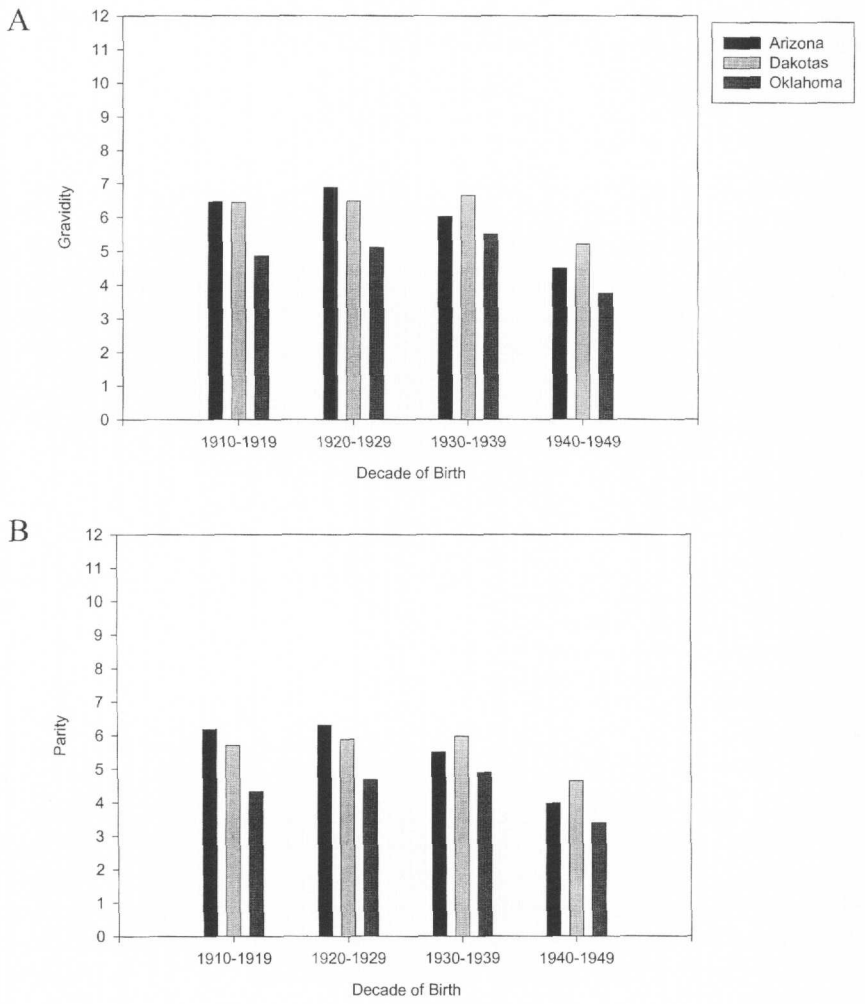

Figure 2. Gravidity and parity of American Indian women by decade of birth.

surgical menopause, in comparison with fewer than 30% in the Dakotas and Arizona (Table 1). The prevalence of surgical menopause by birth cohort was also examined. In the women from the Dakotas and Arizona, the rate of surgical menopause remained relatively constant (at about 30%) across birth cohorts (nonsignificant) (Figure 3). In contrast, among women from Oklahoma the rate was relatively stable (about 40%) throughout the first 3 birth cohorts, with a dramatic increase to more than 60% in the last birth cohort ($\chi^2 = 7.80, p \leq 0.05$).

Table 3. Reproductive Characteristics of Ever-Married, Postmenopausal American Indian Women by Menopausal Status and Strong Heart Study Center

Characteristic	*Arizona*	*Oklahoma*	*Dakotas*	*Total*
Menopausal status				
Natural	468	365	430	1313
Age of menopause	45.6 ± 5.2[a,b,c]	47.7 ± 5.4[a]	47.4 ± 4.7[a]	46.9 ± 5.2[a]
Gravidity	6.0 ± 3.5	5.2 ± 3.0	6.3 ± 3.3	5.9 ± 3.3
Parity	5.5 ± 3.3	4.8 ± 2.8	5.7 ± 3.1	5.4 ± 3.1
Menopausal status				
Surgical	192	305	145	642
Age of menopause	40.4 ± 6.8	39.3 ± 7.7[b]	41.8 ± 5.8	40.2 ± 7.1
Gravidity	6.4 ± 3.5	4.9 ± 2.9	6.8 ± 3.4	5.8 ± 3.3
Parity	5.7 ± 3.5	4.4 ± 2.6	5.9 ± 3.3	5.1 ± 3.1

a. Significantly different from Surgical Menopause Group at $p \leq 0.001$.
b. Significantly different from Dakotas Center within menopausal status.
c. Significantly different from Oklahoma Center within menopausal status.

Because surgical menopause was so common in these populations, the fertility of those women who had a surgical menopause was examined. There were no significant differences between women with a surgical menopause and those with a natural menopause, in gravidity or parity (Table 3).

Oral Contraceptive Use. In terms of ever-use of oral contraceptives, there were significant differences between the 3 SHS populations (Table 1).

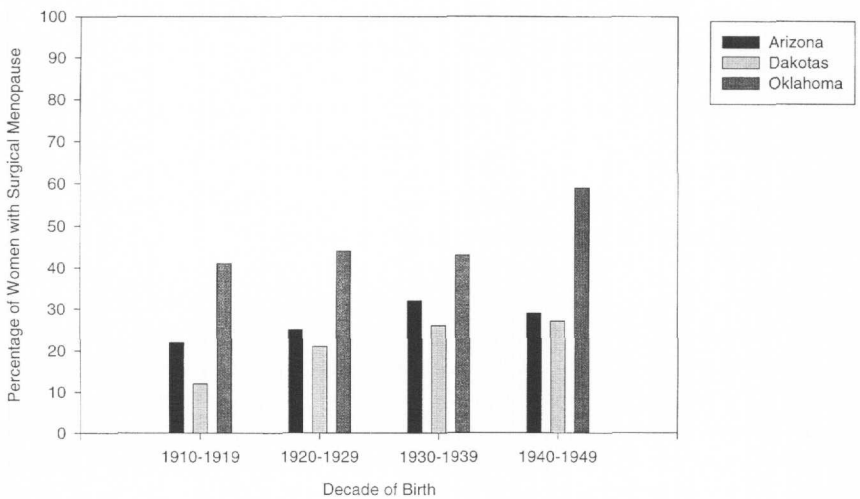

Figure 3. Surgical menopause in American Indian women by decade of birth.

Table 4. Oral Contraceptive Use of Ever-Married, Postmenopausal American Indian Women by Strong Heart Study Center and by Decade of Birth

Characteristic	*Decade 1 1910–1919*	*Decade 2 1920–1929*	*Decade 3 1930–1939*	*Decade 4 1940–1949*
Total sample				
% Ever using oral contraception	1.34	12.50	35.79	55.68[a]
Sample size	149	632	894	273
Arizona				
% Ever using oral contraception	0	13.53	37.13	55.34[a]
Sample size	40	207	307	103
Oklahoma				
% Ever using oral contraception	3.45	14.35	40.28	62.79[a]
Sample size	58	237	288	86
Dakotas				
% Ever using oral contraception	0	9.04	30.10	48.81[a]
Sample size	51	188	299	84

a. Significant between decade difference at $p \leq 0.001$.

Women in Oklahoma reported the highest ever-use of oral contraceptives (31%). However, the only significant correlation between oral contraceptive use and any fertility measure was observed in the Dakota center, between gravidity and oral contraceptive use ($r = -0.144$, $p \leq 0.001$). Because oral contraceptives were not available to women of the first birth cohort, and only marginally available to women of the second birth cohort, the relationship between oral contraceptive use and fertility within birth cohorts was examined. Significant between-decade differences in the ever-use of oral contraceptives were reported in all 3 SHS populations (Table 4). Indeed, once oral contraceptives were available, in all 3 SHS centers the use of oral contraceptives increased from the third to fourth birth cohort. However, there were no significant correlations between ever-use of oral contraception and any fertility measure except in the Dakota center, among women of the third birth cohort, between gravidity and oral contraceptive use ($r = -0.212$, $p \leq 0.03$). In addition, oral contraceptive use did not explain significant variation in parity or gravidity, even in the younger birth cohorts.

Education. There was significant variation between centers in the mean years of education completed (Table 5). When all centers were considered together, there were significant between-decade differences in the mean years of education completed (Table 6). The level of education of the women born during the last decade was significantly different from that of women born in all other decades (Table 6). Trends in educational levels through time also showed significant differences in each center independently (Table 6), with an overall pattern of increase in the level of education across time.

Table 5. Demographic Characteristics of Ever-Married, Postmenopausal American Indian Women by Strong Heart Study Center

Characteristic	*Arizona*	*Oklahoma*	*Dakotas*	*Total*
N	660	670	625	1955
Age (years)				
45–54	233	193	196	622
55–64	282	309	277	868
65–74	145	168	152	465
Annual household income (%)				
<$5,000	43.72	23.87	37.53	35.23[a]
$5,000–$10,000	21.46	23.61	24.28	23.18[a]
>$10,000	34.82	52.52	38.19	41.58[a]
Mean years of education	9.88 (2.76)[b,c]	12.03 (2.61)[b]	10.80 (3.05)	10.91 (2.94)[a]
% Indian blood	97.67 (9.27)	88.77 (21.13)	78.60 (27.08)	88.72 (21.64)[a]

Parentheses indicate the standard deviation from the mean.

a. Significant between center difference at $p \leq 0.001$.

b. Significantly different from Dakotas Center.

c. Significantly different from Oklahoma Center.

Table 6. Mean Years of Education of Ever-Married, Postmenopausal American Indian Women by Strong Heart Study Center and by Decade of Birth

Characteristic	*Decade 1 1910–1919*	*Decade 2 1920–1929*	*Decade 3 1930–1939*	*Decade 4 1940–1949*	*F Statistic*
Total Sample					
Mean years of education	10.275[a]	10.524[a]	11.036	11.664[a,b,c]	10.436[d]
Sample size	119	507	750	229	1605
Arizona					
Mean years of education	9.649	9.509	9.942	10.523	2.806[e]
Sample size	36	167	258	88	549
Oklahoma					
Mean years of education	10.653[a,c,f]	11.872	12.218	12.810	8.088[d]
Sample size	49	196	243	79	567
Dakotas					
Mean years of education	10.412	9.931[a,f]	11.020	11.823	7.044[d]
Sample size	34	144	249	62	489

a. Significantly different from 3rd decade.

b. Significantly different from 1st decade.

c. Significantly different from 2nd decade.

d. Significant between decade difference at $p \leq 0.001$.

e. Significant between decade difference at $p \leq 0.05$.

f. Significantly different from the 4th decade.

Table 7. Adjusted R Square and F Ratio for Regressions of Education and Income on Gravidity and Parity

	Gravidity		*Parity*	
Characteristic	*Adjusted R^2*	*F Statistic*	*Adjusted R^2*	*F Statistic*
Total sample				
Education	8.00%	7.271[a]	8.20%	7.407[a]
Income	2.70%	4.724[a]	2.50%	4.479[a]
Arizona				
Education	8.50%	3.090[a]	8.20%	2.987[a]
Income	N.A.	0.532	N.A.	0.665
Oklahoma				
Education	13.30%	4.953[a]	13.10%	4.853[a]
Income	10.10%	5.950[a]	10.80%	6.389[a]
Dakotas				
Education	7.00%	1.867[b]	6.80%	1.790[b]
Income	N.A.	2.570	N.A.	2.102

a. F statistic significant using Bonferroni correction at $p \leq 0.005$ ($p = 0.01/2$).
b. F statistic significant using Bonferroni correction $p \leq 0.025$ ($p = 0.05/2$).
N.A. = Not applicable

When all women were considered together, a significant inverse linear relationship was detected between both gravidity and parity and level of education (Table 7). Each center was also considered separately, and, in each case, an inverse linear relationship was detected between education and both measures of fertility (Table 7).

Income. There was significant variation between the centers in the percentage of women with annual per capita incomes less than $10,000 (Table 5). In addition, significant inverse correlations were detected between income and both parity and gravidity, when all women were considered together ($r = -0.144$ and -0.147, respectively, $p \leq 0.001$). When each center was considered independently, significant inverse correlations were detected between income and both parity and gravidity only in the Oklahoma center ($r = -0.303$ and -0.307, respectively, $p \leq 0.001$). Additionally, in the Oklahoma center, a significant inverse linear relationship with income was detected for both gravidity and parity (Table 7).

Discussion

As stated earlier, the purpose of this research was: (1) to determine whether fertility differs among American Indian women in the 3 centers participating in the Strong Heart Study; and (2) to determine which factors are associated with variation in the level of completed fertility among these pop-

ulations. To accomplish these goals, we examined several reproductive parameters as well as the possible determinants of fertility among SHS populations.

The median number of live births (parity) for all American Indian women considered together was 5.0, which is larger than the median of 3.0 reported by the National Health and Nutrition Examination Survey (NHANES) among white women of similar age (Ness et al. 1993). Gravidity also was high in comparison to other US populations. For example, 52% of SHS women had 6 or more pregnancies, nearly 2 times the proportion reported in the Hispanic National Health and Nutrition Examination Survey (HANES) (Ness et al. 1995).

We found significant differences in measures of fertility among the 3 American Indian populations. Our data suggest that women living in Arizona and the Dakotas had higher completed fertility than those in Oklahoma. Not only were there differences in completed fertility between these groups, but these data also identified a cohort effect towards lower fertility in more recent birth cohorts in all 3 centers.

Our findings of geographic differences are in concordance with recently published IHS data on the birth rates of American Indians residing in IHS service areas (Indian Health Service 1996). According to IHS data, birth rates varied from area to area, with the highest birth rates reported in the Dakotas, followed by Arizona and Oklahoma. The finding of lower fertility in more recent birth cohorts is also in concordance with IHS data demonstrating that completed fertility levels of American Indian women are decreasing (Indian Health Service 1996).

Except for the IHS data, only limited data are available on the fertility of American Indians. Some studies have examined the differences in fertility between rural and urban and between reservation and nonreservation American Indian populations (e.g., Findley and Orr 1978; Kuznets 1974). The results of these studies have been contradictory (e.g., Liberty et al. 1976a, 1976b; Warren et al. 1990). The Montana American Indian Health Risk Assessment suggested that the average family size both on and off the reservation was similar (3.4 and 3.3) (Warren et al. 1990). However, this analysis was based on a very small sample. Other studies have suggested that fertility is higher on reservations. A 1976 study of Seminole Indians suggested that the rural reservation Indians achieved higher fertility than those in an urban setting (Liberty et al. 1976b). The authors explained the differential fertility on the basis of birth control use (74% urban, 32.5% reservation). This finding is in agreement with the tendency of newly urbanizing populations to reduce the number of children wanted and produced, a finding reported in populations throughout the world (e.g., Bogue 1969; DeJong 1972). In contrast to these findings, Liberty and colleagues reported the opposite relationship between fertility and urbanization in the Omaha Indians of Nebraska (Liberty et al. 1976a), with urban women producing more children than their reser-

vation counterparts. However, the authors caution that there were problems with small sample sizes.

We found significant differences in the age at natural menopause between the 3 American Indian populations. However, since natural menopause was defined as amennorhea for 1 year, there may be biases in these data because a varying proportion of these populations may have prolonged periods of amennorhea due to obesity and insulin resistance. However, no correlation between age at menopause and body mass index, at the time of interview, was detected.

We also examined proximate determinants, distal determinants, and CVD risk factors as possible causes of the significant differences in completed fertility of these 3 groups. For the proximate determinants, we had information only on contraception use. We examined 2 distal determinants, differences in the level of education and differences in mean family income. Because the SHS is a study of CVD, we examined the relationship between CVD risk factors and fertility, but found no linear associations.

Patterns of Contraceptive Use and Surgical Menopause. According to Bongaarts (1982), a major determinant of fertility levels in contemporary populations is contraceptive use. In general, female sterilization, oral contraceptives, and intrauterine devices are common methods of birth control among American Indian women (Warren et al. 1990). In the Strong Heart Study populations, information was available on the ever-use of oral contraceptives and surgical menopause. Since 1979, IHS has mandated that no hysterectomies be completed as a means of sterilization or to limit family size. In many IHS areas, prior to this legislative mandate, this was also the informal policy. Therefore it is assumed that the surgery was done for medical reasons and not to limit fertility.

Women in Oklahoma reported the highest ever-use of oral contraceptives (31%). In all 3 SHS centers, the use of oral contraceptives increased through the years. This increase is not surprising, since oral contraceptives were not available until the mid 1960s. Women in the first 2 birth cohorts had little opportunity to use oral contraceptives during their reproductive years. Women in the third birth cohort had access to oral contraceptives, but not at the inception of their reproductive years. In contrast, women in the fourth birth cohort had the opportunity to use oral contraceptives for the majority of their reproductive years. This change over time in the availability of oral contraceptives may explain why, among all SHS participants, ever-use of oral contraception did not explain a significant amount of the variation of fertility in regressions using either parity or gravidity as the dependent variable.

Surgical menopause was nearly twice as prevalent among women in the Oklahoma center (46%) as in women in Arizona (29%) and the Dakotas (23%). This level of surgical menopause was high compared to an overall US

average of about 20% (Ross 1983). Other studies of American Indians have reported high levels of surgical menopause (more than 30%), but only among women who had had an average of 4 births. Interestingly, for SHS American Indian women there were no significant differences between women with a natural menopause and those with a surgical menopause in either measure of fertility. In addition, the average fertility measures did not vary across menopausal status, even when each population was considered separately. Thus, the prevalence of surgical menopause could not explain variation in fertility between Strong Heart centers.

Based on the evidence from the ever-use of oral contraceptives and surgical menopause, there is no significant relationship between the patterns of contraceptive use and fertility in these 3 populations. However, this is not to say that contraception does not influence fertility in these populations; rather, oral contraceptive use and surgical menopause were not predictive of total fertility.

Education. In the Strong Heart Study centers, there was significant variation between center participants in the mean years of education completed (Table 5). Participants from Arizona had the lowest mean years of education, followed by those from the Dakotas, and then those from Oklahoma. Additionally, there was an overall increase in the level of education across time in participants from all centers (Table 6). These findings are in concordance with recent data published by the Bureau of the Census and IHS (Bureau of the Census 1995b; Indian Health Service 1996). According to the Bureau of the Census, the level of education of American Indians is increasing. As of 1993, approximately 66% of American Indians 25 years and older were high school graduates, and 9% of American Indians had completed a bachelor's degree (Bureau of the Census 1995a, 1995b).

A significant inverse linear relationship was detected between both gravidity and parity and level of education (Table 7). Throughout the birth cohorts, the level of education has increased and fertility has decreased. The most prominent relationship, with more than 13% of the variation in fertility measures explained, was found in the Oklahoma center, where fertility was lowest and the level of education was highest. Interestingly, there was no significant relationship between the level of education and fertility measures in participants from the Dakotas, even though the variance in years of education of these participants was similar to that of participants from the other two centers.

Income. Closely related to education levels, family income level also may influence fertility (Bongaarts 1978; Bongaarts & Potter 1983). In the Strong Heart Study centers there was significant variation among the centers in the percentage of women with annual per capita incomes less than $10,000 (Table 5). Specifically, Arizona had the most participants with annual incomes

less than $10,000 and Oklahoma had the fewest. Additionally, the mean number of people living in each household was significantly lower in the Oklahoma center than in the other two centers (Welty et al. 1995). These findings are in agreement with Bureau of the Census data, which report that per capita income of Indians living on reservations was $4,478, in contrast to $8,328 for all American Indians (Bureau of the Census 1995b).

Significant inverse correlations were detected between income and both parity and gravidity, when all women were considered together. However, when each center was considered independently, income was related to fertility only in Oklahoma. This difference may be explained by the greater variation in income levels in Oklahoma than in Arizona and the Dakotas.

In summary, these data have shown a linear relationship of both education and income with fertility. The lower fertility of women from the Oklahoma center compared to that of women from the Arizona and Dakota centers may be explained, in part, by the fact that, unlike participants from Arizona and the Dakotas, Oklahoma participants do not live on reservations. The hypothesis that cultural (perhaps in concert with environmental) factors may be the basis of any observed differences in fertility rates, independent of reservation experience, should also be considered. Indeed, differences in fertility rates between centers could be due to the diversity of tribes sampled in each center. Unfortunately, the distribution of sample size and the large amount of missing data on tribal status has made it impossible to test this hypothesis. Therefore, it may be that higher fertility actually characterizes the cultural practices of the tribes in Arizona and the Dakotas, rather than the reservation experience per se.

Conclusion

Several conclusions can be drawn from this study. First, there was significant variation in the fertility measures observed in postmenopausal, evermarried American Indian women in the three Strong Heart Study centers. Specifically, women from Oklahoma achieved lower fertility than those from the Dakotas and Arizona, though all centers had higher rates than other, non-Indian populations. Second, several variables were demonstrated to influence the fertility of these populations. While no significant relationship between contraception and the level of fertility was identified, a significant inverse linear relationship of both education and income with fertility was found. In general, women from Oklahoma, who had lower fertility, also were better educated and had higher incomes than the women from Arizona and the Dakotas. The Strong Heart Study contributes important information on the reproductive patterns among several different American Indian populations, information which has been lacking. This study has made it possible to answer some important questions about the completed fertility of American Indian women living in reservation and nonreservation settings.

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