The effects of competition on assisted reproductive technology outcomes

Melinda B. Henne, M.D., M.S.,[a,b] *and M. Kate Bundorf, Ph.D.*[c]

[a] Combined Federal Fellowship in Reproductive Endocrinology and Infertility, Walter Reed Army Medical Center, Washington, D.C.; [b] Center for Health Policy/Primary Care and Outcomes Research, and [c] Department of Health Research and Policy, Stanford University School of Medicine, Stanford, California

Objective: To evaluate the relationship between competition among fertility clinics and assisted reproductive technology (ART) treatment outcomes, particularly multiple births.
Design: Using clinic-level data from 1995 to 2001, we examined the relationship between competition and clinic-level ART outcomes and practice patterns.
Setting: National database registry.
Patient(s): Clinics performing ART.
Intervention(s): The number of clinics within a 20-mile (32.19-km) radius of a given clinic.
Main Outcome Measure(s): Clinic-level births, singleton births, and multiple births per ART cycle; multiple births per ART birth; average number of embryos transferred per cycle; and the proportion of cycles for women under age 35 years.
Result(s): The number of competing clinics is not strongly associated with ART birth and multiple birth rates. Relative to clinics with no competitors, the rate of multiple births per cycle is lower (−0.03 percentage points) only for clinics with more than 15 competitors. Embryo transfer practices are not statistically significantly associated with the number of competitors. Clinic-level competition is strongly associated with patient mix. The proportion of cycles for patients under 35 years old is 6.4 percentage points lower for clinics with more than 15 competitors than for those with no competitors.
Conclusion(s): Competition among fertility clinics does not appear to increase rates of multiple births from ART by promoting more aggressive embryo transfer decisions. (Fertil Steril® 2010;93:1820–30. ©2010 by American Society for Reproductive Medicine.)

Key Words: Assisted reproductive technology, competition, multiple birth rates, patient selection

Over the past three decades, there has been a sharp rise in the number of multiple births, twins and higher order, in the United States. In the 1970s, twins occurred in 1.8% of all births in the United States, and triplets and higher order multiples occurred in only 0.29% of births. By 2004, the twin rate had almost doubled (3.23% of births), while the high-order birth rate (triplets and higher) had increased more than fivefold to 1.8% of births (1). The increased use of infertility treatments has been a key factor driving these trends (2). Although the high-order multiple-birth rate has declined slightly in the past few years, the twin rate continues to rise (1). This shift may be due to a national trend toward transferring fewer embryos during assisted reproductive technology (ART) cycles (3, 4).

Some have suggested that the demand for high rates of pregnancy among women treated for infertility has encouraged a tacit acceptance of certain complications of the treatment, particularly multiple gestations (5). Although transferring more than one embryo in a given cycle increases the likelihood of a pregnancy, it also increases the risk of a multiple pregnancy (6). Transferring two embryos is associated with a more than threefold increase in the birth rate and a more than 16-fold increase in the twin birth rate. Transferring additional embryos is not associated with an increase in either overall or twin-birth-rates, but it is associated with an increase in the rate of high-order multiple births (6).

The desirability of multiple births, particularly twins, is controversial. Although it is readily accepted that triplets and higher order multiple pregnancies are high risk, many patients perceive twins as a favorable outcome (5, 7–11).

Received September 8, 2007; revised and accepted February 25, 2008; published online April 8, 2008.
M.B.H. has nothing to disclose. M.K.B. has nothing to disclose.
Supported by funding from a National Research Service Award training grant from the Agency for Healthcare Research and Quality (AHRQ) and the Iris M. Litt Fund from the Institute for Research on Women and Gender at Stanford University.
Reprint requests: Melinda B. Henne, M.D., M.S., Department of Obstetrics and Gynecology, Walter Reed Army Medical Hospital, 6900 Georgia Ave., NW, Building 2, Room 2J06, Washington, DC 20307 (FAX: 202-782-5492; E-mail: redbbdoc@aol.com).

0015-0282/10/$36.00

doi:10.1016/j.fertnstert.2008.02.159

However, perinatal morbidity and mortality is higher for twins (12–14), and the maternal and fetal risks of twin pregnancies may be underestimated by patients and their physicians (11, 15, 16). Some clinicians believe the risks of multiples are exaggerated, and others believe the risks do not apply to their patients, particularly if they are older (17). These physicians believe that, because the overall birth rate is lower for older patients, the risk of multiple births is minimal.

Some investigators have argued that competition among clinics providing ART has contributed to the sharp rise in multiple birth rates in the past two decades (11, 13, 15, 18, 19). The concern is that clinics competing for patients respond to patient demand to conceive in fewer cycles at lower cost by transferring more embryos per cycle. Although transferring more embryos increases the likelihood of a birth in a given cycle, it also leads to an increase in multiple birth rates among patients being treated for infertility. Concerns surrounding success rates and competition for patients as well as professional livelihood and status may have "distorted a clear assessment of acceptable and appropriate risks following ART" (17).

The widespread availability of information on clinic outcomes may compound these pressures. The Fertility Clinic Success Rate and Certification Act of 1992 made the reporting and public dissemination of clinic outcomes mandatory. The data are now easily accessible on the Internet, and patients do consider success rates when choosing clinics (20, 21). Many believe that, in a health-care market driven by such league tables, providers face pressure to maximize pregnancy rates at the expense of higher multiple birth rates (15, 22). However, little evidence of this type of effect exists. Indeed, two prior studies have documented that clinics in more competitive markets have *lower* rates of multiple births than those in more competitive markets (23, 24).

We evaluated whether greater competition among providers of infertility treatments is associated with higher multiple birth rates. Similar to existing studies, we examined the relationship between clinic competition and rates of births and multiple births. Our analysis departs from existing studies by adopting a different measure of competition. Existing studies defined markets based on the geopolitical area in which the clinic is located, but we identify a clinic's competitors as those within 20 miles (32.19 km) of that clinic. In addition, we directly examine the relationship between the number of competitors and both embryo transfer rates and patient characteristics to provide evidence on the mechanism by which competition is associated with rates of multiple births.

MATERIALS AND METHODS

Data Sources

Assisted reproductive technology The primary source of data for our analysis is the clinic-level reports of utilization and outcomes of infertility treatments produced by the Society for Assisted Reproductive Technologies (SART), an affiliate of the American Society for Reproductive Medicine (ASRM). In 1989, SART established a voluntary reporting system for clinics that provide ART by collecting information about the utilization and outcomes of these services. The Fertility Clinic Success Rate and Certification Act of 1992 federally mandated participation in the system. The results are compiled annually by the U.S. Centers for Disease Control and Prevention (CDC), and the first national report under this law was completed in 1995. Despite the federal requirement for reporting annual data, up to 10% of clinics annually have either failed to report their data to the CDC or did not provide verification that the tabulated success rates were correct (5). These clinics are identified in the CDC/SART reports, although their results are not reported. This dataset includes 2531 total clinic-years from 1995 to 2001. We used all clinics identified in the CDC/SART reports to calculate our measures of competition, but our analysis was limited to the 2374 clinics that reported their results.

The CDC/SART data are publicly accessible from the CDC website (http://www.cdc.gov/ART/index.htm). For each clinic, the CDC/SART reports include the number ART cycles performed by the source of the oocytes (fresh embryos from nondonor eggs, frozen embryos from nondonor eggs, and donor eggs). The reports also provide the percentages of cycles resulting in live births and the percentage of live births that included multiple infants. Clinics do not report use of less invasive therapies such as ovulation induction and artificial insemination.

We calculated the numbers of ART cycles performed in each clinic. From the percentages provided in the CDC/SART reports, we then calculated the number of births, singleton births, multiple births, the proportion of patients under age 35 years, and the age-weighted mean number of embryos transferred per cycle for each clinic for each year. As it is common practice to transfer more embryos in women of older age, the mean number of embryos transferred is weighted by the number of cycles performed in women of each age group by each clinic. Because the reports do not include the number of multiple births resulting from transfer of frozen embryos or embryos conceived with donor oocytes, all calculations are based on the transfer of fresh embryos from a patient's oocytes. Although excluding these other types of cycles may bias our analysis, this bias is likely to be small because 81% of all ART cycles in the analysis are fresh cycles from nondonor oocytes. In addition, the bias will affect our results only if rates of donor or frozen cycles vary by the level of competition.

We analyzed births rather than pregnancies because births are the outcome relevant to patients and populations, and pregnancies serve only as a surrogate of this outcome. Some may argue that the number of multiple pregnancies serves as a surrogate for the number of embryos transferred, but rather than using this surrogate, we directly examined embryo transfer rates. Finally, we examined differences in outcomes by patient age, but the analysis was limited to women under 35 and 35 and over because this is the only age breakdown that has remained consistent over the years of the study.

Measuring competition Our measure of competition is based on the number of clinics within 20 miles of a given clinic. We identified the postal ZIP code of each clinic from information on the address, city, and state in the CDC/SART report, and mapped the ZIP code of each clinic to the relevant county. We obtained the latitude and longitude of the centroid of the ZIP code from the United States Census Bureau (25) for each clinic and calculated the distance between each clinic using the great circle distance formula:

$$\begin{aligned}\text{Distance} = \ & 3693.0 \times \arccos[\sin\ (\text{lat1}/57.2958) \\ & \times \sin\ (\text{lat2}/57.2958) + \cos\ (\text{lat1}/57.2958) \\ & \times \cos\ (\text{lat2}/57.2958) \\ & \times \cos\ ((\text{lon1} - \text{lon2})/57.2958)]\end{aligned}$$

We identified a clinic's competitors as those within 20 miles of the clinic and recalculated the number of competitors faced by each clinic for each year of analysis.

To allow for nonlinear effects of the number of competitors on the study outcomes, we used a categorical rather than a continuous measure of the number of clinics. The categories include monopoly (one clinic within a 20-mile radius) as the basis of comparison, low competition (two to three clinics), moderate competition (four to five clinics), high to moderate competition (5 to 10) clinics, high competition (11 to 15 clinics), and very high competition (>15 clinics).

Market characteristics We included controls for local characteristics that may affect demand for infertility treatments, independent of the number of competitors. The models include the number and age distribution by 5-year increments of women in the age group most likely to use ART services (25 to 44 years old) in the county from 1995 to 2001 (26). Other control variables include the minority rate, per capita personal income, the unemployment rate, and the proportion of adults with at least a college education. We obtained information on the minority rate from the U.S. Census Bureau (26), county-level income from the U.S. Department of Commerce Bureau of Economic Analysis (27), and unemployment statistics from the U.S. Department of Labor Bureau of Labor Statistics (28). All dollar values were converted to 2001 U.S. dollars using the Consumer Price Index (29). From the Area Resource File (30), we obtained the number of adults (over age 25) with college degrees. For data that was not available for all years, we imputed missing values assuming a linear trend.

The model also includes binary indicators of the county in which the clinic is located. These county fixed effects control for characteristics of counties that are constant over time. Because mandates are adopted at the state level and no state adopted a mandate during the period of our study, insurance mandate status is constant within a county during the period of our study. Thus, county fixed effects serve as controls for state mandate status.

All data analyzed in this study are publicly available through the CDC and other government Web sites. Because no patient-specific data were collected or analyzed, this study did not require approval from our institutional review board.

Statistical Analysis

We first presented bivariate analyses of the relationship between the number of competitors and the dependent variables in our analyses. The variables include births per cycle initiated (both singleton and multiple births), mean number of embryos transferred per cycle, and the proportion of ART births with multiple fetuses.

We then estimated multivariate models of the relationship between outcomes and competition, controlling for a variety of market characteristics that may affect demand for infertility treatments. The key independent variable is the measure of competition, the number of clinics within a 20-mile radius, for each clinic in a given year. The control variables include categorical indicators of the county in which the clinic is located to control for differences across clinics in the characteristics of local markets that are fixed over time and categorical indicators of year to control for trends over time that are common to all areas. In addition, we included the number and age distribution of women aged 25 to 44 years in the market, the minority rate, the unemployment rate, the per capita personal income, and the proportion of adults over age 25 years with at least a high school education (Table 1). Because the models included county fixed effects, these variables control for changes over time in these factors that vary across counties.

To provide evidence on the mechanisms by which competition is related to clinic outcomes, we also examined the relationship between competition and embryo transfer practices. The dependent variable in these models is the average number of embryos transferred per cycle in the clinic, weighted by the proportion of patients of different ages treated by the clinic.

Patient characteristics also influence the likelihood of a live birth following IVF. The only risk factor that is linked to outcomes available in the CDC/SART reports is the age distribution of patients treated. The patients with the highest probability of success are those under the age of 35, with a 37% chance of a live birth after a single treatment of IVF. The likelihood of success begins to fall rapidly for women over 35 years old (6). To evaluate the effect of patient characteristics on the relationship between competition and outcomes, we also estimated models of the proportion of cycles performed in patients under the age of 35 and re-estimated all models of outcomes and embryo transfer rates separately for women under age 35 and women age 35 years and older.

All models were estimated using ordinary least squares regression at the clinic-year level, allowing for

TABLE 1

Independent variables, 1995–2001 (observations = 2374).

Variable	Mean	Standard deviation	Minimum	Maximum
Number of women age 25–44 y (1000)	713.6	852.76	9.85	2,994.01
Number of women age 25–44 y (squared) (1,000,000)	12.3×10^5	25.00×10^5	97.00	89.64×10^5
Proportion of reproductive age women age 25–29 y	23.1	0.16	17.07	32.25
Proportion of reproductive age women age 30–34 y	24.9	0.11	21.30	28.66
Proportion of reproductive age women age 35–39 y	26.6	0.81	22.31	29.18
Minority proportion of population	32.1	15.65	1.85	79.73
Per capita personal income (thousands $)	31.3	5.57	5.99	61.13
Unemployment rate	7.2	9.61	1.32	79.53
Percent adults college degree	27.3	5.70	14.21	48.78

Henne. Competition and ART outcomes. Fertil Steril 2010.

heteroskedasticity and nonindependence within clinics over time in the error terms when calculating the statistical significance of the results. Statistical analysis was performed using Stata, version 8 (Stata Corporation, Cary, NC).

RESULTS

The number of clinics performing ART and the number of ART cycles grew rapidly in the United States between 1995 and 2001.The number of clinics performing ART in

FIGURE 1

Number of ART clinics within 20-mile radius by year, 1995–2001.The yellow highlighted areas emphasize the reduction of markets of particular sizes. The blue highlighted areas emphasize the increase in markets of larger sizes. [a]Percentage in parentheses.

Number of Clinics	1995	1996	1997	1998	1999	2000	2001
1	61 (23.7)[a]	57 (19.1)	57 (17.1)	53 (14.8)	56 (15.3)	56 (14.7)	52 (13.7)
2-3	88 (34.2)	91 (30.5)	91 (27.3)	97 (27.1)	99 (27.0)	102 (26.8)	111 (29.1)
4-5	54 (21.0)	65 (21.8)	77 (23.1)	66 (18.4)	56 (15.3)	60 (15.8)	48 (12.6)
6-10	48 (18.7)	62 (20.8)	66 (19.8)	88 (24.6)	94 (25.6)	101 (26.6)	95 (24.9)
11-15	6 (2.3)	9 (3.0)	12 (3.6)	18 (5.0)	21 (5.7)	20 (5.3)	27 (7.1)
>15	0 (0)	14 (4.7)	30 (9.0)	36 (10.1)	41 (11.2)	41 (10.8)	48 (12.6)

Henne. Competition and ART outcomes. Fertil Steril 2010.

TABLE 2

Unadjusted mean outcomes by level of competition, 1995–2001.

Number of clinics	Observations	Births/cycle	Singleton/cycle	Multiples/cycle	Multiples/birth	Mean embryos	Proportion <35
Overall	2374	0.24 (0.097)	0.15 (0.065)	0.09 (0.052)	0.36 (0.153)	3.56 (0.735)	46.18 (12.088)
1	392	0.24 (0.098)	0.15 (0.064)	0.09 (0.051)	0.36 (0.151)	3.53 (0.774)	51.57 (10.234)
2–3	679	0.24 (0.095)	0.15 (0.067)	0.09 (0.051)	0.36 (0.143)	3.47 (0.729)	50.45 (11.452)
4–5	428	0.23 (0.097)	0.14 (0.065)	0.08 (0.054)	0.35 (0.158)	3.67 (0.704)	44.69 (10.817)
6–10	553	0.24 (0.099)	0.15 (0.067)	0.07 (0.053)	0.34 (0.160)	3.55 (0.792)	42.70 (11.883)
11–15	113	0.24 (0.089)	0.15 (0.062)	0.08 (0.045)	0.36 (0.125)	3.57 (0.619)	40.53 (12.423)
>15	209	0.25 (0.101)	0.15 (0.068)	0.08 (0.047)	0.35 (0.161)	3.69 (0.595)	37.50 (11.348)
P value[a]		NS	NS	NS	NS	<.001	<.001

Note: The values represent the mean rate among clinics with a given number of competitors. For example, the average rate of live births per cycle was 0.24 among clinics in monopoly markets. Standard deviation in parentheses.

[a] Statistical significance determined by one-way analysis of variance (ANOVA).

Henne. Competition and ART outcomes. Fertil Steril 2010.

the United States (including the District of Columbia, excluding Puerto Rico) increased 62% from 257 in 1995 to 416 in 2001. The number of ART cycles performed nationwide increased at a faster rate during this time period, from 52,658 in 1995 to 100,242 in 2001 (90% increase).

The amount of competition among clinics also increased dramatically during this period (Figure 1). In 1995, 61 clinics (24%) were monopolies (i.e., one clinic in a 20-mile radius), 34% (88 clinics) had only one to two competitors (two to three clinics within a 20-mile radius), and there were no clinics with >15 competitors within a 20-mile radius. By 2001, only 14% (52 clinics) were monopolies, and only 29% (111 clinics) had only one to two competitors (two to three clinics within 20-mile radius). However, an increasing proportion of clinics had at least five competitors (6 to 10 clinics within a 20-mile radius), and 13% of clinics (48) had more than 15 competitors (≥15 clinics within a 20-mile radius).

Based on the bivariate analyses, competition appears to have little relationship with treatment outcomes (Table 2). Birth and multiple birth rates are similar across all levels of competition. At different levels of competition, the mean birth rate per cycle ranges from 24% to 25%, and the singleton birth rate per cycle is consistently approximately 15%. Rates of multiple births per cycle range from 7% to 9%, and rates of multiple births per birth range from 34% to 35% at different levels of competition. However, the proportion of cycles for women under 35 years of age declines with the number of competitors. Although the bivariate comparisons provide little evidence of relationship between competition and birth outcomes, we estimated multivariate models to determine if these results are confounded by trends over time in outcomes or demographic and socioeconomic characteristics of markets.

Multivariate Analysis

We found no evidence of a statistically significant relationship between competition and birth and singleton birth rates in the multivariate models (Table 3). Clinics with many competitors (>15) have 0.03 (P=.011) fewer multiple births per ART cycle initiated; however, this does not translate to a lower proportion of births that are multiples. A small increase in the multiple-birth rate per cycle at low levels of competition relative to single-clinic markets was not statistically significant and quickly reversed. The test that the coefficients on the categorical indicators of competition are jointly zero approaches statistical significance (P=.058).

From the analysis of clinic outcomes, it appears that increasing competition is associated with slightly lower rates of multiple births at high levels of competition. We tested the hypothesis that the mechanism by which clinics with many competitors reduce multiple birth rates is by transferring fewer embryos by estimating models of the relationship between competition and the mean number of embryos transferred per cycle. We found no evidence that the level of competition is

TABLE 3

Effect of competition on clinic-level outcomes, 20-mile radius, 1995–2001.[a]

Number of clinics[b]	Births/cycle	*P* value	Singletons/cycle	*P* value	Multiples/cycle	*P* value	Multiples/birth	*P* value
2–3 clinics	0.004[c] (0.013)[d]	NS	0.0003 (0.008)	NS	0.001 (0.007)	NS	0.01 (0.019)	NS
4–5 clinics	−0.01 (0.017)	NS	−0.01 (0.011)	NS	−0.001 (0009)	NS	0.03 (0.025)	NS
6–10 clinics	−0.01 (0.018)	NS	−0.01 (0.011)	NS	−0.01 (0.009)	NS	0.01 (0.025)	NS
11–15 clinics	−0.02 (0.023)	NS	−0.01 (0.014)	NS	−0.02 (0.012)	.13	−0.02 (0.028)	NS
>15 clinics	−0.04 (0.023)	.14	−0.02 (0.014)	NS	−0.03 (0.010)	.01	−0.03 (0.030)	NS
Observations	2374		2374		2374		2349[f]	
R squared[e]	0.31		0.23		0.21		0.15	
F statistic for competition	0.85	NS	0.89	NS	2.15	.058	1.61	.16

[a] Models were estimated using multivariate ordinary least squares regression analysis. Control variables include year and market fixed effects as well as the size of the relevant population in singular and quadratic forms, the distribution of the population by age, minority rate, mean per capita personal income, unemployment rate, and percentage of adults with a college education.

[b] The reference category is monopoly market (1 clinic within 20-mile radius).

[c] The values represent the regression coefficient of the model. Clinics in markets with 2–3 clinics had 0.004 more births per cycle (although not statistically significant) than monopoly clinics.

[d] Robust standard errors in parentheses.

[e] R squared is the proportion of the variation in the dependent variable that is explained by the independent variables in the model.

[f] As some clinics had no births during a reporting year, the number of observations with the number of births as the denominator is lower than the number of reporting clinics.

Henne. Competition and ART outcomes. Fertil Steril 2010.

TABLE 4

Effect of competition on the number of embryos transferred and patient selection, 1995–2001.[a]

Number of clinics	Mean number of embryos	*P* value	Proportion of young patients (<35)	*P* value
2–3[b]	−0.08[c] (0.092)[d]	NS	−0.34 (1.185)	NS
4–5	−0.03 (0.139)	NS	−2.45 (1.767)	NS
6–10	−0.02 (0.134)	NS	−3.06 (1.744)	.08
11–15	−0.06 (0.150)	NS	−5.94 (2.248)	.01
>15	0.02 (0.148)	NS	−6.38 (2.667)	.02
Observations	2374		2374	
R squared[e]	0.55		0.45	
F statistic for competition	0.53	NS	2.04	.07

[a] Models were estimated using multivariate ordinary least squares regression analysis. Control variables include year and market fixed effects as well as the size of the relevant population in singular and quadratic forms, the distribution of the population by age, minority rate, mean per capita personal income, unemployment rate, and percentage of adults with a college education.
[b] The reference category is monopoly market (1 clinic within 20-mile radius).
[c] The values represent the regression coefficient of the model. Clinics in markets with 2–3 clinics transferred 0.08 fewer embryos per cycle (although not statistically significant) than monopoly clinics.
[d] Robust standard errors in parentheses.
[e] R squared is the proportion of the variation in the dependent variable that is explained by the independent variables in the model.

Henne. Competition and ART outcomes. Fertil Steril 2010.

associated with the number of embryos transferred (Table 4). We cannot reject the hypothesis that the coefficient for each of the categorical variables is zero nor can we reject the hypothesis that the coefficients on these variables are jointly zero.

An alternative explanation for the association between competition and lower multiple birth rates is that competition is associated with changes the underlying patient mix, and this influences the probability that a cycle results in a multiple birth. These patient characteristics potentially include age, hormone levels, cause and/or duration of infertility, and history of previous live birth or miscarriage. The only patient characteristic available in the CDC/SART data that is linked to outcomes is the age distribution of the patients treated by a clinic. The birth rate, the multiple birth rate, and the proportion of births that are multiples are lower for older women, despite the transfer of more embryos per cycle.

Competition is strongly associated with the distribution of cycles by patient age (see Table 4). The proportion of young patients is 3.06% lower for moderately competitive clinics (6 to 10 clinics within 20 miles) compared with monopoly clinics. The relationship between competition and patient selection becomes even more pronounced at higher levels of competition. The proportion of young patients treated at clinics facing the greatest number of competitors is 6.38% (P=.02) lower than that of monopoly clinics. The test of whether the coefficients on the categorical indicators of competition are jointly zero also approaches statistical significance (P=.07). Because rates of multiple births are lower in older patients, it is likely that the age distribution of patients, rather than differences in embryo transfer practices, contributes to the reduction in multiple births after ART seen in highly competitive markets.

We investigated this further by estimating models of birth outcomes and embryo transfer rates separately by age group (Table 5). For women under age 35, the effects of competition are similar to those when all ages are analyzed together. Total and singleton birth rates per cycle are not associated with competition; however, the rate of multiple births per cycle is 0.04 lower at the highest level of competition relative to monopoly (P=.05). This does not result in a net change in the rate of multiple births per ART birth, and we found no evidence that competition is associated with the number of embryos transferred.

The results for women age 35 years and older differed from those from the pooled sample. Although we found some evidence that births per cycle are lower for clinics facing the highest level of competition, this effect was driven primarily by singleton rather than multiple births per cycle. Rates of both total births and singleton births per cycle are 0.03 lower in clinics with many competitors (>15 clinics) than in monopoly clinics, and this approaches statistical significance (P=.09). However, neither multiple births per cycle nor multiples per ART birth vary by the level of competition. In addition, the results provide no evidence that embryo transfer rates are associated with the number of competitors.

TABLE 5

Effect of competition on outcomes by patient age, 1995–2001.[a]

Number of clinics[b]	Births/ cycle	*P* value	Singleton/ cycle	*P* value	Multiples/ cycle	*P* value	Multiples/ birth	*P* value	Mean number of embryos	*P* value
Women age < 35 y										
2–3	0.01[c] (0.017)[d]	NS	0.01 (0.017)	NS	0 (0.009)	NS	0 (0.024)	NS	−0.07 (0.105)	NS
4–5	−0.01 (0.021)	NS	0 (0.021)	NS	0 (0.013)	NS	0.03 (0.027)	NS	−0.02 (0.162)	NS
6–10	0 (0.022)	NS	0 (0.022)	NS	−0.01 (0.013)	NS	0 (0.028)	NS	0.02 (0.155)	NS
11–15	0.01 (0.027)	NS	0.01 (0.027)	NS	−0.02 (0.017)	NS	−0.03 (0.035)	NS	−0.04 (0.176)	NS
>15	−0.03 (0.028)	NS	−0.03 (0.028)	NS	−0.04 (0.019)	.05	−0.04 (0.038)	NS	0.12 (0.185)	NS
Observations[e,f]	2372		2372		2372		2326		2372	
F statistic for competition	1.17	NS	1.17	NS	1.17	NS	1.10	NS	0.8	NS
Women age ≥35 y										
2–3	−0.01[c] (0.012)[d]	NS	−0.01 (0.012)	NS	0 (0.005)	NS	0.04 (0.034)	NS	−0.10 (0.098)	NS
4–5	−0.01 (0.016)	NS	−0.01 (0.016)	NS	0 (0.007)	NS	0.03 (0.045)	NS	−0.05 (0.137)	NS
6–10	−0.02 (0.016)	NS	−0.01 (0.016)	NS	0 (0.008)	NS	0.07 (0.042)	NS	−0.07 (0.136)	NS
11–15	−0.01 (0.020)	NS	−0.01 (0.020)	NS	0 (0.010)	NS	0.04 (0.046)	NS	−0.10 (0.151)	NS
>15	−0.03 (0.020)	.09	−0.03 (0.020)	.09	−0.01 (0.009)	NS	0.01 (0.044)	NS	−0.13 (0.145)	NS
Observations[e,f]	2366		2366		2366		2276		2366	
F statistic for competition	0.69	NS	0.69	NS	1.28	NS	1.83	NS	0.39	NS

[a] Models were estimated using multivariate ordinary least squares regression analysis. Control variables include year and market fixed effects as well as the size of the relevant population in singular and quadratic forms, minority rate, mean per capita personal income, unemployment rate, and percentage of adults with a college education.

[b] The reference category is monopoly market (1 clinic within 20-mile radius).

[c] The values represent the regression coefficient of the model. For example, in women under age 35 years, clinics in markets with 2–3 clinics had 0.01 more births per cycle (although not statistically significant) than monopoly clinics.

[d] Robust standard errors in parentheses.

[e] R squared is the proportion of the variation in the dependent variable that is explained by the independent variables in the model.

[f] All clinics did not treat patients of all ages. Of 2374 clinics, only 2372 performed cycles in women under age 35 years, and 2366 performed cycles in women over age 35 years. For this reason, the number of observations analyzed is lower for models of outcomes by age than for models in the data are pooled by age.

Henne. Competition and ART outcomes. Fertil Steril 2010.

DISCUSSION

The effect of competition in health-care markets is controversial, and studies of other health-care markets have produced conflicting results. For example, some studies have found that competition among hospitals led to reductions in overall costs (31), but others found that competition increased costs (32, 33). A potentially important issue in these types of studies is the existence of bias due to unobserved case mix and patient selection (32, 34, 35).

Because the market for infertility services differs from other health-care markets in several ways, it is particularly important to understand the effects of competition in this setting. Treatments for infertility are performed in outpatient clinics and are largely elective, allowing patients more opportunity to choose their providers than they may have in urgent settings. The relevant outcomes, births and multiple births as a proportion of treatment cycles, are easily measured, and success rates for clinics providing ART services are readily available to the public for review and comparison. Finally, infertility treatments are often not covered by insurance but instead are paid directly by the patients. Because of these differences, the effects of competition on the market for infertility services may differ from those in other health-care markets.

We found that multiple births per ART cycle are lower rather than higher, as has been suggested, for clinics in highly competitive markets. However, we found no evidence that this was a result of differences in embryo transfer practices. Rather, it may be due to differences in patient mix. Relative to monopoly clinics, clinics with many competitors treat a lower proportion of young patients, and success rates for fertility treatments are lower for older women. Age was the risk factor we were able to examine, but it is conceivable that clinics in highly competitive markets also treat a greater proportion of women with other factors that may reduce their likelihood of success.

The potential for patient case mix to explain lower rates of multiple births in highly competitive markets is supported by our separate analyses of younger and older women. We did not find evidence of a strong relationship between competition and the number of embryos transferred per cycle for either older or younger women. In younger women, we found that multiple birth rates per cycle were lower in highly competitive markets without a reduction in singleton birth rates. However, in older women, we found that a reduction in birth rates was driven by a reduction in singleton births without a contribution by differences in multiple birth rates. These findings suggest that unobserved patient mix, rather than embryo transfer practices, drives the observed reductions in birth rates.

Two recent studies have found that competition among fertility clinics is associated with lower rates of multiple births (23, 24). Both defined markets based on geopolitical boundaries, such as the Metropolitan Statistical Areas, Core-Based Statistical Areas, Combined Statistical Areas[1] or the county. Our study contributes to this literature by testing an alternative market definition. Depending on the definition, the geopolitical boundaries used in other studies may be too small to account for all relevant competitors or so large as to inappropriately include irrelevant clinics as competitors. We evaluated the effects of competition defining markets based on the number of clinics within a fixed radius.

Identifying the relevant competitors as clinics within a 20-mile radius is correct only under certain assumptions. For example, if there are many clinics to choose from within 20 miles, patients may be unwilling to travel greater distances for care. Conversely, if there are very few clinics within 20 miles, it is likely they are in a more sparsely populated area and there may be very few additional clinics located within the greater distance. If these assumptions are correct, the geopolitical market definitions or larger market definitions may misspecify the market.

We conducted a variety of tests to determine whether our conclusions are sensitive to the 20-mile radius assumption. We analyzed the impact of competition using geopolitical market definitions and found no differences in outcomes at any level of competition (data not shown). Also, when analyzing ART outcomes and treatment patterns of clinics, expanding the market definition to a 50-mile radius did not change the results of the models for outcomes but obscured the effect of competition on patient selection (data not shown). We also estimated models in which we included the number of clinics within 20 miles as well as the incremental number of clinics within 20 to 50 miles as independent variables. The coefficients on the variables measuring the number of competitors within 20 to 50 miles were not statistically significant (data not shown). Finally, we interacted each category of competition at a 20-mile radius with an indicator of whether there were additional clinics within an additional 30-mile increment. Again, the coefficients with this interaction were not statistically significant (data not shown). In general, our results suggested that they were not sensitive to the choice of 20 miles as the radius to define competitors.

[1] In 2000, the U.S. Office of Management and Budget (OMB) announced the adoption of standards for defining metropolitan and micropolitan statistical areas. These new standards replaced the 1990 standards for defining metropolitan areas. In 2003, these metropolitan and micropolitan statistical areas were redefined as core-based statistical areas (CBSAs). A CBSA consists of a county (or equivalent entity) and is defined as "a geographic entity associated with at least one core, plus adjacent territory that has a high degree of social and economic integration with the core, as measured by commuting ties." The core must have at least 50% of its population in an urban area with at least 10,000 (micropolitan) or 50,000 (metropolitan) people. A county qualifies as an outlying county of the CBSA if at least 25% of the employed residents of the county work in the core or at least 25% of workers in the county live in the core. Any two or more adjacent CBSAs will form a Combined Statistical Area (CSA) when there is at least 25% employment interchange (commuting), or by local opinion if there is between 15% to 25% employment interchange.

Like Steiner et al. (23), we did not find that competition was associated with overall birth rates per ART cycle, but it was associated with a reduction in rates of multiple births. Although they observed a greater difference in multiple rates at more intermediate levels of competition, they measured high-order multiple gestations whereas we measured all multiple births. Because it is not possible to determine how many of the high-order multiple gestations were reduced to twins or singletons, actual births are a more concrete measure of the impact of competition on ART outcomes. We further evaluated embryo transfer practices, which have been suggested to correlate with multiple gestations, but found no difference in embryo transfer practices at various levels of competition. However, we did find that greater competition was associated with a change in patient mix; clinics with more competitors treated a greater proportion of lower fertility women.

Hamilton and McManus (24) found that the numbers of embryos transferred are lower in non-monopoly markets. They proposed that their findings were not driven by patient risk characteristics because low-fertility patients are likely to transfer more, rather than fewer, embryos. However, women with lower probability of success may also have fewer embryos available to transfer. The number of embryos *available* for transfer is more predictive of success than the number of embryos *actually* transferred (16).

One potential limitation in our study was the use of the fixed radius measure, which may not accurately measure competition if the size of the market varies across areas (36). For example, in rural areas, patients may be willing to travel farther for treatment than in urban areas, creating a larger geographic market. However, patient flow data would be necessary to determine the extent to which the 20-mile radius measure reflects actual treatment patterns (37, 38).

It is possible that our findings with respect to the relationship between competition and patient mix are driven by clinic location decisions. Markets may be more competitive in areas where the demand for infertility treatment is greater due to differences in patient characteristics, particularly the age of women in the region. In fact, the coasts have much more densely located ART clinics than the more central states. If women in these markets are more likely to delay childbearing for education and careers, then the proportion of young patients seen in those markets would be lower. We included controls for a variety of market-level demographics, but in the absence of detailed patient-level data, it is possible that these types of differences affect results across markets.

A potentially important difference across markets is the extent to which insurers cover the treatment of infertility. Many states have adopted mandates requiring insurers to cover the treatment of infertility, and research examining the effects of these mandates indicates that they influence treatment patterns (39, 40) as well as the composition of the population seeking treatment for infertility (41). In our analysis, we directly control for the presence of these types of mandates by including binary indicators of the county in which the clinic is located. These variables control for characteristics of counties that are fixed over time. Because mandates are adopted at the state level and state mandate status did not change during the period of our study, these county fixed effects control for differences due to insurance mandates. Thus, our results are unlikely to be influenced by differences across markets in regulations influencing the extent of insurance coverage.

From these results, we conclude that the extent of competition among clinics providing ART is unlikely to influence the number of embryos transferred as suggested by previous studies. Instead, we argue that, in the most competitive markets, clinics provide a greater proportion of cycles for women with a less favorable prognosis (i.e., older patients). Although this may signal the existence of greater access to care for patients who might otherwise not have the opportunity for treatment in less competitive markets, it is also possible that the clinics are more likely to locate in areas with greater demand for infertility treatment among poor-prognosis patients.

REFERENCES

1. Martin JA, Hamilton BE, Sutton PD, Ventura SJ, Menacker F, Kirmeyer S. Births: final data for 2004. Natl Vital Stat Rep 2006;55:1–101.
2. Martin JA, Park MM. Trend in twin and triplet births: 1980–1997. Natl Vital Stat Rep 1999;47:1–16.
3. Stern JE, Cedars MI, Jain T, Klein NA, Beaird CM, Grainger DA, et al. Assisted reproductive technology practice patterns and the impact of embryo transfer guidelines in the United States. Fertil Steril 2007;88:275–82.
4. Jain T, Missmer SA, Hornstein MD. Trends in embryo-transfer practice and in outcomes of the use of assisted reproductive technology in the United States. N Engl J Med 2004;350:1639–45.
5. Bhattacharya S, Templeton A. In treating infertility, are multiple pregnancies unavoidable? N Engl J Med 2000;343:58–60.
6. Center for Disease Control. Assisted Reproductive Technology Reports. Available at: www.cdc/gov/reproductivehealth/art.htm. Accessed March 1, 2004.
7. Hoffman DI. Should we consider twins a success in OI and ART? Yes … given the limitations of technology and our health-care system, twins are acceptable, if not desirable. Contemp Obstet Gynecol 2002;2002:44–61.
8. Goldfarb J, Kinzer DJ, Boyle M, Kurit D. Attitudes of in vitro fertilization and intrauterine insemination couples toward multiple gestation pregnancy and multifetal pregnancy reduction. Fertil Steril 1996;65:815–20.
9. Gleicher N, Campbell DP, Chan CL, Karande V, Rao R, Balin M, et al. The desire for multiple births in couples with infertility problems contradicts present practice patterns. Hum Reprod 1995;10:1079–84.
10. Murdoch A. Triplets and embryo transfer policy. Hum Reprod 1997;12: 88–92.
11. Ryan GL, Zhang SH, Dokras A, Syrop CH, Van Voorhis BJ. The desire of infertile patients for multiple births. Fertil Steril 2004;81:500–4.
12. Adashi EY, Barri PN, Berkowitz R, Peter B, Bryan E, Carr J, et al. Infertility therapy–associated multiple pregnancies (births): an ongoing epidemic. Reprod Biomed Online 2003;7:515–42.
13. Fritz MA. Infertility treatment and the multifetal gestation epidemic: too much of a good thing. Contemp Obstet Gynecol 2002;2002:65–92.
14. Reindollar RH. Should we consider twins a success in OI and ART? No … the costs to the couple and society are too high. Contemp Obstet Gynecol 2002;2002:44–61.
15. Faber K. IVF in the US: multiple gestation, economic competition, and the necessity of excess. Hum Reprod 1997;12:1614–6.

16. Templeton A. The multiple gestation epidemic: the role of the assisted reproductive technologies. Am J Obstet Gynecol 2004;190:894–8.
17. Templeton A. Avoiding multiple pregnancies in ART: replace as many embryos as you like—one at a time. Hum Reprod 2000;15:1662.
18. Schlaff W. Impact of insurance coverage on in vitro fertilization practice patterns: a complex relationship. Fertil Steril 2003;80:30–1.
19. Wells M. Doctors warn on test-tube births. Guardian November 5, 1999.
20. Marcus HJ, Marcus DM, Marcus SF. How do infertile couples choose their IVF centers? An Internet-based survey. Fertil Steril 2005;83:779–81.
21. Lass A, Brindsden P. How do patients choose private in vitro fertilization treatment? A customer survey in a tertiary fertility center in the United Kingdom. Fertil Steril 2001;75:893–7.
22. Fisk NM, Trew G. Two's company, three's a crowd for embryo transfer. Lancet 1999;354:1572–3.
23. Steiner AZ, Paulson RJ, Hartmann KE. Effects of competition among fertility centers on pregnancy and high-order multiple gestation rates. Fertil Steril 2005;83:1429–34.
24. Hamilton BH, McManus B. Infertility Treatment markets: the effects of competition and policy. John B. Olin School of Business. St. Louis, MO: Washington University, 2005.
25. United States Census Bureau. 2000 U.S. Gazetteer. Available at: http://www.census.gov/cgi-bin/gazetteer. Accessed February 7, 2005.
26. U.S. Census Bureau. Population Estimates. Available at: http://www.census.gov/popest/archives. Accessed August 2, 2004.
27. U.S. Department of Commerce Bureau of Economic Analysis. Per Capita Personal Income. Available at: http://www.bea.doc.gov/regional/reis. Accessed August 4, 2004.
28. U.S. Department of Labor Bureau of Labor Statistics. Local Area Unemployment Statistics. Available at: http://data.bls.gov/cgi-bin/surveymost?la. Accessed August 2, 2004.
29. U.S. Department of Labor Bureau of Labor Statistics. Consumer Price Index. Available at: http://www.bls.gov/cpi/home.html#tables. Accessed August 4, 2004.
30. U.S. Department of Health and Human Services, Heath Resources and Services Administration, Bureau of Health Professions. Area Resource File. Rockville, MD. Accessed February 2003.
31. Rivers PA, Glover S, Munchus G. Hospital competition in major U.S. metropolitan areas: empirical evidence. J Health Hum Serv Adm 2000;23:37–49.
32. Robinson JC, Luft HS. The impact of hospital market structure on patient volume, average length of stay, and the cost of care. J Health Econ 1985;4:333–56.
33. Frech HE. Competition and monopoly in health care. Press A, ed. Washington, DC. 1996.
34. Tay A. Assessing competition in hospital care markets: the importance of accounting for quality differentiation. Rand J Econ 2003;34:786–814.
35. Kessler DP, McClellan MB. Is hospital competition socially wasteful? Q J Econ 2000;115:577–615.
36. Gresenz CR, Rogowski J, Escarce JJ. Updated variable-radius measures of hospital competition. Health Serv Res 2004;39:417–30.
37. Gaynor M, Vogt WB. Competition among hospitals. Rand J Econ 2003;34:764–85.
38. Phibbs CS, Robinson JC. A variable-radius measure of local hospital market structure. Health Serv Res 1993;28:313–24.
39. Jain T, Harlow BL, Hornstein MD. Insurance coverage and outcomes of in vitro fertilization. N Engl J Med 2002;347:661–6.
40. Reynolds MA, Schieve LA, Jeng G, Peterson HB. Does insurance coverage decrease the risk for multiple births associated with assisted reproductive technology? Fertil Steril 2003;80:16–23.
41. Henne M, Bundorf M. Insurance mandates and trends in infertility treatments. Fertil Steril 2008;89:66–73.