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A cross-sectional evaluation of the first cohort of young adults conceived by in vitro fertilization in the United States

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Abstract

Objective—To assess the quality-of-life and susceptibility for chronic disease development of the oldest generation of young adults conceived by IVF in the U.S.

Design—Cross-sectional.

Setting—Tertiary, single clinic.

Patients—young adults conceived by standard IVF between 1981 and 1990.

Intervention—Self-administered questionnaire.

Main outcome measures—indicators of physical, psychological and behavioral health.

Results—173 (31%) of 560 eligible young adults completed the questionnaire. Mean age was 21.2 years (range 18–26) and male-to-female sex ratio was 3:4. A limited number was conceived through gamete donation but none through oocyte/embryo micromanipulation. Prevalence rates of overweight and obesity were 35% and 10%, respectively. Over 65% were ever diagnosed with a chronic condition; most diagnoses were psychiatric, ocular, respiratory and cardiometabolic in nature. Nearly 40% of respondents were lifetime smokers, 62% reported binge drinking in the previous year and over 90% were physically active in the previous month. Survey participants were mostly comparable to a sub-sample of the 1999–2004 National Health and Nutrition Examination Survey on selected health indicators.

Conclusions—Young adults conceived by IVF appear to be healthy and well-adjusted, although the preponderance of psychological health problems requires further investigation.

Keywords

in vitro fertilization; cross-sectional; chronic disease; behavior

Introduction

Epidemiologic studies suggest a link between early developmental exposures and chronic diseases in adult life (1,2). Despite its increasing application and success, in vitro fertilization

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(IVF) has sparked many controversies since its inception at the turn of the 20th century. Evidence supporting harmful health effects of IVF remains equivocal (1). Currently an established technique for assisted reproduction, IVF contributes to over 1% of annual births in westernized countries (2).

Although IVF success rates are mostly assessed through pregnancy and live birth achievement, there are lingering questions with regard to IVF safety (1). IVF involves several steps, including hormonal stimulation, oocyte retrieval, fertilization, embryo culture and intrauterine embryo transfer; it has been speculated that each of these steps can engender health risks in the short- and long-run (4). ‘Programming’ at the germinal and embryonic stages of life may be altered by genetic, epigenetic and environmental factors, potentially affecting growth and development of the offspring (2). Despite a concerted effort in most countries to reduce the number of embryos transferred per IVF cycle, multiple embryo transfer and more rarely embryo splitting, result in enhanced likelihood of twins, triplets and occasionally higher-order pregnancies (2). Adverse IVF outcomes, including preterm delivery, low birthweight (LBW) and fetal growth restriction, may be partly outcomes of plurality (2). Physical, psychological and social well-being of IVF offspring may also be influenced by underlying parental sub-fertility, parenting stress, parent-child relationship and other aspects of IVF, including issues of secrecy and disclosure (1,5). Efforts aimed at disentangling respective roles of the IVF procedure, plurality and alternative explanations have proven to be challenging.

Substantial evidence exists for marginal associations between assisted reproductive technologies (ART), including IVF, and risks of adverse pregnancy outcome, congenital malformations and rare epigenetic defects; by contrast, studies of long-term outcomes that manifest during childhood, adolescence and young adulthood are relatively scarce and have mostly yielded conflicting results (6). Given the recent nature of ART, no studies have evaluated the health of young adults conceived by standard IVF.

In this study, we surveyed the oldest generation of IVF live births in the U.S., delivered between 1981 and 1990. Our program reported the first IVF birth in the U.S. (Elizabeth Carr), which was also the first successful pregnancy achieved using gonadotropin stimulation. The main objective of this study was to perform a comprehensive assessment of IVF-conceived young adults in an effort to identify health problems and other quality-of-life aspects that might benefit from further investigation. In the process, we examined gender disparities and whether selected risk factors for chronic disease development were more frequently encountered among IVF-conceived young adults versus the general U.S. population.

Materials and Methods

We conducted a cross-sectional evaluation of the first cohort of young adults conceived by IVF at the Jones Institute for Reproductive Medicine (JIRM), the Division of Reproductive Endocrinology and Infertility at Eastern Virginia Medical School (EVMS) in Norfolk, Virginia. The Institutional Review Board at EVMS approved the study with a waiver of informed consent.

Young adults conceived by standard IVF were enrolled through their parents. At the time, neither oocyte nor embryo micromanipulation were applied; however, a limited number were conceived through gamete donation or frozen embryos. Arslan *et al.* (7) and Riggs *et al.* (8) published reviews of IVF procedures during the first two decades of experience at our center. Using a specialized database for patients seeking IVF at the JIRM, a list of IVF cycles that resulted in a live birth was created and a sampling frame was generated by reconciling this list against a mailing list. The mailing list contains personal data on former JIRM patients, including names and addresses. A contact list was created by applying eligibility criteria to the

sampling frame. Former patients were included on the contact list if they sought IVF treatment between January 1st, 1981 and December 31st, 1990 and delivered at least one live-born infant. Those who were not willing to be contacted, those who had not disclosed method of conception to their IVF offspring or had no surviving offspring conceived by IVF were excluded from the contact list. A total of 417 former patients and 560 young adults met all eligibility criteria.

Initial contact and follow-up letters were mass-mailed to former patients on the contact list. These letters described study procedures and asked patients to complete and mail an enclosed form in a self-addressed envelope; the form enquired about their willingness to partake in the study by forwarding survey materials to offspring. To maintain confidentiality, young adults were instructed to contact a third-party key-holder at the JIRM, on a voluntary basis; this contact person was responsible for assigning each young adult a unique identifier and granting them access to the survey instrument. At closing date, 209 (50.1%) of former patients had not replied to the letters, 18 (4.3%) were untraceable and 17 (4.1%) refused to participate, leaving 173 (41.4%) who forwarded survey materials to their offspring. Of 189 subjects given a unique identifier, 173 (91.5%) completed the survey by the closing date. Of 146 mothers to 173 respondents, 9 (6.2%) conceived through egg donation and 3 (2.0%) through sperm donation; 7 of the 173 respondents were outcomes of frozen-thawed embryos. The estimated response rate was 31% (Figure 1).

A 90-item self-administered questionnaire was developed using QuestionPro (9). The instrument was entirely focused on young adults and no parental data were obtained. In this study, we evaluated selected health characteristics, namely body size, chronic diseases, cigarette smoking, alcohol drinking and physical exercise. Self-reported weight (kg) and height (m) were used to compute body mass index (BMI) in kg/m². Respondents were asked to report whether they had ever been diagnosed by a health professional with attention deficit disorder (ADD), attention deficit hyperactivity disorder (ADHD), asthma, autism, cancer, cerebral palsy, chronic bronchitis, cystic fibrosis, clinical depression, type 1 diabetes, type 2 diabetes, eating disorders, heart disease, HIV/AIDS, hypercholesterolemia, hypertension, ocular, hearing, speech problems or other health conditions. Lifetime and recent (previous 30 days) experiences with cigarette smoking were evaluated and respondents were classified as ‘never smokers’, ‘ex-smokers’ and ‘current smokers’. Use of alcohol, including frequency (times/week), quantity (drinks/occasion) and binge drinking (≥ 5 alcoholic drinks within a 2-hour period) in the year preceding the survey were evaluated. Performance of light, moderate and vigorous physical exercise in the previous 30 days was categorized as ‘No’, ‘Yes, but not daily’ and ‘Yes, daily’.

Health characteristics were analyzed by gender. Statistical significance was evaluated using Chi-square, Fisher’s exact and independent samples t-tests; logistic regression was performed to calculate odds ratios (OR) and their 95% confidence intervals (CI). Respondents were compared on selected characteristics to a sub-sample of the National Health and Nutrition Examination Survey (NHANES). Since 1999, NHANES has become a continuous surveillance system. We, therefore, combined the 1999–2004 NHANES datasets for the current analyses. Most survey respondents were non-Hispanic White and their ages ranged between 18 and 26 years; thus, 1,315 non-Hispanic Whites 18–26 years of age from the 1999–2004 NHANES were compared to the 173 respondents. Standard errors were estimated assuming simple random sampling for our sample and stratified multistage probability cluster sampling for the NHANES sample. Two-sided statistical tests were evaluated at alpha of 0.05.

Results

Table 1 presents demographic characteristics by gender. Male-to-female sex ratio was 3:4, mean age was 21.2 years and 11.5% were LBW (versus 12% in the U.S.). Nearly 37% were

multiple births; of those, 83% were twins, 11% were triplets and 6% were quadruplets. Whereas 87% were neither married nor cohabiting, 44% had at least a Bachelor's degree and 41% were unemployed. None of the respondents reported having attempted a pregnancy. Nearly 40% reported ever smoking and 14% were current smokers. Although lifetime smoking prevalence did not differ significantly by gender, males were 2.5 times more likely than females to be current smokers. Whereas 11% were non-drinkers of alcohol, 62% reported binge drinking at least once in the past year. Binge drinking was significantly more prevalent among males compared to females. Daily performance of light, moderate and vigorous physical exercise was prevalent in 53%, 55% and 36% of survey respondents, respectively.

Table 2 describes body size and chronic disease characteristics of respondents by gender. Prevalence rates of overweight and obesity were 34.6% and 10.3%, respectively. Over 65% had ever been diagnosed with a chronic disease; most prevalent types of diagnoses were psychiatric (31.2%), ocular (29.5%), respiratory (21.4%) and cardiometabolic (10.4%) in nature. Diagnoses prevalent in over 10% of surveyed young adults were clinical depression (15.6%), attention deficit/hyperactivity disorder (27.1%) and asthma/allergies (19.7%). Females were nearly six times more likely to be diagnosed with clinical depression than males. Congenital malformations and cancers were rare occurrences; two respondents were diagnosed with cardiovascular defects (mitral valve prolapse and bicuspid aortic valve malformation) and two others were diagnosed with cancer (basal cell carcinoma and Hodgkin's disease) during their lifetime. All cardiovascular and cancer diagnoses were reported by young adults who were the outcome of a multiple gestation. It is worth noting, however, that no significant differences were observed in the selected health indicators according to plurality (data not shown).

With few exceptions, the IVF and NHANES samples were comparable on selected risk factors for chronic disease development. Whereas BMI did not differ significantly across populations, current smoking was less prevalent in the IVF sample and IVF females reported alcohol use and binge drinking more frequently than NHANES counterparts. Interestingly, IVF-conceived young adults reported a higher prevalence of light, moderate or vigorous physical exercise than those in the NHANES sample (Table 3).

Discussion

To our knowledge, this study is the first to evaluate a broad range of long-term health consequences for the IVF procedure beyond infancy, childhood and adolescence (11). To date, only three studies have examined adolescent health; one study went up to 15 years (12) and two studies went up to 18 years (13,14) of age. Using a cross-sectional design, we performed a multi-dimensional assessment of the oldest U.S.-based generation of IVF offspring, currently 18–26 years of age. We focused our attention on health problems and quality-of-life aspects that are typical of this age group; young adults conceived by IVF were found to be similar to the U.S. general population on most risk factors for chronic disease development. Few congenital and cancer diagnoses were reported by survey participants; whereas gender disparities were noted, the role of plurality in long-term physical, psychological and behavioral health outcomes appears to be limited.

Previous studies have compared ART to naturally conceived offspring through an examination of 'obstetric, perinatal, neonatal, post-neonatal outcomes' (15), 'chromosomal aberrations' (16), 'congenital malformations' (17), 'growth and metabolic disorders' (6) or 'motor, neurological, cognitive and socio-emotional development' (18). Recent reviews (2,6, 11) have concluded that, despite the dearth of evidence, neurological, developmental and psychological outcomes of ART- and naturally-conceived offspring appear to be comparable; by contrast, excess morbidity in the ART population has been primarily attributed to perinatal

outcomes, congenital anomalies and imprinting diseases such as Langerhan's histiocytosis (11), Prader-Willi (19), Angelman (11) and Beckwith-Wiederman (11) syndromes. A major concern for parents is future fertility of ART children which obviates the need to thoroughly examine pubertal development. Basatemur and Sutcliffe (11) also highlighted the importance of continued monitoring of ART offspring in order to evaluate long-term health risks, including cardiovascular disease and cancer.

Unlike previous studies, our results suggest a preponderance of psychological problems, especially among females. Up to 25 years of age, the lifetime prevalence of clinical depression is expected to be 12.7% with a male-to-female ratio of 1:2 (20). In this study, lifetime prevalence of clinical depression was estimated at 15.9% with a male-to-female ratio of 1:6. Frequently diagnosed prior to 7 years of age, attention deficit/hyperactivity disorders (ADD/ADHD) is known to affect 3–5% of the general population and often persists into adult years (21,22). Our survey suggests that 27.1% of surveyed young adults had ever been diagnosed with ADD/ADHD. The latter finding is consistent with past reports (1) and levels of physical exercise exceeding those of the general U.S. population.

Cardiometabolic and respiratory morbidities may be reflective of altered fetal programming as suggested by the Barker hypothesis; our results did not suggest excessive rates of obesity-associated problems. Whereas biological mechanisms that might explain the role of IVF in physical health have been clearly delineated, psychosocial mechanisms appear to be more complex (11). Past research has suggested a high level of stress among prospective parents undergoing IVF; those who achieve a live birth may be over-protective of their offspring. This can potentially affect parent-child relationships and the child's socio-emotional development (24). IVF family dynamics are particularly vulnerable to issues of secrecy and disclosure, especially when genetic relatedness between parents and children is incomplete (5). Consequently, behavioral problems may occur more frequently among offspring conceived through IVF. In this study, lifetime and current smoking behaviors were within the expected range; however, the prevalence of binge drinking among females in the study sample was nearly 1.5 times higher than females in the NHANES sample. This pattern of alcohol consumption, which can manifest later in life as chronic alcoholism, has been previously reported in 42% of U.S. adults, 18–25 years of age (25).

Our results need to be interpreted cautiously in light of several limitations. First, cross-sectional design precludes ascertainment of temporal relationships. Second, low response rate (31%) and retrospective self-reporting can result in self-selection and measurement error, respectively. Of particular concern is the issue of survivor bias whereby an appreciable number of non-respondents may have consisted of IVF-conceived offspring diagnosed with life-threatening medical problems and who may have died prior to survey administration; this limitation may have underestimated the burden of disease among IVF-conceived offspring. Also, self-reporting of weight is notoriously error-prone and may have resulted in under-estimation of BMI in our survey and the NHANES sample. Ability to establish direct contact with eligible subjects and access to their medical records data would have reduced some of those validity issues. Third, sample size may have limited our ability to discern existing associations. Finally, all participants were conceived through standard IVF and aware of their IVF status; most were highly educated and non-Hispanic White. This could affect generalization to other ethnic, socioeconomic and clinical populations.

In conclusion, surveyed young adults appear to be healthy and well-adjusted with no increased susceptibility to chronic diseases; the relatively high prevalence of clinical depression, ADD/ADHD and binge drinking needs further investigation through large prospective cohort studies. Although a high percentage reported at least one chronic condition, few of these conditions have been previously linked with IVF. Future IVF studies should focus on psychiatric,

respiratory and cardiometabolic conditions that often manifest during childhood, adolescence and young adulthood. These studies should attempt to identify the respective roles of the IVF procedure, parental age, sub-fertility diagnosis, plurality and other characteristics that are typical of IVF families. Maintenance of high pregnancy rates by double embryo transfers resulting in reduction of high order multiples and increasing use of selective single embryo transfers as performed in some centers will continue to have a positive impact on IVF outcomes (26,27).

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Figure 1.
Flowchart of recruitment and enrollment procedures.

Table 1

Demographic and behavioral characteristics of study sample by gender

	Total (n=173) n (%)	Males (n=75) n (%)	Females (n=98) n (%)	Males vs. Females OR 95% CI
<i>Age (yrs)</i>				
Mean(n)±SD	21.2(173)±2.3	20.9(75)±2.2	21.3(98)±2.3	$p^b = 0.34$
<i>Plurality</i>				$p^a = 0.62$
Singleton	109 (63.4)	46 (61.3)	63 (64.9)	1.00 --
Multiple	63 (36.6)	29 (38.7)	34 (35.0)	1.17 0.63–2.18
<i>Birth weight (grams)</i>				$p^a = 0.32$
<2500	17 (11.5)	5 (8.3)	12 (13.6)	1.00 --
≥ 2500	131 (88.5)	55 (91.7)	76 (86.4)	0.57 0.19–1.73
<i>Marital status</i>				$p^a = 0.24$
Single	151 (87.3)	68 (90.7)	83 (84.7)	1.76 0.68–4.55
Married/Cohabiting	22 (12.7)	7 (9.3)	15 (15.3)	1.00 --
<i>Education</i>				$p^a = 0.13$
High school or less	42 (24.3)	16 (21.3)	26 (26.5)	1.00 --
College-Associate degree	55 (31.8)	30 (40.0)	25 (25.5)	1.95 0.86–4.42
Bachelor-Graduate degree	76 (43.9)	29 (38.7)	47 (47.9)	1.00 0.46–2.18
<i>Employment</i>				$p^a = 0.60$
Unemployed	71 (41.5)	35 (46.7)	36 (37.5)	0.75 0.34–1.66
Volunteer	18 (10.5)	6 (8.0)	12 (12.5)	1.46 0.45–4.69
Part-time/Temporary	44 (25.7)	18 (24.0)	26 (27.1)	1.05 0.44–2.53
Full-time	38 (22.2)	16 (21.3)	22 (22.9)	1.00 --
<i>Cigarette smoking</i>				$p^c = 0.15$
Never smoker	104 (60.5)	42 (56.0)	62 (63.9)	1.00 --
Ex-smoker	44 (25.6)	18 (24.0)	26 (26.8)	1.02 0.49–2.09
Current smoker	24 (13.9)	15 (20.0)	9 (9.3)	2.46 0.99–6.14
Alcohol drinking				$p^d = 0.54$
<i>Alcohol drinker (past 12 months)</i>				

	Total (n=173) n (%)	Males (n=75) n (%)	Females (n=98) n (%)	Males vs. Females <i>OR</i> 95% <i>CI</i>
No	18 (10.4)	9 (12.0)	9 (9.2)	1.00 --
Yes	155 (89.6)	66 (88.0)	89 (90.8)	0.74 0.28–1.97
<i>Frequency (past 12 months)</i>				
<i>p^a = 0.31</i>				
Non-drinker	18 (10.6)	9 (12.2)	9 (9.4)	1.00 --
< 1 time/week	45 (26.5)	22 (29.7)	23 (23.9)	0.96 0.32–2.85
1 time/week	28 (16.5)	11 (14.9)	17 (17.7)	0.65 0.19–2.14
2 times/week	47 (27.7)	15 (20.3)	32 (33.3)	0.47 0.16–1.42
3+ times/week	32 (18.8)	17 (22.9)	15 (15.6)	1.13 0.36–3.60
<i>Quantity (past 12 months)</i>				
<i>p^a = 0.55</i>				
Non-drinker	18 (10.6)	9 (12.2)	9 (9.4)	1.00 --
1–2 drink/occasion	67 (39.4)	27 (36.5)	40 (41.7)	0.68 0.24–1.92
3–4 drinks/occasion	42 (24.7)	16 (21.6)	26 (27.1)	0.62 0.20–1.88
5+ drinks/occasion	43 (25.3)	22 (29.7)	21 (21.9)	1.05 0.35–3.15
<i>Binge drinker (past 12 months)</i>				
<i>p^a = 0.02</i>				
No	65 (38.0)	21 (28.4)	44 (45.4)	1.00 --
Yes	106 (61.9)	53 (71.6)	53 (54.6)	2.09 1.10–3.99
Physical exercise				
<i>Light activity</i>				
<i>p^a = 0.74</i>				
No	40 (23.3)	19 (25.3)	21 (21.7)	1.00 --
Yes, but not daily	41 (23.8)	16 (21.3)	25 (25.8)	0.71 0.29–1.71
Yes, daily	91 (52.9)	40 (53.3)	51 (52.6)	0.87 0.41–1.83
<i>Moderate activity</i>				
<i>p^a = 0.98</i>				
No	13 (7.5)	6 (8.0)	7 (7.1)	1.00 --
Yes, but not daily	65 (37.6)	28 (37.3)	37 (37.8)	0.88 0.27–2.92
Yes, daily	95 (54.9)	41 (54.7)	54 (55.1)	0.89 0.28–2.84
<i>Vigorous activity</i>				
<i>p^a = 0.48</i>				
No	37 (21.8)	15 (20.0)	22 (23.2)	1.00 --
Yes, but not daily	80 (47.1)	33 (44.0)	47 (49.5)	1.52 0.65–3.56
Yes, daily	53 (31.2)	27 (36.0)	26 (27.4)	1.03 0.47–2.28

Notes:

^a Chi-square test;

^b t-test;

^c Fisher's exact test.

Table 2

Body size and chronic diseases of study sample by gender

	Total (n=173) n (%)	Males (n=75) n (%)	Females (n=98) n (%)	Males vs. Females >OR >95% CI
Body size				
<i>Weight (kg)</i>				
Mean(n)±SD	74.9(165)±16.0	86.1(69)±14.8	66.9 (96)±11.5	$p^k < 0.0001$
<i>Height (m)</i>				
Mean(n)±SD	1.7 (172)±0.1	1.8(74)±0.07	1.6 (98) ± 0.08	$p^k < 0.0001$
<i>Body mass index (kg/m²)</i>				$p^l = 0.007$
< 20	3 (1.8)	0 (0.0)	3 (3.1)	-- --
20–24.9	88 (53.3)	28 (40.6)	60 (62.5)	1.00 --
25–29.9	57 (34.6)	31 (44.9)	26 (27.1)	2.56 1.28–5.02
30+	17 (10.3)	10 (14.5)	7 (7.3)	3.06 1.06–8.88
Mean(n)±SD	25.2(165)±3.7	26.3(69)±3.9	24.5(96)±3.4	$p^l = 0.001$
Chronic diseases				
<i>Any</i>	113 (65.3)	46 (61.3)	67 (68.4)	1.36 0.73–2.56
<i>Psychiatric</i>	54 (31.2)	20 (26.7)	34 (34.7)	1.46 0.76–2.82
Attention Deficit Disorder	29 (16.7)	15 (20.0)	14 (14.3)	0.67 0.29–1.48
Attention Deficit Hyperactivity Disorder	18 (10.4)	11 (14.7)	7 (7.1)	0.44 0.16–1.22
Clinical Anxiety	5 (2.9)	2 (2.7)	3 (3.1)	1.15 0.18–7.07
Clinical Depression [*]	27 (15.6)	4 (5.3)	23 (23.5)	5.44 1.79–16.52
Eating Disorders	7 (4.0)	2 (2.7)	5 (5.1)	1.96 0.37–10.40
Other psychiatric ^a	6 (3.5)	3 (4.0)	3 (3.1)	0.76 0.15–3.87
<i>Ocular</i>	51 (29.5)	17 (22.7)	34 (34.7)	1.81 0.92–3.58
<i>Respiratory</i>	37 (21.4)	16 (21.3)	21 (21.4)	0.76 0.10–5.52
Asthma/Allergies	34 (19.7)	14 (18.7)	20 (20.4)	1.12 0.52–2.39
Other respiratory ^b	4 (2.3)	2 (2.7)	2 (2.0)	NA NA
<i>Cardiometabolic</i>	18 (10.4)	6 (8.0)	12 (12.2)	0.62 0.18–2.10
Cardiovascular ^c	2 (1.2)	1 (1.3)	1 (1.0)	0.76 0.047–12.39

	Total (n=173) n (%)	Males (n=75) n (%)	Females (n=98) n (%)	Males vs. Females >OR >95% CI
Metabolic ^d	16 (9.3)	5 (6.7)	11 (11.2)	1.77 0.59–5.33
Speech	12 (6.9)	6 (8.0)	6 (6.1)	0.75 0.23–2.42
Neurological ^e	8 (4.6)	4 (5.3)	4 (4.1)	0.76 0.18–3.12
Hearing impairment	5 (2.9)	3 (4.0)	2 (2.0)	0.50 0.081–3.07
Reproductive ^f	4 (2.3)	0 (0.0)	4 (4.1)	NA NA
Gastrointestinal	3 (1.7)	0 (0.0)	3 (3.1)	NA NA
Cancer ^g	2 (1.2)	2 (2.7)	0 (0.0)	NA NA
Musculoskeletal ^h	2 (1.2)	0 (0.0)	2 (2.0)	NA NA
Hematology ⁱ	1 (0.6)	0 (0.0)	1 (1.0)	NA NA
Urogenital ^j	1 (0.6)	0 (0.0)	1 (1.0)	NA NA

Notes: NA=Not Available;

* Statistically significant difference ($P < 0.05$) between males and females;

^a Other psychiatric conditions include panic disorder (n=2), bipolar disorder (n=2), obsessive compulsive disorder (n=1) and social anxiety disorder (n=1);

^b Other respiratory conditions include pneumothorax (n=2), sinusitis (n=1) and chronic bronchitis (n=1);

^c Cardiovascular conditions include mitral valve prolapse (n=1) and bicuspid aortic valve malformation (n=1);

^d Metabolic conditions include hypercholesterolemia (n=6), hypertension (n=5), hypothyroidism (n=4), insulin resistance (n=1) and polycystic ovary syndrome (n=1);

^e Neurological conditions include migraines (n=5), epilepsy (n=1), Tourette syndrome (n=1) and mental handicap (n=1);

^f Reproductive conditions include polycystic ovary syndrome (n=1) and menstrual problems (n=3);

^g Cancer conditions include basal cell carcinoma (n=1) and Hodgkin's disease (n=1);

^h Musculoskeletal conditions include degenerative disc disease (n=1) and rheumatoid arthritis (n=1);

ⁱ Hematology conditions include immune thrombocytopenic purpura (n=1);

^j Urogenital conditions include polycystic kidney disease (n=1);

^k Chi-square test;

^l t-test.

Table 3
Comparison of young adults conceived by IVF to the 1999–2004 NHANES sub-sample on selected risk factors for chronic disease

	Total			Males			Females		
	IVF Pct. (95% CI)	NHANE ^{9a} Pct. (95% CI)	N	IVF Pct. (95% CI)	NHANE ^{9a} Pct. (95% CI)	N	IVF Pct. (95% CI)	NHANE ^{9a} Pct. (95% CI)	N
Body mass index									
<i>Overweight/Obese</i>									
Yes	44.9 (37.0–52.0)	46.5 (43.1–49.8)	59.4 (48.0–71.0)	51.6 (47.7–55.5)	34.4 (25.0–44.0)	41.3 (37.4–45.2)			
Cigarette smoking									
<i>Ever smoker</i>									
Yes	39.5 (33.0–47.0)	50.3 (44.4–56.2)	44.0 (33.0–55.0)	54.6 (48.7–60.5)	36.1 (27.0–46.0)	45.9 (40.0–51.8)			
<i>Current smoker</i>									
Yes	13.9 * (9.0–19.0)	38.8 * (34.9–42.7)	20.0 * (11.0–29.0)	44.4 * (38.1–49.9)	9.3 * (4.0–15.0)	33.1 * (29.1–36.9)			
Alcohol drinking									
<i>Used alcohol</i>									
Yes	89.6 (85.0–94.0)	79.1 (71.3–86.9)	88.0 (81.0–95.4)	84.3 (78.4–90.2)	90.8 * (85.1–96.5)	73.8 * (64.0–83.6)			
<i>Binge drinker</i>									
Yes	61.9 (55.0–69.0)	52.3 (46.4–58.2)	71.6 (61.0–82.0)	67.7 (61.7–73.5)	54.6 * (45.0–65.0)	36.5 * (30.6–42.4)			
Physical exercise									
<i>Light activity</i>									
Yes	76.3 * (70.0–83.0)	47.1 * (43.1–50.9)	74.7 * (65.0–85.0)	53.5 * (49.1–56.9)	77.6 * (69.0–86.0)	40.5 * (34.1–45.9)			
<i>Moderate activity</i>									
Yes	92.5 * (89.0–96.0)	61.4 * (55.5–67.2)	92.0 * (83.0–97.0)	58.1 * (52.0–63.9)	92.9 * (88.0–98.0)	64.7 * (60.1–67.9)			
<i>Vigorous activity</i>									
Yes	77.3 * (71.0–84.0)	58.2 * (52.3–64.1)	80.0 * (69.0–88.0)	63.9 (58.0–69.8)	75.3 * (67.0–84.0)	52.4 * (46.5–58.3)			

Notes:

^a Using STATA survey commands, we applied recommended sub-sample weights for the period of 1999–2004. Mobile Examination Center (MEC) exam weights were used for all analyses. Masked variance units were used to estimate variances using the Taylor series linearization method. Prevalence rates and their 95% confidence intervals were computed, taking sampling weights into consideration;

* statistically significant difference between the IVF sample and the NHANES sample.