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Assisted Reproductive Technology Surveillance --- United States, 2002

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Abstract

Problem/Condition: In 1996, CDC initiated data collection regarding assisted reproductive technology (ART) procedures performed in the United States, as mandated by the Fertility Clinic Success Rate and Certification Act (FCSRCA) (Public Law 102-493, October 24, 1992). ART includes fertility treatments in which both eggs and sperm are handled in the laboratory (i.e., in vitro fertilization and related procedures). Patients who undergo ART treatments are more likely to deliver multiple-birth infants than women who conceive naturally. Multiple births are associated with increased risk for mothers and infants (e.g., pregnancy complications, premature delivery, low-birthweight infants, and long-term disability among infants).

Reporting Period Covered: 2002.

Description of System: CDC contracts with the Society for Assisted Reproductive Technology (SART) to obtain data from ART medical centers located in the United States. Since 1997, CDC has compiled data related to ART procedures.

Results: In 2002, a total of 115,392 ART procedures were reported to CDC. These procedures resulted in 33,141 live-birth deliveries and 45,751 infants. Nationally, 74% of ART procedures used freshly fertilized embryos from the patient's eggs; 14% used thawed embryos from the patient's eggs; 8% used freshly fertilized embryos from donor eggs; and 3% used thawed embryos from donor eggs. Overall, 42% of ART transfer procedures resulted in a pregnancy, and 34% resulted in a live-birth delivery (delivery of one or more live-born infants). The highest live-birth rates were observed among ART procedures using freshly fertilized embryos from donor eggs (50%). The highest numbers of ART procedures were performed among residents of California (15,117), New York (13,276), Massachusetts (8,631), New Jersey (7,744), and Illinois (7,492). These five states also reported the highest number of infants conceived through ART. Of 45,751 infants born through ART, 53% were born in multiple-birth deliveries. The multiple-birth risk was highest for women who underwent ART transfer procedures using freshly fertilized

embryos from either donor eggs (42%) or their own eggs (35%). Number of embryos transferred, embryo availability (an indicator of embryo quality), and patient's age were also strong predictors of multiple-birth risk. Approximately 1% of U.S. infants born in 2002 were conceived through ART. Those infants accounted for 17% of multiple births nationally. The percentage of ART infants who were low birth rate ranged from 9% among singletons to 95% among triplets or higher order multiples. The percentage of ART infants born preterm ranged from 15% among singletons to 97% among triplets or higher order multiples.

Interpretation: Whether an ART procedure resulted in a pregnancy and live-birth delivery varied according to different patient and treatment factors. ART poses a major risk for multiple births. This risk varied according to the patient's age, the type of ART procedure performed, the number of embryos transferred, and embryo availability (an indicator of embryo quality).

Public Health Actions: ART-related multiple births represent a sizable proportion of all multiple births nationally and in selected states. Efforts should be made to limit the number of embryos transferred for patients undergoing ART. In addition, adverse infant health outcomes (e.g., low birthweight and preterm delivery) should be considered when assessing the efficacy and safety of ART.

Introduction

For ≥ 2 decades, assisted reproductive technologies (ARTs) have been used by couples to overcome infertility. ARTs include those infertility treatments in which both eggs and sperm are handled in the laboratory for the purpose of establishing a pregnancy (i.e., in vitro fertilization and related procedures). Since the birth of the first U.S. infant conceived with ART in 1981, use of these treatments has increased dramatically. Each year, both the number of medical centers providing ART services and the total number of procedures performed have increased notably (*1*).

In 1992, Congress passed the Fertility Clinic Success Rate and Certification Act (FCSRCA),* which requires each medical center in the United States that performs ART to report data to CDC annually on every ART procedure initiated. CDC uses the data to report medical center-specific pregnancy success rates. In 1997, CDC published the first surveillance report under this mandate (*2*). That report was based on ART procedures performed in 1995. Since then, CDC has continued to publish a surveillance report annually that details each medical center's success rates. CDC has also used this surveillance data file to perform more in-depth analyses of infant outcomes (e.g., multiple births) (*3--8*). Multiple-infant births are associated with greater health problems for both mothers and infants, including higher rates of caesarean deliveries, prematurity, low birthweight, and infant death and disability. In the United States, ART has been associated with a substantial risk for multiple gestation pregnancy and multiple birth (*3--8*). In addition to the multiple-birth risks, recent studies suggest an increased risk for low birthweight among singleton infants conceived through ART (*9,10*). This report is based on ART surveillance data provided to CDC's National Center for Chronic Disease Prevention and Health Promotion (NCCDPHP), Division of Reproductive Health, regarding procedures performed in 2002. A report of these data according to the medical center in which the procedure was performed was published separately (*1*). In this report, emphasis is on presenting state-specific data and presenting more detailed data regarding risks associated with ART (e.g., multiple birth, low birthweight, and preterm delivery).

Methods

Each year, the Society for Assisted Reproductive Technology (SART), an organization of ART providers affiliated with the American Society for Reproductive Medicine, collects data regarding ART procedures from medical centers performing ART in the United States and its territories and provides these data to CDC by contract. A full description of the ART data reporting system has been previously published (*11*). Data collected include patient demographics, medical history and infertility diagnoses, clinical information pertaining to the ART procedure, and information regarding resultant pregnancies and births. The data file is organized with one record per ART procedure performed. Multiple procedures from a single patient are not linked. Despite the federal mandate, certain centers (<10%/year) have not reported their data; the majority of these are believed to be smaller-than-average practices. For this report, data pertaining to ART procedures initiated January 1--December 31, 2002, are presented.

ART data and outcomes from ART procedures are presented by patient's state of residence at time of ART treatment. In cases of missing residency data (<9%), the state of residency was assigned as the state in which the ART

procedure was performed. In addition, data regarding the number of ART procedures in relation to the total population for each state are indicated.[†] Data regarding number of procedures are also presented by treatment type and stage of treatment. ART procedures are classified into four groups according to whether a woman used her own eggs or received eggs from a donor and whether or not the embryos transferred were freshly fertilized or previously frozen and thawed. Because both live-birth rates and multiple-birth risk vary substantially among these four treatments groups, data are presented separately for each type.

In addition to treatment types, within a given treatment procedure, different stages exist. A typical ART procedure begins when a woman starts taking drugs to stimulate egg production or begins having her ovaries monitored with the intent of having embryos transferred. If eggs are produced, the procedure progresses to the egg-retrieval stage. After the eggs are retrieved, they are combined with sperm in the laboratory, and if fertilization is successful, the resulting embryos are selected for transfer. If the embryo implants in the uterus, the cycle progresses to a clinical pregnancy (i.e., the presence of a gestational sac detectable by ultrasound). The resulting pregnancy might progress to a live-birth delivery. A live-birth delivery is defined as the delivery of one or more live-born infants. Only ART procedures involving freshly fertilized eggs include an egg-retrieval stage; ART procedures using thawed eggs do not include egg retrieval, because eggs were fertilized during a previous procedure and the resulting embryos were frozen until the current procedure. An ART procedure can be discontinued at any step for medical reasons or by the patient's choice.

Variations in a typical ART procedure are noteworthy. Although a typical ART procedure includes in vitro fertilization (IVF) of gametes, culture for ≥ 2 days and embryo transfer into the uterus (i.e., transcervical embryo transfer), in certain cases, unfertilized gametes (eggs and sperm) or zygotes (early embryos [i.e., a cell that results from fertilization of the egg by a sperm]) are transferred into the fallopian tubes within a day or two of retrieval. These are known as gamete and zygote intrafallopian transfer (GIFT and ZIFT). Another adaptation is intracytoplasmic sperm injection (ICSI) in which fertilization is still in vitro but is accomplished by selection of a single sperm that is injected directly into the egg. This technique was originally developed for couples with male factor infertility but is now commonly used for an array of diagnostic groups.

Data are presented for each of the four treatment types: freshly fertilized embryos from the patient's eggs, freshly fertilized embryos from donor eggs, thawed embryos from the patient's eggs, and thawed embryos from donor eggs. Detailed data are additionally presented in this report for the most common treatment type, those using freshly fertilized embryos from the patient's eggs. These procedures account for >70% of the total number of ART procedures performed each year. For those procedures that progressed to the embryo-transfer stage, percentage distribution of selected patient and treatment factors were calculated. In addition, success rates, defined as live-birth deliveries per ART-transfer procedure, were calculated according to the same patient and treatment characteristics.

Patient factors included the age of the woman undergoing ART, whether she had previously given birth, the number of previous ART attempts, and the infertility diagnosis of both the female and male partners. The patient's age at the time of the ART procedure were grouped into five categories: aged <35 years, 35--37 years, 38--40 years, 41--42 years, and >42 years. Diagnoses ranged from one factor in one partner to multiple factors in one or both partners and were categorized as

- tubal factor --- the woman's fallopian tubes are blocked or damaged, causing difficulty for the egg to be fertilized or for an embryo to travel to the uterus;
- ovulatory dysfunction --- the ovaries are not producing eggs normally; such dysfunctions include polycystic ovarian syndrome and multiple ovarian cysts;
- diminished ovarian reserve --- the ability of the ovary to produce eggs is reduced; reasons include congenital, medical, or surgical causes or advanced age;
- endometriosis --- involves the presence of tissue similar to the uterine lining in abnormal locations; this condition can affect both fertilization of the egg and embryo implantation;
- uterine factor --- a structural or functional disorder of the uterus that results in reduced fertility;
- male factor --- a low sperm count or problems with sperm function that cause difficulty for a sperm to fertilize an egg under normal conditions;
- other causes of infertility --- immunological problems or chromosomal abnormalities, cancer chemotherapy, or serious illnesses;
- unexplained cause --- no cause of infertility was detected in either partner;

- multiple factors, female --- diagnosis of one or more female cause; or
- multiple factors, male and female --- diagnosis of one or more female cause and male factor infertility.

Treatment factors included

- the number of days the embryo was cultured;
- the number of embryos that were transferred;
- whether the procedure was IVF-transfer only, IVF with ICSI, GIFT, ZIFT, or a combination of IVF with or without ICSI and either GIFT or ZIFT;
- whether extra embryos were available and cryopreserved; and
- whether a woman other than the patient (a surrogate) received the transferred embryos with the expectation of gestating the pregnancy (i.e., a gestational carrier).

The number of embryos transferred in an ART procedure was categorized as 1, 2, 3, 4, or ≥ 5 . The number of days of embryo culture was calculated by using dates of egg retrieval and embryo transfer and was categorized as 1--6. However, because of limited sample sizes, live-birth rates are presented only for the two most common days, 3 and 5. For the same reason, live-birth rates are presented for IVF with and without ICSI and not for GIFT and ZIFT. ICSI was subdivided as to whether it was used among couples diagnosed with male factor (the original indication for ICSI treatment) or couples not diagnosed with male factor.

Chi-square tests were run separately to evaluate differences in live-birth rates by select patient and treatment factors within each age group. Multivariable logistic regression was also performed to evaluate the independent effects of patient factors --- diagnosis, number of previous ART procedures, and number of previous births --- on chance to have a live birth as a result of an ART treatment. Because age is known to be a strong predictor for live birth, separate models were constructed for each of the five age groups such that these models provide an indication of the variability in live births based on patient factors within each age strata. For these analyses, the referent groups included patients with a tubal factor diagnosis, no previous ART procedures, and no previous births. Multivariable models did not include treatment factors because of multicollinearity between certain treatment factors and multiple potential effect modifications. Rather, detailed stratified analyses were performed to elucidate additional detail related to associations between different treatment factors and live birth.

In addition to presenting live-birth rates as a measure of success, a second measure of success based on singleton live births is also presented according to treatment group and patient age. Singleton live births are a key measure of ART success, because they have a much lower risk than multiple-infant births for adverse health outcomes, including prematurity, low birthweight, disability, and death.

Multiple birth as a separate outcome measure was also assessed. Multiple birth was assessed in two ways. First, each multiple-birth delivery was defined as a single event. A multiple-birth delivery was defined as the delivery of two or more infants in which at least one was live-born. The multiple-birth risk was thus calculated as the proportion of multiple-birth deliveries among total live-birth deliveries. Multiple birth was also assessed according to the proportion of infants from multiple deliveries among total infants (i.e., each infant was considered separately in this calculation). The proportion of live-born infants who were multiples (twins and triplets or higher order multiples) was then calculated.[§] Each of these measures represents a different focus. The multiple-birth risk, based on number of deliveries (or infant sets), provides an estimate of the individual risk posed by ART to the woman for multiple birth. The proportion of infants born in a multiple-birth delivery provides a measure of the effect of ART treatments on children in the population. Both measures are presented by type of ART treatment and by maternal age for births conceived with the patient's eggs. Multiple-birth risk is further presented by number of embryos transferred and whether additional embryos were available and cryopreserved for future use. Embryo availability (an indicator of embryo quality) has been demonstrated to have added predictive value independent of the number of embryos transferred (3,6). Proportion of infants born in a multiple-birth delivery is presented separately by patient's state of residency at time of ART treatment.

To assess the impact of ART on total births in the United States in 2002, additional analyses including all ART infants born in 2002 are presented. Because the goal of the analysis was to assess the effect of ART on the 2002 U.S. birth cohort and the Assisted Reproductive Technology Surveillance System is organized according to the date of the ART procedure rather than the infant's date of birth, a separate ART data file was created for these analyses. This data file was drawn from two different ART reporting years and was composed of 1) infants conceived from ART

procedures performed in 2001 and born in 2002 (approximately 2/3 of live-birth deliveries reported to the ART Surveillance System for 2001); and 2) infants conceived from ART procedures performed in 2002 and born in 2002 (approximately 1/3 of live-birth deliveries reported to the ART Surveillance System for 2002). Data regarding the total number of live births and multiple births in the United States in 2002 were obtained from birth certificate data (U.S. natality files) from CDC's National Center for Health Statistics (14). These data represent 100% of births registered in the United States in 2002. Data are presented in relation to the total number of infants born in the United States in 2002 by plurality of birth.

Adverse infant health outcomes, including low birthweight, very low birthweight, and preterm delivery were also evaluated. Because ART providers do not provide continued prenatal care after a pregnancy is established, birthweight and date of birth were collected via active follow-up with ART patients (83%) or their obstetric providers (17%). Low birthweight and very low birthweight were defined as <2,500 grams and <1,500 grams, respectively. Gestational age was calculated as date of birth minus date of egg retrieval (and fertilization). If date of retrieval was missing and for procedures that used frozen embryos, gestational age was calculated as date of birth minus date of embryo transfer. For comparability with the general population, date of theoretical last menstrual period (LMP) was adjusted by adding 14 days to the gestational age estimate. Preterm delivery was defined as gestational age <37 weeks. Preterm low birthweight was defined as gestational age <37 weeks and birthweight <2,500 grams. Term low birthweight was defined as gestational age \geq 37 weeks and birthweight <2,500 grams. The rates for low birthweight, very low birthweight, preterm low birthweight, and term low birthweight among ART infants born in 2002 are presented by plurality of birth. Data for each of the five outcomes are additionally presented for ART singletons born in 2002 by type of procedure. For the most common procedure type, those using freshly fertilized embryos from the patient's eggs, the rates for each outcome are additionally presented according to maternal age, maternal race/ethnicity, and number of previous live births. Chi-square tests were run separately to evaluate differences in the five outcomes by type of ART procedure, maternal age, maternal race/ethnicity, and number of previous births. All analyses were performed by using the SAS[®] software system (15).

Results

Of 428 medical centers in the United States and surrounding territories that performed ART in 2002, a total of 391 (91%) provided data to CDC ([Figure 1](#)). The majority of medical centers that provided ART services were located in the eastern United States, in or near major cities. Within states, the number of medical centers performing ART was variable. States with the largest number of ART centers that reported data in 2002 were California (57), New York (32), Florida (29), Texas (29), and Illinois (23). Four states and two U.S. territories had no ART medical centers (Alaska, Guam, Maine, Montana, the U.S. Virgin Islands, and Wyoming).

Number and Type of ART Procedures

Overall, 115,392 ART procedures performed in 2002 were reported to CDC ([Table 1](#)). This number excludes less than 1% (n = 146) of ART procedures performed in 2002 that involved the evaluation of a new treatment procedure. The largest number of ART procedures occurred among patients who used their own freshly fertilized embryos (85,826; 74%). Of the 115,392 procedures started, 96,325 (83%) progressed to embryo transfer. Overall, 42% of ART procedures that progressed to the transfer stage resulted in a pregnancy; 34% resulted in a live-birth delivery; and 22% resulted in a singleton live birth. Pregnancy rates, live-birth rates, and singleton live-birth rates varied according to type of ART. The highest success rates were observed among ART procedures using donor eggs and freshly fertilized embryos (58% pregnancy rate, 50% live-birth rate, and 29% singleton live-birth rate). The lowest rates were observed among procedures using the patient's eggs and thawed embryos (31% pregnancy rate, 25% live-birth rate, and 19% singleton live-birth rate).

In all, the 33,141 live-birth deliveries from ART procedures resulted in 45,751 infants ([Table 1](#)); the number of infants born was higher than the number of live-birth deliveries because of multiple-infant births. A total of 21,597 singleton infants were born as a result of ART. The largest proportion of infants born (74%; n = 33,776) were from ART procedures in which patients used freshly fertilized embryos from their own eggs.

The number of ART procedures performed among residents of each state approximately paralleled the data by medical center location ([Table 2](#)). The greatest numbers of ART procedures reported in 2002 were performed among

residents of California (15,117), New York (13,276), Massachusetts (8,631), New Jersey (7,744), and Illinois (7,492). The five states with the largest number of ART procedures performed also ranked highest in terms of numbers of live-birth deliveries and infants born. ART was used by residents of certain states and territories without an ART medical center (Alaska, Guam, Maine, Montana, U.S. Virgin Islands, and Wyoming); however, each accounted for a limited percentage of total ART usage in the United States. Non-U.S. residents accounted for <2% of ART procedures, live-birth deliveries, and infants born. The ratio of number of ART procedures per million population ranged from 82 in Puerto Rico to 1,344 in Massachusetts, with a national average of 395 ART procedures started per million persons.

Characteristics of Patients and ART Treatments Among Women Who Used Freshly Fertilized Embryos from Their Own Eggs

Forty-six percent of ART-transfer procedures using freshly fertilized embryos from the patient's eggs were performed on women aged <35 years; 23% on women aged 35--37 years; 19% on women aged 38--40 years; 8% on women aged 41--42 years; and 4% on women aged >42 years. Patient and treatment characteristics of these women varied by age ([Table 3](#)). The most common infertility diagnoses reported among couples in which the woman was aged <41 years were male factor and tubal factor; however, diagnoses varied overall. Tubal factor, male factor, and endometriosis were more commonly reported among younger women than women in older age categories. In contrast, diminished ovarian reserve was reported for only 1% of women aged <35 years; it was reported for 15% of women aged 41--42 years and 24% of women aged >42 years. Among all women, 10%--13% were reported as having unexplained infertility; 10%--17% were reported as having multiple female factors; and 18%--21% were reported as having both male and female factors.

Approximately 62% of women aged <35 years were undergoing their first ART procedure. The percentage of women who had undergone at least one previous ART procedure increased with age: only 42% of women aged >42 years were undergoing their first ART procedure. The percentage of women who had had a previous birth followed similar patterns. Although 20% of women aged <35 years reported at least one previous birth, this increased steadily with age: 36% of women in the oldest age group had had a previous birth.[¶]

The majority of ART procedures used IVF with or without ICSI. Less than 1% of ART procedures used GIFT or ZIFT. ICSI use among couples with and without a diagnosis of male factor infertility varied by patient age. Despite variation among all age groups, the total proportion of ICSI use (i.e., combined ICSI for male factor and ICSI for other diagnoses) was greater than the proportion of in vitro fertilization with transcervical embryo transfer (IVF-ET) without ICSI.

Among all age groups, the majority of procedures included embryo culture for 3 days; the next most common procedure involved embryo culture to day 5. Culture to day 5 coincides with development of the embryo to the blastocyst stage; this technique was used more frequently among younger women.

Although limited variation existed by age, the majority of ART procedures involved transfer of more than one embryo. Among women aged <35 years, 95% of procedures involved transfer of two or more embryos, and 53% involved transfer of three or more embryos. For women aged >42 years, 85% involved transfer of two or more embryos, and 65% involved transfer of three or more embryos. The availability of extra embryos (an indicator of overall embryo quality) decreased with age. Extra embryos were available and cryopreserved for approximately 43% of women aged <35 years, whereas only 5% of women aged >42 years had extra embryos available and cryopreserved (data were not available regarding extra embryos that were not cryopreserved for future use). Overall, 1% of ART transfer procedures used a gestational carrier or surrogate. Limited variation existed by patient age.

Live-Birth Rates Among Women Who Used Freshly Fertilized Embryos from Their Own Eggs

Live-birth rates for women who underwent ART procedures using freshly fertilized embryos from their own eggs also varied by patient age and selected patient and treatment factors ([Table 4](#)). Although the average live-birth rate for ART-transfer procedures performed among women who used their own freshly fertilized eggs was 35%, live-birth rates ranged from 43% among women aged <35 years to 7% among women aged >42 years. Women aged ≤40 years who had an infertility diagnosis of tubal factor, ovulatory dysfunction, endometriosis, male factor, or had unexplained infertility tended to have higher than average live-birth rates. Women aged ≤40 years with an infertility

diagnosis of diminished ovarian reserve or uterine factor tended to have lower than average live-birth rates. The average live-birth rate for women aged 41--42 years was 15%; however, the average live-birth rate for women in this age category with a diagnosis of uterine factor or endometriosis was >19%. The variation in success rates across diagnostic categories was not statistically significant for the oldest age group (women aged >42 years). Across all age groups, women who had undergone a previous ART procedure had lower live-birth rates than women undergoing their first ART procedure. However, the number of previous ART procedures cannot be subdivided by whether they were successful or not, because data are not available. Women in all age groups who had had one or more previous births had higher live-birth rates than those with no previous births. However, the difference in live-birth rates for both the number of previous ART procedures and the number of previous births did not reach statistical significance for the two oldest age groups (women aged 41--42 years and women aged >42 years). Multivariable adjustment for patient factors within each age strata demonstrated similar patterns to those observed in [Table 4](#) (data not presented).

In all age groups, live-birth rates were higher among ART procedures that used IVF-ET without ICSI, in comparison with procedures that used ICSI, whether or not male factor was reported ([Table 4](#)). Among women aged ≤ 40 years, live-birth rates were particularly low among couples who used ICSI in the absence of male factor infertility. In all age groups, live-birth rates were increased among women who had extended embryo culture to day 5, transferred two or more embryos, and had extra embryos available and cryopreserved for future use. Variations in live-birth rates were statistically significant for these treatment factors within all age groups. Although live-birth rates also appeared to increase when a gestational carrier was used, these results reached statistical significance in only one age group (women aged 41--42 years). All of the results for treatment factors need to be considered cautiously, because treatment was not randomized but rather based on medical center assessment and patient choice.

Although variability among patients who used different treatment options cannot be adjusted completely, stratified analyses were used to examine associations between treatment factors and live-birth rates among more homogenous groups of patients. To address concerns that in the absences of male factor infertility ICSI might be used preferentially for women considered difficult to treat, multiple groups of patients with an indication of being difficult to treat were evaluated separately. These groups included women with previous failed ART cycles, women diagnosed with diminished ovarian reserve, and women with a low number of eggs retrieved (less than five). Within each of these groups, age-specific live-birth rates for IVF-ET with and without ICSI were examined. In all analyses, women who used IVF with ICSI had lower success rates compared with women who used IVF without ICSI (data not presented). Thus, the pattern of results remained consistent with the findings presented ([Table 4](#)). To address concerns that extended (i.e., day 5) embryo culture might be used preferentially for women with a presumed better prognosis, data regarding women deemed to have a higher likelihood of success were evaluated separately; these subgroups included women with >10 eggs retrieved, women with diagnoses other than diminished ovarian reserve, and women with extra embryos cryopreserved for future use. Again, within each of these subgroups, women who used IVF with ICSI had lower success rates compared with women who used IVF without ICSI ([Table 4](#)) (data not presented). Finally, analyses were conducted in which the data were stratified by patient age, number of embryos transferred, and number of embryos available simultaneously. These results are included with the discussion regarding multiple-birth risk.

Total live-birth rates are compared with singleton live-birth rates for women who underwent ART procedures in which freshly fertilized embryos from their own eggs were used ([Figure 2](#)). Both live-birth rates and singleton live-birth rates decreased with patient age. Across all age groups, singleton live-birth rates were lower than live-birth rates. However, the magnitude of the difference between these two measures declined with patient age. Total live-birth rates ranged from 43% among women aged <35 years to 7% among women aged >42 years, and singleton live-birth rates ranged from 26% among women aged <35 years to 6% among women age >42 years.

Multiple-Birth Risks Associated with ART

Of 11,544 multiple-birth deliveries, 8,601 (75%) were from pregnancies conceived with freshly fertilized embryos from the patient's eggs; 890 (8%) were from thawed embryos from the patient's eggs; 1,779 (15%) were from freshly fertilized embryos from a donor's eggs; and 274 (2%) were from thawed embryos from a donor's eggs ([Table 5](#)). In comparison with ART procedures using the patient's eggs and freshly fertilized embryos, the risks for multiple-birth delivery were increased when eggs from a donor were used and decreased when thawed embryos were used. Among ART procedures in which freshly fertilized embryos from the patient's own eggs were used, a strong inverse relation

existed between multiple-birth risk and patient age. The average multiple-birth risk (i.e., multiple-birth delivery rate) for ART procedure in which freshly fertilized embryos from the patient's eggs were used was 35%. This rate varied from 39% among women aged <35 years to 7% among women aged >42 years.

Of 45,751 infants born through ART, 53% (24,154) were born in multiple-birth deliveries ([Table 5](#)). The proportion of infants born in a multiple-birth delivery also varied by type of ART procedure and patient age.

A more detailed examination of multiple-birth risk for women who underwent ART procedures in which freshly fertilized embryos from their own eggs were used revealed that number of embryos transferred was a risk factor for multiple-birth delivery, but the magnitude of the risk varied according to patient age (Figures [3--6](#)). Among all age groups, transfer of two or more embryos resulted in increased live-birth delivery rates. However, the multiple-birth risk was also substantially increased. Among women aged ≤ 40 years (Figures [3--5](#)), the percentage of multiple-birth deliveries increased with increasing number of embryos transferred from two to five or more. As a result, if success were evaluated in terms of singleton live-birth deliveries rather than total live-birth deliveries, the two youngest age groups had lower singleton success rates when three or more embryos were transferred than when two embryos were transferred (Figures [3](#) and [4](#)). For women aged 38--40 years ([Figure 5](#)), transfer of three or more embryos offered a certain advantage in terms of live-birth delivery rates. However, as among younger age groups, the percentage of twin deliveries and triplets or higher order multiple-birth deliveries were increased with three or more embryos having been transferred compared with two. For women aged 41--42 years ([Figure 6](#)), both the live-birth delivery rate and the multiple-birth risk increased steadily with an increased number of embryos having been transferred. Data are not provided for women aged >42 years, because in this age group, limited sample size precluded analysis for all number of embryos transferred categories.

A further assessment of multiple-birth risk among patients who used freshly fertilized embryos from their own eggs and set aside extra embryos for future use is also presented (Figures [7--10](#)). This group can be thought of as those with elective embryo transfer, because they are known to have chosen to transfer fewer embryos than the total number available. For women with elective embryo transfer who were aged <35 years ([Figure 7](#)), live-birth rates were >47% when only one embryo was transferred. Moreover, limited variation existed in live-birth rates by number of embryos transferred. For example, only a slight difference in live-birth rates was noted among patients with single versus double elective embryo transfers (47% versus 52%). Transferring two embryos posed a substantial multiple-birth risk (approximately 40%) for this group. Transferring three or more embryos posed a substantial total multiple-birth risk (47%--50%) and a substantial risk for higher-order multiple births (8%--10%). For women with elective embryo transfer who were aged 35--37 and 38--40 years, live-birth rates were high (48% and 43%, respectively) when only two embryos were transferred (Figures [8](#) and [9](#)). Live-birth rates were also high (30%) among women aged 35--37 years with elective embryo transfer of a single embryo ([Figure 8](#)). The number of cases of elective transfer of one embryo among women aged 38--40 and 41--42 years was too limited to allow adequate evaluation. Live-birth rates with elective transfer of two to five or more embryos demonstrated limited variation for these age groups. Data are not provided for women aged >42 years, because in this age group, limited sample size precluded analysis for all number of embryos transferred categories.**

The total number and percentage of infants born in multiple-birth deliveries by maternal state of residence is presented ([Table 6](#)). The states with the highest number of ART-associated live-birth deliveries also had the highest number of infants born in multiple-birth deliveries. These include California (3,189), New York (2,448), New Jersey (1,614), Massachusetts (1,489), Texas (1,408), and Illinois (1,352). Nationally, the percentage of infants born in multiple-birth deliveries after ART was used was 53%; the percentage of twins and triplets or higher order multiples were 45% and 8%, respectively. The percentage of infants born in multiple-birth deliveries was >50% in the majority of states. The states with the highest proportion of infants born in multiple-birth deliveries were New Mexico (64%), Maine (64%), Wyoming (63%), Idaho (60%), Kentucky (60%), North Carolina (60%), and Vermont (60%); however, these findings should be interpreted with care because of an overall low number of live births resulting from ART in certain states.

The contribution of ART infants to the total number of U.S. infants born in 2002 is presented ([Table 7](#)). Of 4,021,726 total infants born in the United States in 2002, a total of 42,483 (1%) were conceived by ART. Infants conceived with ART accounted for 0.5% of singleton births and 17% of multiple births nationally. Sixteen percent of all twins and 44% of infants born in triplets or higher order multiples were conceived with ART.

Perinatal Risks Associated with ART

The proportion of ART infants born in 2002 that were low birthweight, very low birthweight, preterm, preterm low birthweight, and term low birthweight are presented by plurality of birth ([Table 8](#)). The percentage of infants with low birthweight varied from 9% among singletons to 95% among triplets or higher order multiples. The percentages of very low birthweight, preterm, and preterm low birthweight followed similar patterns.

The percentages of ART singletons that were low birthweight, very low birthweight, preterm, preterm low birthweight, and term low birthweight varied by procedure type and selected maternal factors ([Table 9](#)). In comparison with singletons born after procedures using freshly fertilized embryos derived from the patient's eggs, singletons born after procedures using freshly fertilized embryos derived from donor eggs were at increased risk for four perinatal outcomes --- low birthweight, very low birthweight, preterm delivery, and preterm low birthweight. Singletons born after procedures using thawed embryos were at decreased risks for low birthweight, very low birthweight, preterm low birthweight, and term low birthweight; however, they were at increased risk for preterm delivery overall. The variation in risk across procedure types did not reach statistical significance for very low birthweight.

More detailed analysis of maternal factors among singletons born after procedures using freshly fertilized embryos derived from the patient's eggs indicated limited variation in risk for any outcome according to maternal age. Lower risks were observed with a maternal race/ethnicity of non-Hispanic white. Lower risks were also observed among mother-infant pairs with one previous birth, although the difference did not reach statistical significance for very low birthweight and term low birthweight.

Discussion

According to the latest estimates of infertility in the United States from the 1995 National Survey of Family Growth, 15% of women of reproductive age (aged 18--44 years) reported a previous infertility-associated health-care visit, and 2% reported a visit in the previous year (*16*). Among married couples in which the woman was of reproductive age, 7% reported they had not conceived after 12 months of unprotected intercourse. With advances in ART, couples are increasingly turning to these treatments to overcome their infertility.

Since the birth of the first infant through ART in the United States in 1981, use of ART has grown substantially. Since 1997, CDC has been monitoring ART procedures performed in the United States. During that time, a notable and consistent increase in the use of ART has occurred. The increased use of ART coupled with higher ART success rates has resulted in dramatic increases in the number of children conceived through ART each year. From 1996 (i.e., the first full year for which CDC collected data) through 2002, the number of ART procedures performed increased 78%, from 64,681 to 115,392 (*1*). Additionally, during 1996--2002, live-birth rates for all types of ART procedures increased substantially. For the most common type of ART procedure, using freshly fertilized embryos from the patient's eggs, live-birth rates increased from 28% in 1996 to 35% in 2002. The number of infants conceived through ART increased 120%, from 20,840 infants conceived through ART procedures performed in 1996 to 45,751 infants conceived through ART procedures performed in 2002.

This report documents that in 2002, ART use varied according to patient's state of residency. Residents of California, New York, Massachusetts, New Jersey, and Illinois reported the highest number of ART procedures. These states also reported the highest number of infants conceived through ART. In 2002, ART use by state of residency was not completely in line with expectations based on the total population within states (*12,13*). Whereas Massachusetts had the third highest number of ART procedures performed, it ranked thirteenth in terms of total population size.^{††} Likewise, residents of Maryland, New Jersey, and Rhode Island underwent more ART procedures than would have been expected based on their population sizes. As a result, state-specific ratios of ART procedures by population varied according to state of residency. States with the highest ratio of number of ART procedures among state residents per million population were Massachusetts (1,344), New Jersey (903), the District of Columbia (857), Maryland (771), and Rhode Island (710). This divergence is not unexpected, because in 2002, Massachusetts, Maryland, New Jersey, and Rhode Island had statewide mandates for insurance coverage for ART procedures. The state variation might also be related to availability of ART services within each state. However, the relation between demand for services and availability cannot be disentangled (i.e., increased availability in certain states might reflect the increased demand for ART among state residents).

Patients with different characteristics used ART services. Among ART treatments in which freshly fertilized embryos from the patient's eggs were used (i.e., the most frequent type of ART treatment), substantial variation was observed in patient age, infertility diagnoses, history of previous ART procedures, and previous births.

Success rates from ART use are affected by numerous patient and treatment factors; hence, considering one single measure of success in evaluating ART efficacy is not informative. At a minimum, ART treatments need to be subdivided into categories on the basis of the source of the egg (patient or donor) and the status of the embryos (freshly fertilized or thawed), because success rates vary substantially across these types. Within the type of ART treatment, further variation exists in success rates by patient and treatment factors, most notably patient age. Other factors to consider when assessing success rates are infertility diagnosis, number of previous ART procedures, number of previous births, method of embryo fertilization and transfer, number of days of embryo culture, number of embryos transferred, availability of extra embryos, and use of a gestational carrier (surrogate). Variation exists in success rates according to each of these factors.

CDC's primary focus in collecting ART data has been live-birth deliveries as an indicator of success, because ART surveillance activities were developed in response to a federal mandate to report ART success rate data. This mandate requires that CDC collect data from all ART medical centers and report success rates, defined as all live births per ovarian stimulation procedures or ART procedures, for each ART clinic. Thus, a key role for CDC has been to publish standardized data related to ART success rates, including information regarding factors that affect these rates. With these data, couples can make informed decisions regarding whether to undergo this time-consuming and expensive treatment (17,18).^{§§} However, success-rate data should also be balanced with consideration of effects on maternal and infant health. Thus, CDC also closely monitors multiple births conceived through ART.

Multiple births are associated with an increased health risk for both mothers and infants (19--21). Women with multiple-gestation pregnancies are at increased risk for maternal complications (e.g., hemorrhage and hypertension). Infants born in a multiple-birth delivery are at increased risk for prematurity, low birthweight, infant mortality, and long-term disability. The health risks associated with multiple births have also contributed to rising health-care costs. The estimated costs per live birth in 2002 ranged from \$39,688--\$87,788 (18).

In the United States, multiple births have increased substantially during the previous 2 decades (14,22). The rise in multiple births has been attributed to an increased use of ART and delayed childbearing (5,23,24). Although infants conceived with ART accounted for 1% of the total births in the United States in 2002, the proportion of twins and triplets or higher order multiples attributed to ART were 16% and 44%, respectively.

In certain states, such infertility treatments as ART might not be covered by insurance carriers, and patients might feel pressure to maximize the opportunity for live-birth delivery. Additionally, anecdotal evidence suggests that certain ART providers might feel pressure to maximize their publicly reported success rates, if defined solely as total live-birth delivery, by transferring multiple embryos (25). Indeed, in the United States, high-order embryo transfer is still common practice. In 2002, approximately 62% of ART cycles that used fresh, nondonor eggs or embryos and progressed to the embryo-transfer stage involved the transfer of three or more embryos; approximately 28% of cycles involved the transfer of four or more; and 10% of cycles involved the transfer of five or more embryos (1). Recent reports published in the scientific literature have advocated for the presentation of singleton live-birth rates as a distinct indicator of ART success (26--31). This report includes this measure and presents it with total live-birth rates. Success rates based on singleton live-birth deliveries will provide patients with a measure that more directly highlights infant outcomes with the optimal short- and long-term prognosis. Twins, albeit to a lesser extent than triplets or higher order multiples, have substantially increased risks for infant morbidity and mortality. The risks for low birthweight and preterm birth both exceed 50% for twins, and the risk for very low birthweight is 10% (14). In addition, twins are at substantially increased risk for perinatal and infant mortality (14,20,24). Thus, presentation of singleton live-birth rates is warranted.

Data regarding multiple-birth deliveries and proportion of multiple-birth infants as distinct outcomes are also provided. Data in this report indicate that 53% of infants born through ART in 2002 were multiple births; this compares with 3% in the general U.S. population during the same period (14). The twin rate was 45%, approximately 15 times higher than in the general U.S. population (3%); the triplet and higher order multiples rate was 8%, approximately 42 times higher than the general U.S. population (0.2%). Regarding the specific type of ART

treatment, multiple-birth rates were among the highest for women who underwent ART procedures using freshly fertilized embryos from their own eggs (53%) or from donor eggs (60%).

In the majority of states, >50% of infants conceived through ART were born in multiple-birth deliveries. Idaho, Kentucky, Maine, New Mexico, North Carolina, Vermont, and Wyoming reported ART-associated multiple-birth rates $\geq 60\%$. Multiple births resulting from ART are an increasing public health concern, nationally and for the majority of states.

For women who underwent ART procedures using freshly fertilized embryos from their own eggs, the multiple-birth risk increased when multiple embryos were transferred (two or more). However, embryo availability (an indicator of embryo quality) was also a strong predictor of multiple-birth risk and had added predictive value beyond the number of embryos transferred. When patient age, number of embryos transferred, and embryo availability were jointly considered, high live-birth rates and singleton live-birth rates were achieved; which was particularly evident among younger women as transfer of a single embryo was efficacious. Among the majority of groups, multiple-birth risk can be minimized by limiting the number of embryos transferred without compromising success rates.

In addition to the known multiple-birth risks associated with ART, singleton infants conceived from ART are at increased risk for low birthweight and preterm delivery. In this report, 9% of singleton infants conceived with ART were low birthweight, compared with 6% in the general U.S. population during the same period (14). The percentage of singleton infants conceived from ART that were very low birthweight (2%) was twice that of singletons conceived in the general U.S. population (1%), and the percentage of ART singletons born preterm (15%) was also higher than the general U.S. population (10%). Thus, adverse infant health outcomes among singletons (e.g., low birthweight and preterm delivery) should also be considered when assessing the efficacy and safety of ART.

A comparison of perinatal outcomes among ART twins and triplets or higher order multiples with their counterparts in the general population is inadvisable. First, both ART and non-ART infertility treatments are estimated to account for a substantial proportion of multiple births in the United States, and distinguishing naturally conceived from iatrogenic multiple births is not possible. ART accounts for only 1% of the total U.S. births; however, it accounts for 16% of twins and 44% of triplets or higher order multiples in the United States. Second, the majority of multiple births conceived after ART treatment are likely dizygotic from multiple embryo transfer. Among natural conceptions, approximately one third to one half of twins might be monozygotic, depending on maternal age (32). Monozygotic twins are at increased risk for adverse outcomes in comparison with dizygotic twins (33).

This analysis was subject to certain limitations. First, ART surveillance data are reported for each ART procedure performed rather than for each patient who used ART. Linking procedures among patients who underwent more than one ART procedure in a given year is not possible. Because patients undergoing more than one procedure in a given year are most likely to be those who failed one or more treatments, the success rates reported might underestimate the true per-patient success rate. Additionally, ratios of ART procedures per population might be higher than the unknown ratio of number of persons undergoing ART per population. Second, these data represent couples who sought ART services in 2002; therefore, success rates do not represent all couples with infertility who were potential ART users in 2002. Third, approximately 9% of medical centers that performed ART in 2002 did not report their data to CDC as required.

ART data are reported to CDC by the ART medical center where the procedure was performed rather than by the state where the patient resided. In this report, ART data are presented by the female patient's state of residence. In previous reports (23), ART data were not presented by state of residence because of incomplete residency data. In 2002, residency data were missing for <9% of all live-birth deliveries reported to CDC. The range of missing residency data varied by medical center. Medical centers located in 41 states had <5% missing residency data; medical centers located in three states had 5%--10% missing residency data; and medical centers located in four states had >10% missing residency data. These states were Georgia, Massachusetts, Minnesota, and New York. In cases of missing residency data, residency was assigned as the state in which the ART procedure was performed. Thus, the number of procedures performed among state residents, number of infants, and number of multiple-birth infants might have been overestimated for these states. Concurrently, the numbers might be underestimated in states bordering states with missing residency data, particularly states in the Northeast region of the United States. Nonetheless, the effects of missing residency data were not substantial. Statistics were evaluated separately according to the state in which the ART medical center was located rather than the patient's state of residence. The

rankings of the states in terms of total number of infants and multiple-birth infants were similar to the rankings based on patient's state of residence (data not presented).

A further concern to consider in reviewing the state-based statistics in this report is that the patient's state of residence was reported at the time of ART treatment. The possibility of migration during the interval between ART treatment and birth exists. Data from the U.S. Census Bureau demonstrate that annually, approximately 3% of the U.S. population move between states (34). This rate is even higher for persons aged 20--34 years.

One group with a recognized high potential for migration is members of the U.S. armed forces. Therefore, ART procedures performed among patients who attended military medical centers were evaluated separately. In 2002, a total of 739 (0.6%) ART procedures were performed in four military medical centers. These medical centers were located in California, the District of Columbia, Hawaii, and Texas. In certain of these facilities, a substantial number of distinct states were listed for patient's state of residence. States and territories for which $\geq 1\%$ of ART procedures among state residents were performed in a military medical center were Alaska, the District of Columbia, Georgia, Guam, Hawaii, Maryland, Maine, North Carolina, North Dakota, New Mexico, South Carolina, South Dakota, Texas, Virginia, the U.S. Virgin Islands, and Wyoming. States for which $>5\%$ of ART procedures among state residents were performed in a military medical center were the District of Columbia, Guam, Virginia, and the U.S. Virgin Islands.

Despite these limitations, findings from national surveillance of ART procedures performed in the United States provide useful information for patients contemplating ART, ART providers, and health-care policy makers. First, ART surveillance data can be used to monitor trends in ART use and outcomes from ART procedures. Second, data from ART surveillance can be used to assess patient and treatment factors that contribute to higher success rates. Third, ongoing surveillance data can be used to assess the risk for multiple births and adverse perinatal outcomes among singleton births. Fourth, surveillance data provide information to assess changes in clinical practice related to ART treatment.

Multiple births are one of the most important public health concerns associated with using ART. Increased use of ART treatments and the widespread practice of transferring multiple embryos during ART treatments have led to a substantial increase in multiple-birth rates in the United States (5,14,22). Balancing the chance of success with ART against the risk for multiple births is difficult in certain cases. Implementation of approaches to limit the number of embryos transferred for patients undergoing ART should reduce the occurrence of multiple births resulting from ART. Such efforts will ultimately require ART patients and providers to view treatment success in terms of singleton pregnancies and births. Additionally, continued research is critical to understanding the effect of ART on maternal and child health. CDC will continue to provide updates of ART use in the United States as data become available.

Acknowledgments

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* Fertility Clinic Success Rate and Certification Act of 1992 (FCSRCA), Public L. 102-493 (October 24, 1992).

† Data regarding population size are based on July 1, 2002, estimates from the U.S. Census Bureau (12,13).

§ Includes only the number of infants live-born in a multiple-birth delivery. For example, if three infants were born in a live-birth delivery and one of the three infants was stillborn, the total number of live-born infants would be two. However, these two infants would still be counted as triplets.

¶ Data were not available to distinguish whether previous births were conceived naturally or conceived with ART or other infertility treatments.

** Results are based on total multiple-birth risk and therefore do not provide an indication of pregnancies that began as twins, triplets, or a higher order but reduced (either spontaneously or through medical intervention) to singletons or twins (Figures 3--10).

†† Data regarding population size are based on July 1, 2002, estimates from the U.S. Census Bureau (12,13).

§§ Estimated cost for one cycle of IVF averages \$12,400 (17).

Table 1

TABLE 1. Outcomes of assisted reproductive technology (ART), by procedure type — United States, 2002

ART procedure type	No. of ART procedures started	No. of procedures progressing to retrievals	No. of procedures progressing to transfers	No. of pregnancies	Pregnancies per transfer procedure (%)	No. of live-birth deliveries	Live-birth deliveries per transfer procedure (%)	No. of singleton live births	Singleton live births per transfer procedure (%)	Total no. of live-born infants
Patient's eggs used										
Freshly fertilized embryos	85,826	74,519	69,857	29,423	42.1	24,324	34.8	15,723	22.5	33,776
Thawed embryos	16,383	N/A*	14,598	4,562	31.3	3,620	24.8	2,730	18.7	4,592
Donor eggs used										
Freshly fertilized embryos	9,261	8,647	8,394	4,854	57.8	4,195	50.0	2,416	28.8	6,088
Thawed embryos	3,922	N/A	3,476	1,207	34.7	1,002	28.8	728	20.9	1,295
Total	115,392†	N/A	96,325	40,046	41.6	33,141	34.4	21,597	22.4	45,751

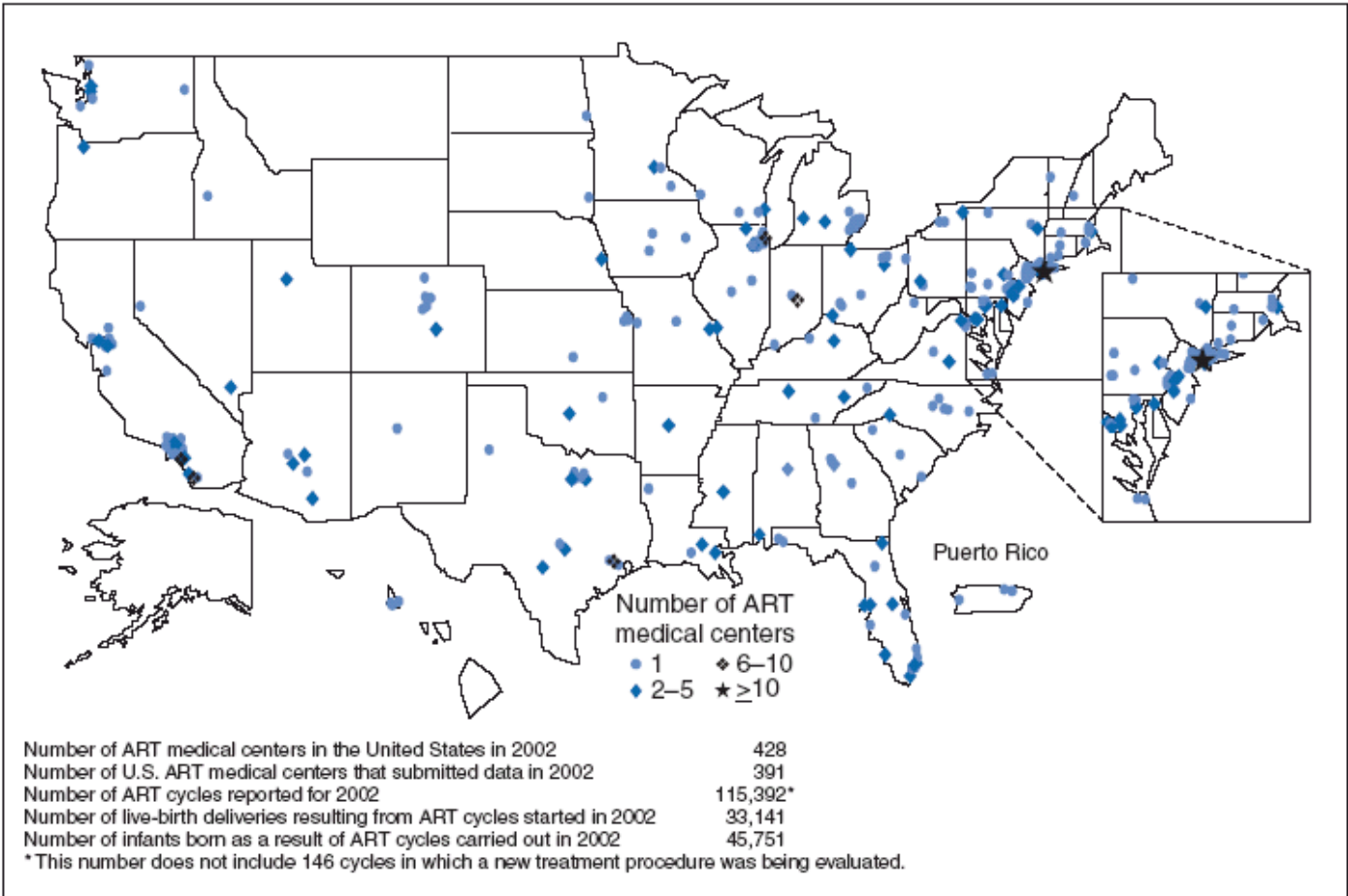
* Not applicable.

† This number does not include 146 ART procedures in which a new treatment procedure was being evaluated.

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Figure 1

FIGURE 1. Location of assisted reproductive technology (ART) medical centers — United States and Puerto Rico, 2002



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Table 2

TABLE 2. Number of reported assisted reproductive technology (ART) procedures performed, number of pregnancies, and number of live-birth deliveries, by patient's state/territory of residence* at time of treatment — United States, 2002

Patient's state/ territory of residence	No. of ART procedures started	No. of transfer procedures	No. of pregnancies	No. of live-birth deliveries	No. of infants born	Ratio of no. of ART procedures started/population (million) [†]
Alabama	549	471	210	181	258	122.6
Alaska [§]	94	74	32	29	41	146.5
Arizona	1,661	1,404	561	463	668	305.3
Arkansas	407	343	136	118	161	150.4
California	15,117	13,039	5,258	4,344	6,001	431.9
Colorado	1,624	1,420	783	681	973	360.8
Connecticut	1,656	1,293	553	460	625	478.8
Delaware	414	317	131	114	154	513.7
District of Columbia [§]	488	409	167	138	177	857.4
Florida	4,999	4,151	1,751	1,469	2,020	299.5
Georgia [§]	2,553	2,099	922	768	1,082	298.8
Guam [§]	11	11	11	11	11	11
Hawaii [§]	775	647	203	167	233	624.7
Idaho	371	317	164	140	203	276.2
Illinois	7,492	6,113	2,368	1,991	2,598	595.2
Indiana	1,871	1,531	575	470	668	303.9
Iowa	998	796	376	309	422	339.9
Kansas	706	584	252	221	317	260.3
Kentucky	868	727	343	306	450	212.2
Louisiana	605	490	206	173	231	135.2
Maine [§]	176	144	68	56	84	135.9
Maryland [§]	4,200	3,374	1,327	1,062	1,423	770.6
Massachusetts	8,631	7,282	2,807	2,318	3,086	1,344.0
Michigan	3,288	2,720	1,089	931	1,282	327.4
Minnesota	2,211	1,920	860	714	942	440.0
Mississippi	370	314	122	101	145	129.1
Missouri	1,260	1,030	508	423	608	222.2
Montana	111	95	44	39	55	121.9
Nebraska	675	562	223	190	260	390.7
Nevada	603	492	223	175	251	278.2
New Hampshire	512	446	162	137	191	401.8
New Jersey	7,744	6,215	2,805	2,266	3,106	903.1
New Mexico [§]	223	201	121	99	149	120.4
New York	13,276	10,942	4,358	3,471	4,742	693.8
North Carolina [§]	1,947	1,658	691	612	896	234.4
North Dakota [§]	207	178	66	61	85	326.5
Ohio	3,411	2,863	1,193	1,033	1,457	299.0
Oklahoma	535	463	238	203	280	153.3
Oregon	815	694	353	300	425	231.5
Pennsylvania	4,329	3,427	1,264	1,045	1,449	351.1
Puerto Rico	318	291	110	83	119	82.4
Rhode Island	759	671	257	216	285	710.5
South Carolina [§]	772	656	324	265	362	188.1
South Dakota [§]	146	127	47	45	59	192.0
Tennessee	787	647	302	249	366	135.9
Texas [§]	5,716	4,827	2,159	1,828	2,559	263.0
Utah	574	483	207	183	258	247.5
Vermont	175	151	75	65	95	283.9
Virgin Islands, U.S. [§]	11	11	11	11	11	11
Virginia [§]	3,364	2,874	1,227	994	1,324	461.6
Washington	2,101	1,797	803	677	931	346.3
West Virginia	172	143	61	54	75	95.3
Wisconsin	1,231	1,087	397	337	478	226.3
Wyoming [§]	68	65	39	33	48	136.3
Non-U.S. resident	1,414	1,243	520	429	589	N/A
Total	115,392	96,325	40,046	33,141	45,751	395.0**

* In cases of missing residency data, the patient's state of residency was assigned as the state in which the ART procedure was performed. Medical centers in all but four states had missing residency data for <10% of ART infants. Medical centers located in Georgia, Massachusetts, Minnesota, and New York had >10% missing residency data.

† Source of population size: July 1, 2002, state population estimates. Population Division, U.S. Census Bureau.

§ A total of 0.6% of ART procedures were reported from military medical centers located in California, the District of Columbia, Hawaii, and Texas. States and territories for which ≥1% of ART procedures among state residents were performed in a military medical center were Alaska, the District of Columbia, Georgia, Guam, Hawaii, Maine, Maryland, New Mexico, North Carolina, North Dakota, South Carolina, South Dakota, Texas, the U.S. Virgin Islands, Virginia, and Wyoming. States and territories for which >5% of ART procedures among state residents were performed in a military medical center were the District of Columbia, Guam, the U.S. Virgin Islands, and Virginia.

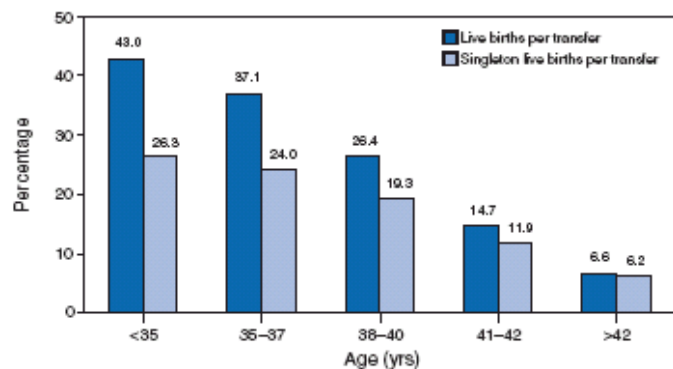
1 Data not indicated to preserve confidentiality but included in totals.

** Non-U.S. residents excluded.

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Figure 2

FIGURE 2. Live births per transfer and singleton live births per transfer for assisted reproductive technology procedures performed among women who used freshly fertilized embryos from their own eggs, by patient's age — United States, 2002



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Table 3

TABLE 3. Percentage distribution of selected patient and treatment factors for assisted reproductive technology (ART) transfer procedures among patients who used freshly fertilized embryos from their own eggs,* by patient age — United States, 2002

	Patient age (yrs)				
	<35 (n = 32,288) (%)	35–37 (n = 15,781) (%)	38–40 (n = 13,571) (%)	41–42 (n = 5,660) (%)	>42 (n = 2,557) (%)
Patient factors					
Diagnosis					
Tubal factor	14.3	15.4	14.4	9.7	7.3
Ovulatory dysfunction	8.2	5.2	4.0	3.0	3.1
Diminished ovarian reserve	1.4	2.9	7.0	14.8	24.3
Endometriosis	8.2	7.6	5.2	3.1	2.2
Uterine factor	0.9	1.5	1.8	1.9	1.8
Male factor	23.9	19.7	16.1	10.1	7.0
Other causes	4.3	5.2	6.5	7.9	8.6
Unexplained cause	10.4	12.7	12.4	12.2	10.0
Multiple factors, female only	10.2	11.5	14.0	16.2	16.5
Multiple factors, female and male	18.1	18.3	18.6	21.1	19.2
Number of previous ART procedures					
0	62.2	52.5	48.7	43.8	41.9
≥1	37.5	47.1	51.0	55.9	57.8
Number of previous births					
0	79.8	69.1	66.1	65.4	63.6
≥1	19.8	30.5	33.5	33.8	35.6
Treatment factors					
Method of embryo fertilization and transfer†					
IVF-ET without ICSI	36.3	38.1	39.3	40.1	42.6
IVF-ET with ICSI	62.9	61.2	59.9	58.7	56.0
IVF-ET with ICSI among couples diagnosed with male factor infertility	38.2	34.1	31.1	27.5	22.3
IVF-ET with ICSI among couples not diagnosed with male factor infertility	24.7	27.1	28.8	31.2	33.7
GIFT	0.2	0.2	0.3	0.3	0.6
ZIFT	0.5	0.4	0.5	0.7	0.6
Combination	0.1	0.1	0.1	0.2	0.3
No. of days of embryo culture§					
1	0.4	0.3	0.4	0.4	0.5
2	4.9	4.6	4.7	4.7	4.9
3	70.6	75.1	79.4	81.8	81.9
4	2.6	2.9	3.0	3.7	4.5
5	18.6	14.5	10.4	7.8	6.1
6	1.9	1.6	1.0	0.8	0.6
Number of embryos transferred					
1	4.6	6.4	8.3	12.0	15.3
2	42.8	27.3	18.8	16.6	19.6
3	36.9	36.6	29.7	22.2	19.3
4	11.5	21.7	27.2	22.6	18.1
≥5	4.2	8.1	15.9	26.5	27.6
Extra embryo(s) available and cryopreserved					
Yes	42.7	30.7	18.6	8.9	4.6
No	57.3	69.3	81.4	91.2	95.4
Use of gestational carrier					
Yes	0.7	1.1	1.2	1.2	1.1
No	99.3	98.9	98.8	98.8	98.9

*N = 69,857.

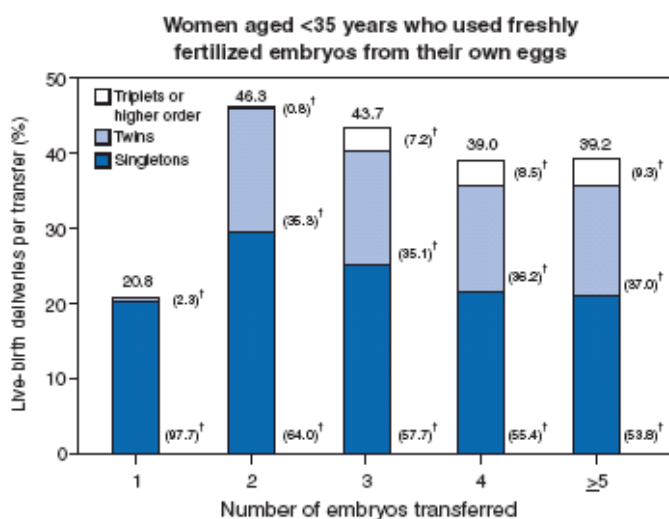
†IVF-ET = in vitro fertilization with transcervical embryo transfer; ICSI = intracytoplasmic sperm injection; GIFT = gamete intrafallopian transfer; ZIFT = zygote intrafallopian transfer; and Combination = a combination of IVF with or without ICSI and either GIFT or ZIFT.

§In cases of GIFT, gametes were not cultured but were transferred on day 1.

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Figure 3

FIGURE 3. Live birth rates and multiple-birth risk, by number of embryos transferred — United States, 2002*



* Numbers might not add to 100% because of rounding.

[†] Percentages of live births that were singletons, twins, and triplets or higher order are in parentheses.

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Table 4

TABLE 4. Live-birth rates for assisted reproductive technology (ART) transfer procedures performed among patients who used freshly fertilized embryos from their own eggs, by patient age and selected patient and treatment factors — United States, 2002

	Patient age (yrs)				
	<35 Live births per transfer procedure (%)	35–37 Live births per transfer procedure (%)	38–40 Live births per transfer procedure (%)	41–42 Live births per transfer procedure (%)	>42 Live births per transfer procedure (%)
Total	43.0	37.1	26.4	14.7	6.6
Patient factors					
Diagnosis					
Tubal factor	43.4*	37.2*	28.3*	14.5*	6.4
Ovulatory dysfunction	45.0	40.5	27.3	15.3	6.3
Diminished ovarian reserve	35.7	29.2	21.7	16.5	7.1
Endometriosis	43.9	37.4	31.6	20.3	7.0
Uterine factor	37.2	30.0	24.7	19.4	6.7
Male factor	45.2	39.2	28.2	15.4	4.4
Other causes	40.9	40.1	28.3	16.9	6.3
Unexplained cause	43.1	39.6	28.6	15.3	8.6
Multiple factors, female only	41.0	32.7	23.5	12.7	6.7
Multiple factors, female and male	40.9	35.7	23.9	12.1	5.9
Number of previous ART procedures					
0	45.2*	39.2*	28.1*	15.1	6.1
≥1	39.4	34.8	24.9	14.3	7.0
Number of previous births					
0	41.6*	35.6*	25.2*	14.0	6.4
≥1	48.5	40.3	28.7	15.9	7.0
Treatment factors					
Method of embryo fertilization and transfer†					
IVF-ET without ICSI	45.3*	39.9*	28.2*	17.2*	8.2*
IVF-ET with ICSI among couples diagnosed with male factor infertility	43.2	37.1	25.9	12.6	5.1
IVF-ET with ICSI among couples not diagnosed with male factor infertility	39.5	33.6	24.5	13.6	5.5
Number of days of embryo culture‡					
3	41.9*	36.8*	25.7*	14.5*	6.3*
5	49.7	42.7	35.1	20.9	14.8
Number of embryos transferred					
1	20.8*	14.6*	10.4*	3.5*	1.0*
2	46.3	37.7	23.3	10.4	5.0
3	43.6	39.6	28.9	13.5	5.9
4	39.0	38.4	29.9	16.6	8.4
≥5	39.2	38.1	28.1	21.8	10.2
Extra embryo(s) available and cryopreserved					
Yes	50.4*	46.7*	38.1*	24.4*	15.3*
No	37.5	32.9	23.8	13.7	6.2
Use of gestational carrier					
Yes	49.2	43.7	27.8	24.2*	11.1
No	42.9	37.0	26.4	14.6	6.6

* P<0.05; chi-square to test for variations in live-birth rates across patient and treatment factor categories within each age group.

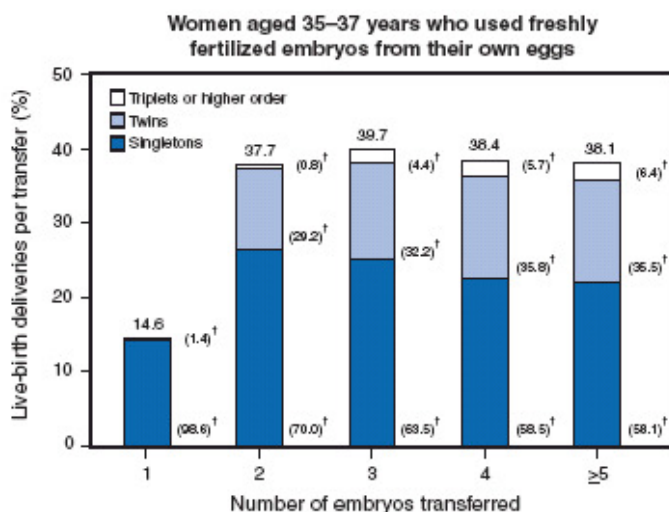
† IVF-ET = in vitro fertilization with transcervical embryo transfer, and ICSI = intracytoplasmic sperm injection. ART procedures including GIFT, ZIFT, and a combination of IVF with or without ICSI and either GIFT or ZIFT were not included because each of these accounted for a limited proportion of procedures.

‡ Limited to 3 and 5 days to embryo culture. ART procedures including 1, 2, 4, and 6 days to embryo culture were not included because each of these accounted for a limited proportion of procedures.

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Figure 4

FIGURE 4. Live birth rates and multiple-birth risk, by number of embryos transferred — United States, 2002*



* Numbers might not add to 100% because of rounding.

† Percentages of live births that were singletons, twins, and triplets or higher order are in parentheses.

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Table 5

TABLE 5. Multiple-birth risk, by type of assisted reproductive technology (ART) transfer procedure performed — United States, 2002

	Patient age (yrs)	No. of live-birth deliveries	No. of multiple-birth deliveries	Multiple-birth deliveries (%)*	No. of infants born	No. of infants born in multiple-birth deliveries	Infants born in multiple-birth deliveries (%)
Patient's eggs used							
Freshly fertilized embryos	All ages	24,324	8,601	35.4	33,776	18,053	53.4
	<35	13,882	5,399	38.9	19,842	11,359	57.2
	35–37	5,856	2,072	35.4	8,132	4,348	53.5
	38–40	3,587	965	26.9	4,628	2,006	43.3
	41–42	830	154	18.6	995	319	32.1
	>42	169	11	6.5	179	21	11.7
Thawed embryos	All ages	3,620	890	24.6	4,592	1,862	40.5
	<35	2,145	563	26.2	2,767	1,185	42.8
	35–37	836	189	22.6	1,043	396	38.0
	38–40	466	92	19.7	563	189	33.6
	41–42	116	30	25.9	145	59	40.7
	>42	57	16	28.1	74	33	44.6
Donor's eggs used†							
Freshly fertilized embryos	All ages	4,195	1,779	42.4	6,088	3,672	60.3
Thawed embryos	All ages	1,002	274	27.3	1,295	567	43.8
Total	All ages	33,141	11,544	34.8	45,751	24,154	52.8

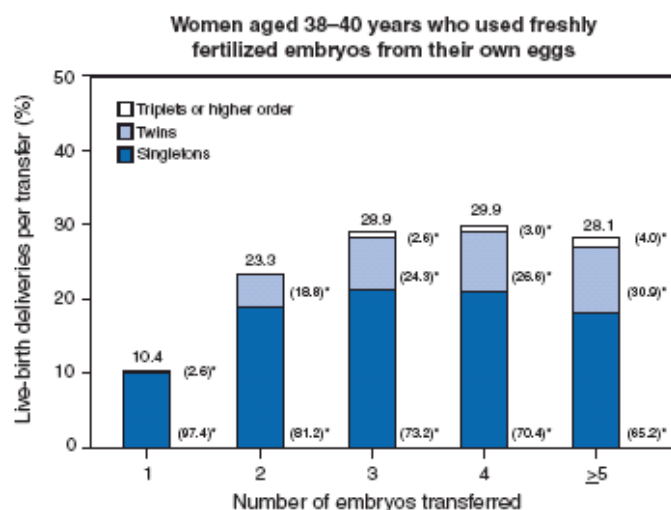
* Multiple-birth risk.

† Age-specific statistics are not presented for procedures that used donor eggs because only limited variation by age exists among these procedures.

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Figure 5

FIGURE 5. Live birth rates and multiple-birth risk, by number of embryos transferred — United States, 2002



* Percentages of live births that were singletons, twins, and triplets or higher order are in parentheses.

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Table 6

TABLE 6. Number and percentage of infants born in multiple-birth deliveries by patient's state/territory of residence* at time of assisted reproductive technology (ART) treatment — United States, 2002

Patient's state of residency	No. of infants born	No. of infants born in multiple-birth deliveries	Infants born in multiple-birth deliveries† (%)	Infants born in twin deliveries (%)	Infants born in triplet or higher order deliveries (%)
Alabama	258	144	55.8	42.6	13.2
Alaska§	41	23	56.1	48.8	7.3
Arizona	668	381	57.0	44.6	12.4
Arkansas	161	82	50.9	42.2	8.7
California	6,001	3,189	53.1	46.5	6.7
Colorado	973	556	57.1	47.6	9.6
Connecticut	625	319	51.0	45.3	5.8
Delaware	154	75	48.7	40.3	8.4
District of Columbia§	177	75	42.4	37.3	5.1
Florida	2,020	1,055	52.2	45.0	7.3
Georgia§	1,082	590	54.5	43.3	11.2
Guam§	11	11	11	11	11
Hawaii§	233	124	53.2	42.9	10.3
Idaho	203	121	59.6	52.2	7.4
Illinois	2,598	1,352	52.0	44.8	7.3
Indiana	668	368	55.1	41.6	13.5
Iowa	422	220	52.1	47.9	4.3
Kansas	317	187	59.0	51.4	7.6
Kentucky	450	268	59.6	45.6	14.0
Louisiana	231	110	47.6	38.5	9.1
Maine§	84	54	64.3	57.1	7.1
Maryland§	1,423	702	49.3	45.0	4.4
Massachusetts	3,086	1,489	48.3	43.1	5.2
Michigan	1,282	675	52.7	45.9	6.7
Minnesota	942	440	46.7	40.7	6.1
Mississippi	145	78	53.8	31.0	22.8
Missouri	608	353	58.1	48.7	9.4
Montana	55	30	54.5	43.6	10.9
Nebraska	260	132	50.8	40.8	10.0
Nevada	251	148	59.0	50.2	8.8
New Hampshire	191	104	54.5	48.2	6.3
New Jersey	3,106	1,614	52.0	45.2	6.7
New Mexico§	149	96	64.4	56.4	8.1
New York	4,742	2,448	51.6	45.2	6.4
North Carolina§	896	540	60.3	51.1	9.2
North Dakota§	85	46	54.1	44.7	9.4
Ohio	1,457	803	55.1	45.8	9.3
Oklahoma§	280	147	52.5	40.7	11.8
Oregon	425	241	56.7	50.6	6.1
Pennsylvania	1,449	764	52.7	43.7	9.0
Puerto Rico	119	65	54.6	36.1	18.5
Rhode Island	285	141	49.5	47.4	2.1
South Carolina§	362	189	52.2	43.9	8.3
South Dakota§	59	26	44.1	28.8	15.3
Tennessee	366	213	58.2	41.0	17.2
Texas§	2,559	1,408	55.0	48.5	6.6
Utah	258	143	55.4	47.3	8.1
Vermont	95	57	60.0	50.5	9.5
Virgin Islands, U.S.§	11	11	11	11	11
Virginia§	1,324	629	47.5	40.2	7.3
Washington	931	492	52.8	47.0	5.8
West Virginia	75	40	53.3	45.3	8.0
Wisconsin	478	272	56.9	49.2	7.7
Wyoming§	48	30	62.5	62.5	0.0
Non-U.S. resident	589	306	52.0	45.5	6.5
Total	45,751	24,154	52.8	45.3	7.5

*In cases of missing residency data, the patient's state of residency was assigned as the state in which the ART procedure was performed. Medical centers in all but four states had missing residency for <10% of ART infants. Medical centers located in Georgia, Massachusetts, Minnesota, and New York had >10% missing residency data.

†Numbers might not sum to total because of rounding.

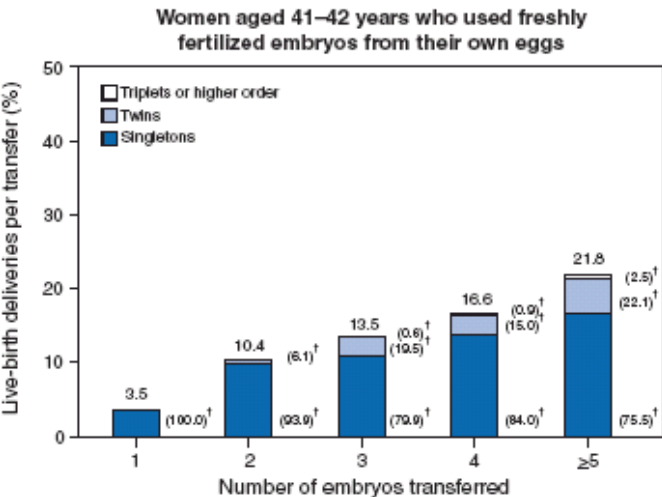
§A total of 0.6% of ART procedures were reported from military medical centers located in California, District of Columbia, Hawaii, and Texas. States and territories for which ≥1% of ART procedures among state residents were performed in a military medical center were Alaska, the District of Columbia, Georgia, Guam, Hawaii, Maine, Maryland, New Mexico, North Carolina, North Dakota, South Carolina, South Dakota, Texas, the U.S. Virgin Islands, Virginia, and Wyoming. States and territories for which >5% of ART procedures among state residents were performed in a military medical center were the District of Columbia, Guam, the U.S. Virgin Islands, and Virginia.

¶Data not indicated to preserve confidentiality but included in total.

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Figure 6

FIGURE 6. Live birth rates and multiple-birth risk, by number of embryos transferred — United States, 2002*



* Numbers might not add to 100% because of rounding.
† Percentages of live births that were singletons, twins, and triplets or higher order are in parentheses.

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Table 7

TABLE 7. Effect of assisted reproductive technology (ART) on the total live-born infants in the United States, by plurality — United States, 2002

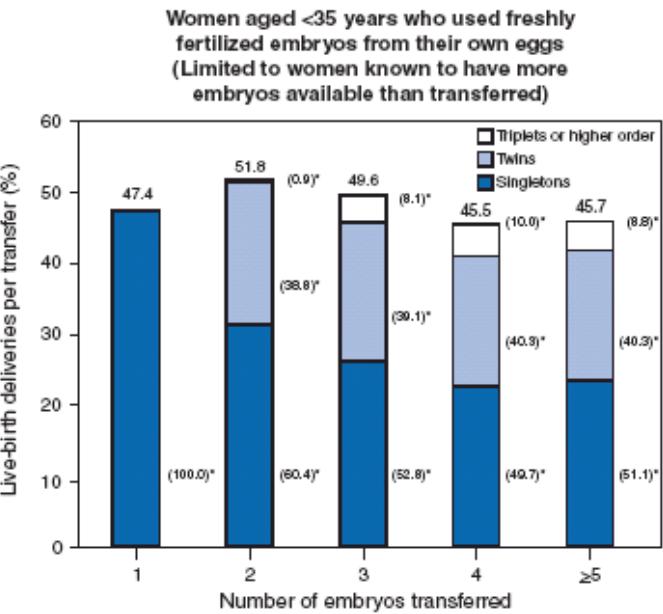
Plurality	Number of ART infants ^{††} (% of total)	Number of total U.S. infants [§] (% of total)	Contribution of ART to total infants born in the United States (%)
Infants born in singleton deliveries	19,829 (46.7%)	3,889,191 (96.7%)	0.5
Infants born in multiple-birth deliveries	22,654 (53.3%)	132,535 (3.3%)	17.1
Twin deliveries	19,409 (45.7%)	125,134 (3.1%)	15.5
Triplets or higher-order deliveries	3,245 (7.6%)	7,401 (0.2%)	43.8
Total number of infants	42,483	4,021,726	1.1

* Source: Assisted Reproductive Technology Surveillance System.
† Includes infants conceived from ART procedures performed in 2001 and born in 2002 and infants conceived from ART procedures performed in 2002 and born in 2002.
§ Source: U.S. natality file, CDC, National Center for Health Statistics.

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Figure 7

FIGURE 7. Live birth rates and multiple-birth risk, by number of embryos transferred — United States, 2002



* Percentages of live births that were singletons, twins, and triplets or higher order are in parentheses.

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Table 8

TABLE 8. Percentage of adverse perinatal outcomes* among assisted reproductive technology (ART) infants born in 2002, by plurality — United States†

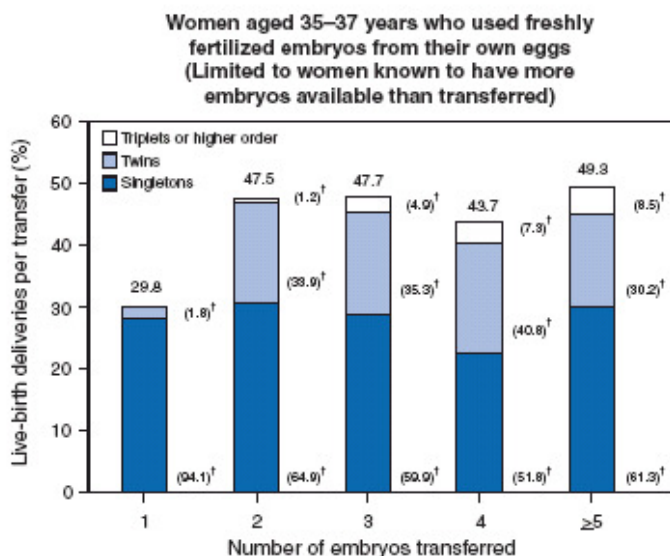
Plurality	LBW (%)	VLBW (%)	Preterm (%)	Preterm LBW (%)	Term LBW (%)
ART singletons (n = 19,829)	9.1	1.9	14.5	7.1	2.1
ART twins (n = 19,409)	54.3	8.8	61.7	44.9	9.5
ART triplets or higher-order multiples (n = 3,245)	94.8	30.7	97.2	92.6	§

* LBW = low birthweight (<2,500 g); VLBW = very low birthweight (<1,500 g); preterm = gestational age <37 weeks; preterm LBW = gestational age <37 weeks and low birthweight (<2,500 g); and term LBW = gestational age ≥37 weeks and low birthweight (<2,500 g).
† Includes infants conceived from ART procedures performed in 2001 and born in 2002 and infants conceived from ART procedures performed in 2002 and born in 2002. Samples for calculation of percentages of outcomes were reduced from totals because of missing values for birthweight and gestational age.
§ Data not provided because of limited numbers.

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Figure 8

Figure 8. Live birth rates and multiple-birth risk, by number of embryos transferred — United States, 2002*



* Numbers might not add to 100% because of rounding.

† Percentages of live births that were singletons, twins, and triplets or higher order are in parentheses.

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Table 9

TABLE 9. Adverse perinatal outcomes* among assisted reproductive technology (ART) singleton infants born in 2002, by procedure type and selected maternal factors — United States†

Procedure type/Maternal factor	LBW (%)	VLBW (%)	Preterm (%)	Preterm LBW (%)	Term LBW (%)
Freshly fertilized embryos, patient eggs (n = 14,615)	9.3§	1.9	13.3§	7.0§	2.3§
Maternal age (yrs)					
<35	9.3	1.8	13.5	7.0	2.3
35–37	9.1	2.1	13.0	7.0	2.1
38–40	9.6	1.9	13.4	7.2	2.4
41–42	10.0	2.5	13.7	7.5	2.4
>42	7.0	1	9.5	1	1
Maternal race/ethnicity**					
Non-Hispanic white	9.2††	1.7††	13.5††	6.9††	2.2
Non-Hispanic black	18.2	5.1	21.9	14.3	4.0
Hispanic	12.7	2.3	15.7	10.0	2.7
Asian	11.0	2.5	12.3	7.5	3.3
Number of previous births§§					
0	9.8††	2.0	13.2††	7.3††	2.5
1	7.5	1.4	12.4	5.7	1.7
≥2	10.0	2.2	16.7	7.8	2.3
Freshly fertilized embryos, donors eggs (n = 2,199)	10.7	2.1	16.3	9.0	1.8
Thawed embryos¶¶ (n = 3,015)	7.2	1.6	18.9	6.0	1.2

* LBW = low birthweight (<2,500 g); VLBW = very low birthweight (<1,500 g); preterm = gestational age <37 weeks; preterm LBW = gestational age <37 weeks and low birthweight (<2,500 g); and term LBW = gestational age ≥37 weeks and low birthweight (<2,500 g).

† Includes infants conceived from ART procedures performed in 2001 and born in 2002 and infants conceived from ART procedures performed in 2002 and born in 2002. Samples for calculation of percentages of outcomes were reduced from totals because of missing values for birthweight and gestational age.

§ P<0.01; chi-square to test for variations in adverse perinatal outcomes across procedure types.

1 Risk for outcome not provided if number of cases in a given subgroup is <10.

** Analysis did not include 43% of ART singletons for whom data on maternal race/ethnicity were missing. Analysis did not include 0.1% of ART singletons with mothers whose race/ethnicity was Native American or Other because of limited sample size and ensuing unstable estimates for perinatal outcomes.

†† P<0.01; chi-square to test for variations in adverse perinatal outcomes across maternal factor categories.

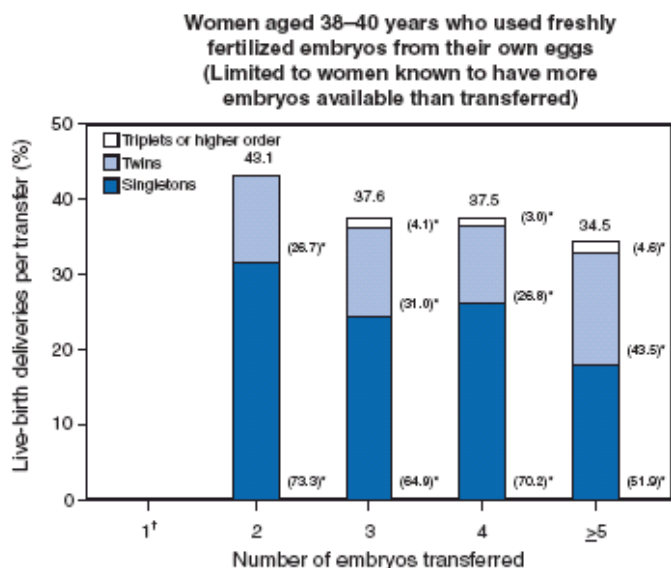
§§ Analysis did not include 0.4% of ART singletons for whom maternal data on number of previous births were missing.

¶¶ Includes cycles in which thawed embryos were used from patient eggs and donor eggs.

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Figure 9

Figure 9. Live birth rates and multiple-birth risk, by number of embryos transferred — United States, 2002



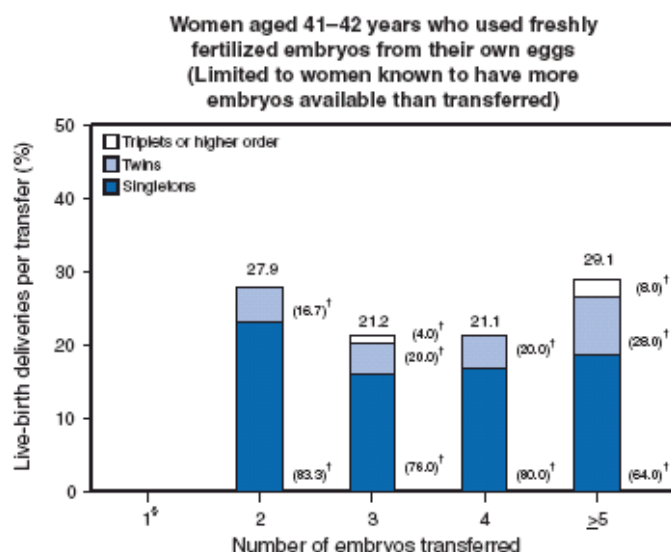
* Percentages of live births that were singletons, twins, and triplets or higher order are in parentheses.

† Statistics are not provided in cases where the denominator is <10.

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Figure 10

Figure 10. Live birth rates and multiple-birth risk, by number of embryos transferred — United States, 2002*



* Numbers might not add to 100% because of rounding.

† Percentages of live births that were singletons, twins, and triplets or higher order are in parentheses.

§ Statistics are not provided in cases where the denominator is <10.

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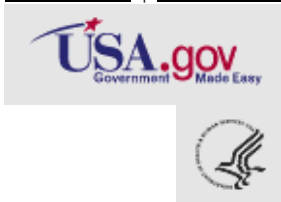
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