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The Effects of Fertility Enhancing Drugs on Low Birth Weight, United States, 2009-2015

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성 수 진

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Abstract

The Effects of Fertility Enhancing Drugs on Low Birth Weight, United States, 2009-2015

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Risk of infertility has increased in recent decades as delay of childbearing has become increasingly common among women in developed countries. At the same time, with advances in technology, births from infertility treatments are rising and there is growing concern over the health outcomes of the infants, since infertility treatments are associated with increased risk of low birth weight. Studies suggest that there is a higher rate of low birth weight among singleton infants conceived with assisted reproductive technology than among all infants, but they did not address the issue of whether the singleton infants were conceived as part of a multiple gestation that was later reduced or spontaneously to a single pregnancy. In order to address this issue, this study focuses on low birth weight singleton infants conceived with fertility enhancing drugs. Findings imply that use of fertility enhancing drugs has a negative affect on birth weight, and the decrease in birth weight results in a decrease in wage as an adult outcome.

Keywords: Birth weight, Low birth weight, infertility treatment, fertility enhancing drugs.
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I. Introduction

Risk of infertility has increased in recent decades as delay of childbearing has become increasingly common among women in developed countries. Since the late 1970s, technological advances have made more options available and enabled individuals experiencing fertility problems to conceive and deliver their own biological children. As births from infertility treatments are rising, there is growing concern over the health outcomes of the infants, since infertility treatments are associated with increased risk of low birth weight.

Birth weight is used as the leading indicator of health at birth, and low birth weight is conventionally defined as birth weight of less than 2,500 grams. Low birth weight infants have worse outcomes of one-year mortality rates in the short-run, and educational attainment and earnings in the longer-run (Black et al., 2007). The experience of severe health and developmental difficulties of low birth weight infants can impose substantial costs on society. The expected costs of delivery and initial care of an infant that weighs 1,000 grams at birth can exceed $100,000 (in year 2000 USD). For infants weighing between 2,000-2,100 grams, an additional 454 grams of weight is associated with a $10,000 difference in hospital charges for inpatient services (Almond et al., 2005).

The use of assisted reproductive technology (ART) is an important contributor to the rate of low birth weight in the United States as it is associated with a higher rate of multiple births, and multiple births is associated with low birth weight (Schieve et al., 2002). There have been studies that suggest that there is a higher rate of low birth weight among singleton infants conceived with ART than among all infants, but they did not address the issue of whether the singleton infants were conceived as part of a multiple gestation that was later reduced or spontaneously to a single pregnancy (Schieve et al., 2002). In order to address this issue, this study focuses on low birth weight singleton infants conceived with fertility enhancing drugs, instead of assisted reproductive technology.

Using data from US natality files, ordinary least squares regression analysis is used to find the effect on birth weight of singleton infants with the use of fertility enhancing drugs for conception. The main findings show that birth weight is estimated to decrease with the use of fertility enhancing drugs, and the decrease is observed to be about 2.7%, which is associated to wage difference and income loss in terms of adult outcomes and can incur costs on society.

This study also finds the effects of fertility enhancing drugs on other birth outcomes. The use of fertility enhancing drugs is estimated to increase adverse outcomes of low birth weight, pre-term birth, C-section delivery and five-minute APGAR score. Results suggest that the birth outcomes are affected significantly by mother's education level and by race and ethnicity, with the worst outcomes results from black mothers.

The remainder of this paper unfolds as follows. Section II discusses infertility and birth weight, in terms of trends and economic significance. Section III describes the methodology and data used in this study, and presents relevant literature. Section IV addresses the main findings and discussion of economic implications, and section V concludes.

II. Infertility and Birth Weight

Infertility is generally defined as "not being able to get pregnant (conceive) after one year of unprotected sex" (CDC: Centers for Disease Control and Prevention website). Infertility treatments can be divided into two main treatments: fertility enhancing drugs and assisted reproductive technology (ART). Fertility enhancing drugs are medicines used to treat infertility in women, usually taken orally or by injection. These medicines generally target hormones or the pituitary gland to address problems with ovulation. Intrauterine insemination (IUI) also falls under the fertility enhancing drugs category of the data used in this study, and in this procedure, specially prepared sperm are inserted into the woman's uterus. Assisted reproductive technology (ART) involves both eggs and sperm being handled outside of the body; generally "assisted reproductive technology (ART) procedures involve surgically removing eggs from a woman's ovaries, combining them with sperm in a laboratory, and returning them to the woman's body or donating them to another woman." (CDC website). The common methods of assisted reproductive technology (ART) are in-vitro fertilization (IVF), zygote intra-fallopian transfer (ZIFT), gamete intra-fallopian transfer (GIFT), and intra-cytoplasmic sperm injection (ICSI).

Infertility has been recognized as a public health issue by the World Health Organization. As can be seen in Table 1, the percentage of births from natural conception in the United States has continually decreased from 2009 to 2015, and thus the percentage of births conceived from infertility treatments has increased.

Table 1. Percentage of births from natural conception and from infertility treatments

	2009	2010	2011	2012	2013	2014	2015
Total Births	4,137,836	4,007,105	3,961,220	3,960,796	3,940,764	3,998,175	3,988,733
Conception							(% out of total births)
Natural	99.22%	98.97%	98.78%	98.68%	98.62%	98.52%	98.44%
Infertility treatment	0.78%	1.03%	1.22%	1.32%	1.38%	1.48%	1.56%
Infertility treatment							(% out of total infertility treatment births)
Fertility enhancing drugs	38.98%	42.84%	44.89%	44.59%	45.65%	46.51%	44.50%
A.R.T	34.57%	40.51%	43.81%	45.79%	47.73%	51.31%	54.95%

Source: NCHS' Vital Statistics Natality Birth Data

Table 2 shows that the mean birth weight of infants has increased over the seven years. For infants born with the help of infertility treatments, the percentage of low birth weight births is showing an increasing trend. These trends are a cause for concern as they result in financial implications as studies have shown that hospital costs decrease with increasing birth weight. Low birth weight and preterm infants' hospital stays averaged USD 15,100 (in 2001) compared to USD 600 for uncomplicated newborns (Russell et al., 2007). In a number of studies and samples, a positive and statistically significant association between birth weight and IQ has been found (Black et al., 2007), and 1,000 grams increase in birth weight is associated with a 3-point increase in IQ (Newcombe et al., 2007). This has important economic consequences since IQ has direct and indirect impacts on lifetime earnings, schooling decisions, and criminal and risky behavior (Cook et al, 2015).

Table 2. Birth weight of infants

	2009	2010	2011	2012	2013	2014	2015
Total births							
Mean birth weight	3,268.47	3,268.54	3,273.72	3,277.73	3,279.25	3,278.34	3,276.29
						(% out of total births)	
% of LBW	8.148%	8.135%	8.082%	7.982%	8.009%	7.988%	8.061%
% of very LBW	1.450%	1.445%	1.435%	1.422%	1.409%	1.401%	1.396%
Infertility treatment							
Mean birth weight	2,859.53	2,878.06	2,911.56	2,916.81	2,939.60	2,948.71	2,979.88
						(% out of total births)	
% of LBW	0.236%	0.297%	0.339%	0.358%	0.361%	0.377%	0.375%
% of very LBW	0.053%	0.065%	0.075%	0.079%	0.077%	0.080%	0.077%
Fertility enhancing drugs							
Mean birth weight	2,917.17	2,938.48	2,970.69	2,977.99	2,995.27	2,989.19	3,009.77
						(% out of total births)	
% of LBW	0.081%	0.111%	0.135%	0.138%	0.146%	0.159%	0.155%
% of very LBW	0.019%	0.024%	0.030%	0.031%	0.031%	0.036%	0.034%
ART							
Mean birth weight	2,745.68	2,781.98	2,810.79	2,832.37	2,864.12	2,888.33	2,938.56
						(% out of total births)	
% of LBW	0.098%	0.142%	0.175%	0.191%	0.197%	0.219%	0.226%
% of very LBW	0.021%	0.030%	0.041%	0.040%	0.040%	0.044%	0.044%

Source: NCHS' Vital Statistics Natality Birth Data

Other previous studies have reported that low birth weight incurs significant costs on infants, not only immediately after birth in terms of hospital charges (Almond et al., 2005) but also throughout the lifetime of longer term outcomes such as health status, educational attainment, employment and earnings (Black et al., 2007). According to the estimates of Black et al. (2007), a 10% increase in birth weight increases the probability of high school completion by a little less than 1 percentage point, is as valuable in the labor market as a quarter of a year of education, and raises full-time earnings by about 1%. From the findings of (Cook et al., 2015), genetic variation related to neuroplasticity impacts low birth weight on adult outcomes: for the least plastic individuals, a 10% increase in birth weight is associated with roughly a 15% increase in wage, and for those with median neuroplasticity scores, a 10% increase in birth weight is associated with roughly a 5% increase in wage. “Neuroplasticity is the brain’s ability to reorganize itself by forming new neural connections throughout life, and allows the neurons in the brain to compensate for injury and disease and to adjust their activities in response to new situations or to changes in their environment.” (MedicineNet.com website medical dictionary).

III. Methodology and Data

A total number of 6,494,230 observations of data were derived from the US natality files, from the Centers for Disease Control and Prevention (CDC) National Center for Health Statistics. Information and statistics regarding infertility treatments were included in these files from 2009, so this study was conducted on data from years 2009 through 2015.

The equation for the ordinary least squares regression analysis of this study is as follows:

$$Y_i = \alpha + \beta D_i + X_i \Gamma + \delta_{year} + \delta_{month} + \varepsilon_i$$

The dependent variable, Y_i, is the newborn infant's birth weight (grams). Variable D_i is the key control variable that indicates whether the mother used fertility enhancing drugs to conceive or not and variable X_i comprises of other control variables that affect the birth weight of infants. They are: mother's age, mother's race (white), mother's race (black), mother's ethnicity (Hispanic), mother's education level, pre-pregnancy BMI, pre-pregnancy smoking, smoking during pregnancy, and risk factors of pregnancy. δ_{year} and δ_{month} are year and month fixed effects, and ε_i is the error term.

As a variable of X_i, mother's age is considered significant since fertility declines with increasing maternal age, and the effectiveness of various reproductive technologies declines while the risk of pregnancy complications and adverse outcome increases with both maternal age and the use of reproductive assistance (Johnson et al., 2012). As can be seen in Table 3, there is a notable difference in the mean age of the mothers for natural conception and conception using infertility treatments. Mother's race and ethnicity have shown to have effect on low birth weight as black mothers are more than two times more likely than white mothers to have a low birth weight birth (Stewart, 2013). Maternal education has been identified as one of the strongest predictors of use of contraception and timing of childbearing (Johnson et al., 2012). Studies have shown that parents with lower education have higher rates of low birth weight than parents with university level of education (Lee and Lim, 2010). [1] There have been research results of pre-pregnancy BMI being independently and positively associated with infant birth weight (Frederick et al., 2007). It is now well recognized that maternal obesity at conception increases the risk of complications during pregnancy, labor, and birth for both the mother and the infant (Heude et al., 2011). [2] In the United States, smoking mothers are at more than double the risk of having low birth weight infants than non-smoking mothers (Almond et al., 2004). The risk factors that have been included in this regression analysis are: pre-pregnancy diabetes, gestational diabetes, pre-pregnancy (chronic) hypertension, gestational hypertension, and eclampsia. All these risk factors can have critical affects on the health of both mother and infant.

This study only uses data of infants born as the first live birth of the mother in order to eliminate repetition of mothers. It is also to exclude any anomalies of the mothers having existing health factors that affected the low birth weight of the infant being repeated. The data is filtered for single births only to control plurality of births, as multiple births are associated with low birth weight (Schieve et al., 2002) and it would be difficult to make a conclusion of the direct effect of fertility enhancing drugs on low birth weight if multiple births are included in the regression analysis.

In the US natality files, infertility treatment is answered as "yes" or "no". Within the mothers who answered "yes" to infertility treatment, they either chose "yes" to fertility enhancing drugs or assisted reproductive technology, or both. If they answered "yes" to either, then the other treatment

[1] In this study, the levels of education have been categorized from 1 to 9 as: 8th grade or less, 9th to 12th grade with no diploma, high school graduate or GED completed, some college credit (but not a degree), associate degree [AA, AS], Bachelor's degree [BA, AB, BS], Master's degree [MA, MS, MEng, MEd, MSW, MBA], and Doctorate [PhD, EdD] or Professional degree [MD, DDS, DVM, LLB, JD].

[2] BMI (body mass index) "provides an indication of the mother's body fat based on her height and pre-pregnancy weight" (US natality files user guide). In the US natality files, pre-pregnancy BMI was calculated as: [mother's pre-pregnancy weight (lb) / [mother's height (in)]^2] x 703. In the data, BMI is cored from 13.0 to 69.9. BMI of less than 18.5 is considered underweight, normal is between 18.5-24.9, overweight is from 25.0-29.9, obesity is from 30.0-39.9 and over 40.0 is classified as extreme obesity.

was filled with a "no" (US natality files user guide). In order to focus the research on the sole effect of fertility enhancing drugs only and to differentiate it from the effects in low birth weight in pregnancies from the use of assisted reproductive technology, the observations that answered "yes" to both fertility enhancing drugs and assisted reproductive technology were not included in the regression analysis.

In addition to the key birth outcome of birth weight, this study considers other birth outcomes of low birth weight, pre-term birth, C-section delivery, and the five-minute APGAR score. Pre-term birth is generally defined as gestation period of at least 20 weeks but less than 37 weeks, and term birth is gestation period of at least 37 weeks but less than 42 weeks. Research has shown that singletons conceived with assisted reproductive technology are at increased risk for pre-term birth and low birth weight (Wang et al., 2005). Studies have confirmed that the use of assisted reproductive technology of infertility treatments results in a higher rate of C-section deliveries (Wang et al., 2005). C-section delivery decreases birth weight of infants, as the procedure is an obstetric intervention that removes infants from the uterus earlier than the time of natural birth (Hong and Lee, 2016). The five-minute APGAR score is a measure for the need for resuscitation and is a predictor of the infant's chances of surviving the first year of life.[3]

[3] The five-minute APGAR score is a summary measure of the infant's condition based on heart rate, respiratory effort, muscle tone, reflex irritability, and color. Each of the measures are scored between 0-2 and the sum of the 5 score values is the AGPAR score. A score between 0-3 implies the need of resuscitation, 4-6 indicates intermediate, and 7-10 means good-excellent health condition (US natality files user guide).

Table 3. Summary statistics of singleton first-live births

	Total Births		Natural conception		Infertility treatment			
					Total		FED	ART
Variables	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Mean
Sample size	6,494,230		6,402,732		91,498		49,887	41,611
Panel A: Birth outcomes of infants								
Birth weight (grams)	3,277.77	550.89	3,278.36	549.84	3,236.47	618.76	3,238.88	3,233.58
Ratio of low birth weight	0.0654	0.2472	0.0650	0.2466	0.0910	0.2876	0.0860	0.0971
Ratio of pre-term birth	0.0869	0.2817	0.0864	0.2810	0.1224	0.3277	0.1103	0.1368
Ratio of C-section delivery	0.3058	0.4607	0.3040	0.4600	0.4271	0.4947	0.3844	0.4782
5 minute APGAR score (1-10)	8.7695	0.8326	8.7698	0.8318	8.7426	0.8867	8.7391	8.7467
Ratio of boys	0.5135	0.4998	0.5135	0.4998	0.5128	0.4998	0.5121	0.5137
Panel B: Key control								
Ratio of fertility enhancing drugs					0.5452	0.4980		
Panel C: Other controls (selected characteristics of mothers)								
Mother's age	26.4929	5.7611	26.3998	5.7138	33.0069	5.3026	31.4476	34.8764
Ratio of race: White	0.7955	0.4033	0.7950	0.4037	0.8341	0.3720	0.8659	0.7959
Ratio of race: Black	0.1092	0.3118	0.1101	0.3130	0.0420	0.2006	0.0383	0.0465
Ratio of ethnicity: Hispanic	0.1901	0.3924	0.1918	0.3937	0.0686	0.2529	0.0685	0.0689
Education level (1-8)	4.5963	1.7097	4.5780	1.7071	5.8739	1.3738	5.7176	6.0613
Pre-pregnancy BMI	25.4428	6.0449	25.4340	6.0401	26.0633	6.3364	26.7660	25.2207
Ratio of pre-pregnancy smoking	0.0979	0.2971	0.0989	0.2985	0.0239	0.1528	0.0313	0.0151
Ratio of smoking during pregnancy	0.0450	0.2074	0.0456	0.2086	0.0064	0.0796	0.0085	0.0038
Ratio of risk factors in pregnancy	0.0026	0.0513	0.0026	0.0512	0.0037	0.0605	0.0037	0.0037

The figures in Table 3 present the sample means of the variables that are used in the regression analysis of this study. This study focuses on singleton infants born as the first live birth to their mothers', so all other observations of multiple births and not-first births have been dropped from the sample. Panel A shows the means of birth outcomes. The mean of the main birth outcome, birth weight, is 3,278.36 grams for infants born from natural conception, while the mean for infants born from infertility treatments is slightly less of 3,236.47 grams. Within infertility treatments, the mean birth weight of infants conceived from fertility enhancing drugs (FED) is 3,238.88 grams, which is about 5.3 grams more than the mean birth weight of infants conceived with assisted reproduction technology (ART). It can be seen from the numbers in panel A that the mean of all birth outcomes show healthier results for infants born from natural conception than from infertility treatments. Fertility enhancing drugs is the key control variable of this regression analysis, and panel B is the ratio of fertility enhancing drugs within infertility treatments.

Panel C presents the means of the other control variables of selected characteristics of mothers. Significant differences between the means of natural conception and the use of infertility treatments can be seen for most of the variables. There is an approximately 6.7 years difference in the average mother's age, and the mean mother's age for the use of assisted reproductive technology is higher than for fertility enhancing drugs. This can be expected as process of infertility treatments usually starts with cycles of fertility enhancing drugs before moving on to assisted reproductive technology methods if the medicines are not successful. There is not a large difference in ratio means for white mothers, but for black mothers and Hispanic mothers, there is a considerable difference. It can be concluded that most of the users of infertility treatments are mothers whose race is white.

The mean education level of mothers who conceived naturally is between some college credit and an associate degree, while the mean for infertility treatments users is between an associate degree and bachelor's degree. It is interesting to note that the mean education level of mothers who used fertility enhancing drugs is between an associate degree and bachelor's degree, but for mothers who used assisted reproductive technology, the mean is between a bachelor's degree and a master's degree. This may be due to the women delaying pregnancy for education or career purposes, and starting to conceive at a later age, so the mean age and education level for users of assisted reproductive technology is greater than the mean of mothers who used fertility enhancing drugs for conception.

As expected, the mean ratio for pre-pregnancy smoking and smoking during pregnancy are significantly greater for natural conception mothers, as mothers who use infertility treatments have had difficulty conceiving and would most likely try their best to stay healthy for giving birth. The ratio means for risk factors in pregnancy show that there may be underlying health factors that have made it difficult for the mothers to conceive naturally.

IV. Effect of Fertility Enhancing Drugs

Table 4 reports the ordinary least squares (OLS) regression results for birth weight of infants (in grams) as a function of the use of fertility enhancing drugs for conception. The data is for all singleton infants born as the first live-birth of their mothers in the United States between 2009 and 2015. The coefficient in column (1) is -39.19, which indicates that the use of fertility enhancing drugs decreases the birth weight of an infant by 39.19 grams. Column (2) presents results from a single regression with selected characteristics of mothers as controls. With these controls included in the analysis, there is an increase in adverse outcomes. Column (3) also shows results from a single regression including controls of selected characteristics of mothers, and also maternal health and lifestyle characteristics controls. There is a further decrease in the estimated value of birth weight of infants. Column (4) illustrates results with all the control variables included in the single regression. With the inclusion of birth outcome controls, the magnitude of adverse outcomes decreases to -46.28 grams of birth weight of infants.

Table 4. OLS regression results

VARIABLES	(1) Birth weight	(2) Birth weight	(3) Birth weight	(4) Birth weight
Fertility enhancing drugs	-39.19***	-77.17***	-88.83***	-46.28***
	(2.476)	(2.463)	(2.447)	(2.056)
Mother's characteristics				
Mother's age		-1.47***	-2.55***	-0.83***
		(0.047)	(0.047)	(0.040)
Race: White		153.46***	144.11***	124.99***
		(0.747)	(0.749)	(0.629)
Race: Black		-50.49***	-80.73***	-38.41***
		(0.967)	(0.971)	(0.816)
Ethnicity: Hispanic		-47.29***	-64.27***	-49.17***
		(0.577)	(0.585)	(0.492)
Education level		22.47***	20.52***	12.28***
		(0.161)	(0.163)	(0.137)
Maternal health & lifestyle				
Pre-pregnancy BMI			6.92***	6.99***
			(0.036)	(0.031)
Pre-pregnancy smoking			4.60***	-1.65**
			(0.960)	(0.806)
Smoking during pregnancy			-196.95***	-184.97***
			(1.356)	(1.139)
Risk factors in pregnancy			-529.51***	-273.08***
			(4.146)	(3.488)
Birth outcome				
Gender of infant: Boy				120.98***
				(0.358)
Gestation period (Wk)				125.53***
				(0.078)
C-section delivery				52.89***
				(0.400)
Constant	3,278.07***	3,106.61***	2,992.04***	-1,981.29***
	(0.217)	(1.318)	(1.530)	(3.322)
Observations	6,494,230	6,471,610	6,471,610	6,471,610
R-squared	0.000	0.023	0.035	0.319

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 5 presents the month and year fixed effects estimates of the effect of fertility enhancing drugs on birth weight of infants. Month and year fixed effects were included in the regressions to reduce the potential of omitted variable bias. Each column in Table 5 shows results from a single regression, with column (1) being the same regression as column (3) of Table 4. Column (2) includes month fixed effect in the regression, and as can be seen from the coefficient of -88.70 of the fertility enhancing drugs variable, the estimated decrease in birth weight has not changed much from -88.83 grams of the result in column (1). Column (3) includes year fixed effect, and the regression result for fertility enhancing drugs on birth weight of the infant does not change compared to the first column with no fixed effect. Column (4) includes both month and year fixed effect, and there is not much difference in the coefficient with an estimated decrease in birth weight of 88.70 grams. Using the mean birth weight of total births (3,277.77 grams as shown in Table 3), the decrease in birth weight with the use of fertility enhancing drugs is observed to be about 2.7% in this study, which translates to a 0.27% decrease in full-time earnings. When the measure for neuroplasticity is considered, a 2.7% decrease in birth weight decreases wage by about 4.05% for the least plastic individuals, and 1.35% for those with median neuroplasticity scores.

In column (5), the use of assisted reproductive technology (ART) was included in the regression and the decrease in birth weight from the use of fertility enhancing drugs increases compared to without the inclusion of the use of ART of column (4). This result is as expected as the singleton infants may have been conceived as part of a multiple gestation that was later reduced.

Table 5. Month and year fixed effects estimates

VARIABLES	(1) Birth weight	(2) Birth weight	(3) Birth weight	(4) Birth weight	(5) Birth weight
Fertility enhancing drugs	-88.83***	-88.70***	-88.83***	-88.70***	-89.76***
	(2.447)	(2.447)	(2.447)	(2.447)	(2.448)
A.R.T.					-72.39***
					(2.692)
Mother's characteristics					
Mother's age	-2.55***	-2.55***	-2.54***	-2.54***	-2.42***
	(0.047)	(0.047)	(0.047)	(0.047)	(0.047)
Race: White	144.11***	144.03***	144.08***	144.00***	144.04***
	(0.749)	(0.749)	(0.749)	(0.749)	(0.749)
Race: Black	-80.73***	-80.74***	-80.62***	-80.63***	-80.69***
	(0.971)	(0.971)	(0.972)	(0.972)	(0.971)
Ethnicity: Hispanic	-64.27***	-64.25***	-64.30***	-64.27***	-64.38***
	(0.585)	(0.585)	(0.585)	(0.585)	(0.585)
Education level	20.52***	20.50***	20.54***	20.53***	20.51***
	(0.163)	(0.163)	(0.163)	(0.163)	(0.163)
Maternal health & lifestyle					
Pre-pregnancy BMI	6.92***	6.92***	6.93***	6.94***	6.93***
	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)
Pre-pregnancy smoking	4.60***	4.59***	4.42***	4.40***	4.22***
	(0.960)	(0.960)	(0.960)	(0.960)	(0.960)
Smoking during pregnancy	-196.95***	-196.92***	-197.00***	-196.96***	-196.92***
	(1.356)	(1.356)	(1.356)	(1.356)	(1.356)
Risk factors in pregnancy	-529.51***	-529.51***	-529.28***	-529.28***	-529.08***
	(4.146)	(4.146)	(4.146)	(4.146)	(4.146)
Constant	2,992.04***	2,987.57***	2,993.91***	2,989.44***	2,986.95***
	(1.530)	(1.687)	(1.636)	(1.784)	(1.786)
Month Fixed Effect	N	Y	N	Y	Y
Year Fixed Effect	N	N	Y	Y	Y
Observations	6,471,610	6,471,610	6,471,610	6,471,610	6,471,610
R-squared	0.035	0.035	0.035	0.035	0.035

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 6 presents OLS regression results of the relationship of fertility enhancing drugs on different birth outcomes. The columns represent the different birth outcomes of infants: birth weight, low birth weight, pre-term birth, C-section delivery, and five-minute APGAR score. The rows are different characteristics variables that are used for this heterogeneity test, and each coefficient result is a single regression. The figures in the panel A indicate the results of different birth outcomes of the original regression. For the baseline estimation, the use of fertility enhancing drugs is estimated to decrease birth weight by -88.70 grams (same result as column (4) of Table 5). It is also estimated to increase the possibility of low birth weight by 2.61 percentage points, pre-term birth by 2.70 percentage points, C-section delivery by 1.36 percentage points, and decrease the five-minute APGAR score by 3.14 scores (scored from 1-10).

In column (1) of Panel B, for mothers who have an education level of higher than a college graduate degree, the use of fertility enhancing drugs is estimated to decrease the birth weight of infants by 70.0594 grams, which is the worst birth weight outcome between the mother's education level variables. It is notable that for the other birth outcomes from column (2) to column (5), the most adverse results lie under the variable of mothers who have a high school degree. This may suggest that socioeconomic status is involved, as low education level is used as an indicator of low socioeconomic status.

Table 6. Estimated effects of fertility enhancing drugs on other birth outcomes

Fertility enhancing drugs	(1) Birth weight	(2) LBW	(3) Pre-term	(4) C-section	(5) APGAR
Panel A: Baseline estimation					
Original regression	-88.7025***	0.0261***	0.0270***	0.0136***	-0.0314***
	(2.447)	(0.001)	(0.001)	(0.002)	(0.004)
Panel B: Mother's education level					
< High school	-34.2989	0.0209*	0.0164	0.1168***	-0.0283
	(22.988)	(0.011)	(0.013)	(0.018)	(0.037)
High school graduate	-57.3807***	0.0323***	0.0353***	0.1202***	-0.1013***
	(9.230)	(0.004)	(0.005)	(0.007)	(0.015)
Some college	-60.0400***	0.0307***	0.0351***	0.0864***	-0.0619***
	(6.823)	(0.003)	(0.003)	(0.006)	(0.010)
College graduate	-64.4422***	0.0253***	0.0305***	0.0614***	-0.0315***
	(3.503)	(0.001)	(0.002)	(0.003)	(0.005)
> College graduate	-70.0594***	0.0263***	0.0291***	0.0520***	-0.0404***
	(4.394)	(0.002)	(0.002)	(0.004)	(0.006)
Panel C: Mother's race					
White	-47.3565***	0.0216***	0.0240***	0.0758***	-0.0324***
	(2.612)	(0.001)	(0.001)	(0.002)	(0.004)
Black	-114.1967***	0.0575***	0.0665***	0.1847***	-0.0979***
	(14.010)	(0.007)	(0.008)	(0.011)	(0.023)
Ethnicity: Hispanic	-69.0801***	0.0362***	0.0366***	0.1426***	-0.0828***
	(9.238)	(0.004)	(0.005)	(0.008)	(0.013)

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Panel C reports that for black mothers, the use of fertility enhancing drugs reduces the birth weight of infants by 114.1967 grams, in column (1), which is almost 2.5 times the result for white mothers. The results for the outcome of low birth weight, pre-term birth and C-section delivery also show a significant difference between black mothers, white mothers, and Hispanic mothers, with the coefficient figures of black mothers being about 2.5 times the coefficients of white mothers. For the five-minute AGPAR score, the difference is more than 3 times the score of white mothers. The regression results of all the birth outcomes for black mothers show worse outcomes compared to mothers who are white in race and also compared to Hispanic mothers.

Table 7. Summary statistics of prenatal care

	Month prenatal care began		Number of prenatal visits	
	Natural	FED	Natural	FED
Panel A: Mother's education level				
< High school	3.4519	3.0187	10.2993	12.1378
High school graduate	3.0889	2.7631	11.2057	12.6866
Some college	2.9723	2.6749	11.5960	12.7412
College graduate	2.7237	2.7019	12.0638	12.7151
> College graduate	2.6349	2.7183	12.2244	12.7106
Panel B: Mother's race				
White	2.8874	2.6749	11.6759	12.7696
Black	3.2085	2.9221	10.7810	12.2349
Ethnicity: Hispanic	3.0733	2.7376	10.9660	12.5550

Source: NCHS' Vital Statistics Natality Birth Data

Table 7 presents the summary statistics of prenatal care, broken down by education level, race, and ethnicity of mothers. It can be seen that mothers who used fertility enhancing drugs to get pregnant started prenatal care earlier than mothers who did not use any form of infertility treatments. The reason for this is evident as users of fertility enhancing drugs would have failed to conceive naturally and would have looked forward to the pregnancy. The average month of pregnancy that prenatal care began is latest for mothers whose education level is less than high school and for black mothers. The difference is significant between mothers who have higher than a college degree and mothers who have less than high school education, as they start prenatal care after the first trimester.

The results show a similar pattern for the average number of prenatal visits during the whole pregnancy, as mothers with less than high school education and black mothers have made the least number of visits before giving birth. The mean numbers show that prenatal care is started later and fewer visits to the clinics have been made for the same category of mothers. This can also be associated with low socioeconomic status as prenatal care may not have been affordable or approachable to those mothers.

The prenatal care observations may be an explanation to the adverse birth outcomes; there may be unknown side effects of the fertility enhancing drugs that causes birth outcomes such as low birth weight, but mothers who did not or were unable to make prenatal visits would not have been able to detect the side effects. However the scientific explanation to the results is beyond the scope of this study, and further research would be needed to figure out the exact causes.

V. Conclusion

As utilization of infertility treatments and fertility enhancing drugs increases, there is growing concern about the potential impact on health outcomes. One of the most significant consequences of infertility treatments is the high frequency of multiple births and associations with low birth weight. By eliminating the element of multiple births and using data of singleton births only, the findings of this study suggest that the use of fertility enhancing drugs decreases birth weight of infants and increases the percentage of low birth weight.

The weight difference of 88.70 grams is from the average birth weight, so it may not be a substantial number from a scientific perspective. The use of low birth weight might be a better measurement in the estimation of the effect of use of fertility enhancing drugs, and it is expected to be as significant as the measurement of birth weight in grams.

There remain possibilities of an endogeneity problem in this analysis. This study focuses on several sources of birth weight variation that are considered important, but there are undoubtedly other factors that have an influence on low birth weight of infants, and there is a possibility of model misspecification. There is also the question of whether low birth weight is caused by infertility treatment itself or due to the underlying infertility of the individual using the treatment. This leaves potential for the regression result to have be an overestimate of the analysis. In order to minimize this problem, this study uses controls, but there may still be a possibility of omitted variables. A more direct approach on this topic may be needed to reach a conclusion to this argument.

The economic consequences of short-term outcomes are the hospital costs that are related to low birth weight, and decrease in wage of adult outcomes in the long-term. These costs on society are expected to continue with the increasing trend of infertility treatments and resulting low birth weight infants. Economic costs can be substantial; therefore, guidelines and further research are needed to minimize low birth weight births.

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국문초록

최근 수십 년간 선진국의 여성들의 출산 시기가 늦어짐에 따라 불임에 대한 위험이 증가되었고 그와 동시에 기술이 발달 되면서 불임치료를 통해 태어난 영아의 수가 증가하고 있다. 불임치료는 저체중아의 위험성의 증가와 연관되어 있기 때문에 영아의 건강에 대한 우려가 늘고 있다. 기존 논문에 따르면 assisted reproductive technology 로 가져진 외둥이 영아들은 높은 저 체중의 가능성을 제시하고 있다. 그러나 연구 결과에서 외둥이 영아들이 다둥이 임신에서 나중에 외둥이가 된 것인지 아니면 자발적으로 외둥이로 임신이 된 것인지에 대한 이슈를 다루지는 않았다. 이 문제를 고려하기 위해 이 논문은 임신촉진제를 사용해서 태어난 저체중 외둥이 영아들에 초점을 맞추었다. 결과적으로 임신촉진제는 출생시 체중에 부정적인 영향을 미칠 수 있고, 출생시 체중이 감소 할수록 성인이 되어서 받는 임금이 낮아질 수 있다는 것을 의미한다.

주요어: 출생시 체중, 저체중아, 불임치료, 임신촉진제.

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