Educational Disparities in the Battle Against Infertility: Evidence from IVF Success*

Fane Groes
Copenhagen Business School

Daniela Iorio
University of Bologna

Man Yee (Mallory) Leung
Washington University in St. Louis
Division of Public Health†

Raül Santaeulàlia-Llopis
MOVE-UAB and Barcelona GSE

May 5, 2017

Abstract

Using administrative data from Denmark (1995-2009) we find that maternal education significantly determines IVF success (live birth). Compared with high school dropouts, patients with a college (high school) degree have a 24% (16%) higher chance of attaining a live birth through IVF. Our explorations of the mechanisms underlying the education gradient rule out financial considerations, clinic characteristics, and medical conditions. Instead, we argue that the education gradient in IVF reflects educational disparities in the adoption of the IVF technology. These results are important because women's career and fertility choices are likely to be influenced by the determinants of IVF success.

*We would like to thank Ingeborg Kristiansen and Edward Sosman for excellent research assistance. We thank Michele Belot, Mette Ejrnæs, Fabian Lange, and seminar participants at Copenhagen Business School, The Copenhagen Education Network workshops 2015, and the Workshop on Health Economics and Econometrics 2015. Raül Santaeulàlia-Llopis thanks the ERC AdG - GA324048 "Asset Prices and Macro Policy when Agents Learn (APMPAL)" and the Spanish Ministry of Economy and Competitiveness through the Severo Ochoa Programme for Centres of Excellence in R&D (SEV-2015-0563) for financial support.

†Current affiliation of M.Y. Leung: Amgen Inc.

1 Introduction

Assisted reproductive techniques (ARTs) are increasingly becoming standard inputs of the fertility decision-making processes as they circumvent the infertility constraints generated by delayed childbearing or biological characteristics of the couple. In Denmark alone, about 5% of all children were born after in vitro fertilization (IVF) in 2009. These numbers continue to increase over time with no sign of deceleration. The proportion of IVF children has been growing steadily since the 1990s from less than 2% in 1995 to slightly more than 5% in 2009 (Figure 1). This pattern echoes the annual growth in ART services in other developed countries, from 5% to 10% in the past decade (de Mouzon et al., 2010; Connolly et al., 2010).

The increase in IVF use goes hand in hand with the decision of many women to delay child-bearing. On the one hand, there is wage premium to delay childbearing (Caucutt et al., 2002; Buckles, 2008; Miller, 2011; Adda et al., 2016).[1] On the other hand, fecundity decreases with age. The introduction of the IVF technology in the '80s relaxed this biological constraint, but by how much depends on the IVF success (i.e., live births) rate. While IVF technology is a well-established treatment for infertility initiated almost 35 years ago, the determinants of IVF success are not fully understood. Prognostic factors identified by medical studies are uterine receptivity, ovarian sensitivity, morphological grading of embryos, and their chromosomal competence, which translate into "luck" in the popular view. In this direction, recent works in the economic literature have considered the outcome of an ART or IVF treatment as a natural experiment, and used it to estimate the effect of a first child on female labor outcomes (Cristia, 2008; Lundborg et al., 2016). But is it really the case that "nature" provides almost perfect randomness of IVF success? In this paper, we reconsider this view. In particular, we focus on socio-economic status, and specifically on education, as a determinant of IVF success.

Quantifying educational disparities in IVF success is important. These disparities potentially shape the opportunity cost of delaying childbearing differently among more and less educated women, which in turn may factor into different fertility choices and labor market outcomes across education groups. In general, highly educated women tend to have fewer children because they are more likely to participate in the labor force (Buckles, 2008; Goldin and Olivetti, 2013; Olivetti, 2014; Goldin and Mitchell, 2016). However, with the adoption of IVF technology, highly educated women can choose to delay child-bearing because of IVF rather than not have a child at all. This could potentially increase fertility in the older ages (Schmidt, 2007)[2] and affect the birth-spacing

[1] Using the same Danish administrative registers that we use in our paper, Leung et al. (2016) also find a negative association between age at first birth and mother's lifetime earnings.

[2] In line with this argument, in our sample, a 1% increase in years of schooling is associated with a 3% increase in the age of women seeking the first IVF treatment. A woman with at least a master's degree is, on average, 1.5

and aggregate fertility. Further, a positive education gradient in IVF could mitigate the well-known negative relationship between fertility and education (Jones et al., 2010).[3]

In order to estimate such a gradient, we would need a rich and large scale dataset on all IVF treatments for each couple, their demographics and socioeconomic statuses, and the clinic characteristics. The Danish administrative registers serve our purpouse well, as they offer both longitudinal and detailed information about individual and family characteristics and the entire history of infertility treatments used by *all* Danish women since 1995. The register also records information on medical conditions and infertility causes in a great level of detail. In addition, while infertility treatments are quite expensive, Danish couples are allowed to receive free fertility treatments at any public hospital in the first three trials with an embryo transfer. Hence, the universal coverage of infertility treatments for childless women in a fertile age largely mitigates the potential selection problem in the utilization of these treatments based on financial constraints.[4]

Our main result is the presence of large and significant education disparities in IVF success, when controlling for individual and partner's characteristics (such as age, income, marital status, and employment status). Among childless women, patients who have at least a college degree are about 24% more likely to attain a live birth at the first trial (cycle) than women who do not have a high school degree. This figure is 16% for childless women with a high school degree or some college. The educational disparities are about the same when we consider the last cycle that women undergo.

We consider possible explanations of these measured disparities. First, we include clinic fixed effects and trends to rule out the possibility that a positive gradient in IVF is the result of patients sorting into different clinics, as patients across clinics might be affected by unobserved clinic characteristics that are correlated with both individual education and IVF success. Hence, we exploit only the variation of education across patients within a clinic, who essentially face the same practitioners, description of protocol, equipment, etc. Second, we include additional controls, such as the number of embryos transferred to the womb, medical conditions before treatment,

years older than a high-school drop out when she seeks an IVf treatment for the first time.

[3]This is consistent with the estimated fertility patterns in our sample, where a 10% increase in years of education is associated with an 11% decrease in the likelihood of having at least one child in the female population and 4.3% decrease for women who undergo IVF treatment to achieve a pregnancy.

[4]Note that 80% of the treatments in our sample are free. Further, the distribution of schooling years in the overall Danish population of childless women 25-45 years old is very similar to that of women who use IVF to achieve a pregnancy, with the latter one only slightly shifted to the right (Figure 2). This figure stands in contrast to the findings of recent papers that have looked at how insurance mandates have affected the utilization of IVF treatments in the United States where there is no universal coverage of these treatments. For example, Schmidt (2007) uses variation across time and space to document that insurance mandates increase first birth rates for women over 35. Bitler and Schmidt (2012) show that insurance mandates have a positive effect on the utilization of infertility treatments (including IVF) for older and more educated women.

infertility causes, body size, and unhealthy behaviors (e.g., smoking and alcohol consumption) to see how much of the estimated gradient can be attributed to these observable factors. Strikingly, our results stand quite robust to the inclusion of these additional confounding factors and clinic fixed effects. It is noteworthy to mention that, contrary to Lundborg et al. (2016), we find a significantly positive education gradient in IVF success in the first trial even when we condition on at least one embryo being implanted into the woman's womb: college graduates are about 20% more likely to attain a live birth than women who do not have a high school degree. This figure is 13% similar for childless women with a high school degree or some college. A possible explanation is that only the best-quality embryo(s) are selected, and the quality itself might have been influenced by education.[5] This finding indicates that, once an embryo has been implanted in the uterus, the "assignment" of children to women who seek their first pregnancy is *not* purely idiosyncratic. This piece of evidence casts some doubts on the validity of using IVF success as a shock to fertility to identify the effect of a first child on female labor supply.

Finally, we study whether education disparities in IVF success increase or decrease with success. When we restrict our attention to those couples that have succeeded at least once, we find an education gradient only for the first pregnancy. While it takes a fewer number of trials for the highly educated women to succeed the first time, the education gradient in IVF success is no longer significant when seeking IVF treatment for the second child. That is, the less-educated patients catch up in terms of success probability in IVF treatments. The fact that the more-educated people are faster at succeeding in achieving a favorable health outcome has received alternative explanations in health economics. Grossman (2006) distinguishes between "allocative efficiency" and "productive efficiency" mechanisms. "Allocative efficiency" refers to the notion that the more-educated individuals choose different health inputs because they face different prices and have access to different resources. For example, individuals with higher levels of education are more likely to adopt newer medical techniques and drugs recently approved by the FDA, as they have lower costs of searching for higher-quality treatment (Lleras-Muney and Lichtenberg, 2005). In the case of the utilization of IVF treatments, however, we find an education gradient even when we exploit variation *within* a clinic (where patients face the same IVF inputs), which seems to rule out this argument. Instead, our results point in the direction of "productive efficiency", i.e., that highly-educated individuals have better health outcomes than lower-educated ones, even when they all face the same prices and constraints. Within a clinic, all IVF patients face the same protocol and IVF inputs: set of injections, nasal sprays, doctor instructions regarding intake procedure, timing and appointments for blood tests, and ultrasound tests (see our description

[5] Evidence from the medical literature indicates that there are ways to help improve the health of the ovaries and the egg quality. Factors that are relevant for egg quality (and in turn for the embryo) include age, diet, BMI, hormonal issues, stress, and smoking.

of the IVF procedure in Section 2). Therefore, a better knowledge on how to use the newly acquired information about the IVF technology, i.e., higher ability to manage similar IVF inputs, can determine the organizational capital that yields higher "IVF productive efficiency" by the more educated individuals.[6] Further, the evidence that the education gradient vanishes when seeking the second pregnancy supports the hypothesis that while higher educated women are better at ending up with a child, the less educated ones can "learn" this skill after they experience a first success.

The rest of the paper is organized as follows. In Section 2, we describe the institutional setting in Denmark, and the administrative Danish register panel data used in our analysis. We also provide descriptive statistics of women seeking a pregnancy through IVF treatments. In Section 3 we pose our benchmark econometric specification and describe the main results. We conduct robustness exercises and explore the mechanisms behind the gradient in Section 4. Section 5 concludes the study.

2 Institutional Background and Data

In this section, we first describe the Danish institutional setting related to the Law of Artificial Insemination, paying particular attention to couples' eligibility for subsidized treatment and their rights. Second, we discuss the Danish register panel data and provide details on the construction of our variable for live births from infertility treatments. Third, we discuss descriptive statistics of IVF in Denmark.

2.1 Institutional Background

During the entire time-span of our sample (1995-2009), Danish women had the right to artificial insemination by an in vitro method if they fulfilled the following three criteria (Ministry of Health, 1997, 2006): (i) the woman must be younger than 45 years of age at the beginning of a treatment period; (ii) the doctor needs the consent of both, the woman and the man in the couple, being treated; (iii) the couple must, in the doctor's opinion, be suitable to take care of a child, and the woman must be able (both mentally and physically) to undergo pregnancy. Further, the eligibility requirements for couples to receive *free* fertility treatments at a public hospital were the following: First, the couple was not allowed to have any joint children. Second, the couple should have

[6] Other examples of education disparities in productive efficiency arise from the efficient adoption of health technologies such as complex contraceptive methods (Rosenzweig and Schultz, 1989), self-management of disease including compliance with AIDS and diabetes treatment which are fairly demanding (Goldman and Smith, 2002), success in quitting smoking (Lillard et al., 2007), and understanding of the risks involved in not wearing a seatbelt (Cutler and Lleras-Muney, 2011).

attempted pregnancy naturally for at least 12 months; however, depending on the woman's age and the couple's medical history, the treatment could start earlier. Third, the woman must not be older than 40 years old at the beginning at the treatment.[7] Fourth, only the first three successful treatments were free. A treatment was considered successful if it transferred at least one healthy embryo into the woman's womb. See Ministry of Health (2006, 2012, 2013) for details. In our sample, 83% of the couples who succeeded in having the first child did so within the allotted free treatments, and 76% were treated in the public sector.

After the initial first three treatments, the couple must go to a private fertility clinic for further treatments, and pay their cost. However, the law does allow leftover frozen eggs from the couple's past treatments to be used at public hospitals when seeking a new pregnancy even after the allotted number of free trials, and, in some regions, free treatment may occur when the couple seeks help to have a second child (Danish Health Insurance, 2013).

Treatments can terminate at any time during the IVF process for a number of reasons, including over-stimulation, cysts in the ovaries, no healthy eggs to retrieve, no fertilization of the eggs, or unsuccessful pregnancy after the embryo transfer. Sucessful IVF treatments involve not only medical interventions but an intensive amount of patient self-management, as its procedure is strict and complex. Clinics follow a standard protocol that is described in detail in Appendix A.

2.2 The Administrative Danish Register Panel Data

We use unique administrative Danish register panel data from the entire Danish population from 1995 to 2009. We are interested in two specific sources of information. The first is the Danish National Board of Health, which contains detailed information about all women using in vitro techniques to achieve a pregnancy (e.g., date of cycle/treatment, reasons for undergoing treatment, if the treatment includes aspiration and/or transference, if the treatment results in a live birth). This is referred to as the IVF register, and includes the medical aspects of the individual fertility treatment histories. The second source is Statistics Denmark, which includes register data of annual information on socioeconomic variables (e.g., age, gender, education), income information (yearly income, earnings, and wealth), characteristics of employment (e.g., employed, self-employed, unemployed, out of the labor market), and general health information of the population. The IVF and the Statistics Denmark registers can be merged through a personal identifier. The data also includes a family-ID to link the individual to her spouse/cohabiting partner, children, parents, and other household members. Labor income and wealth measures

[7] While 40 years is the limit age to receive free IVF treatment in Denmark, paid IVF treatment is allowed for all women younger than 45 years old. That is, it is illegal to provide IVF treatment to women older than 45 years old in Denmark.

are deflated to the year 2000 level using Consumer Price Index data from Denmark. Patients are classified into three mutually exclusive educational categories: less than high school education, high school and trade and some college education, and college and higher education. We also consider specifications where the population is divided into six groups: less than high school, high school, vocational school, two years of college, college, and Master or Ph.D..

The medical records of patients at visits to any general practitioner (GP) contain information about the number of yearly services performed by the GP (e.g. consultation, blood test, vaccination, etc.), and the reimbursement (in Danish Kroner, DKK) that the GP receives from the state for the provided services. The medical records from visits to hospitals are grouped into diagnosis code by the main diagnosis of the ICD10.

For every treatment, the IVF register records when the treatment started, when the eggs were retrieved (aspiration), whether and when the embryo(s) were selected and then transferred to the woman's womb, and whether this resulted in a live birth, which is our measure of IVF success.[8] Before the start of the cycle height in centimeters and weight in kilos were recorded and women completed a questionnarie eliciting lifestyle information (e.g., number of cigarettes smoked per day and number of alcoholic beverages consumed per week,). This information is available from 2006 onward.

In sum, a notable aspect of the dataset is that it contains rich information about the socio-economic status of the couple, the entire history of fertility treatments, infertility causes, medical conditions and health behaviors (smoking, drinking, BMI, etc) prior to treatments, and an identifier of the hospital that provided each treatment. This aspect of the data is important because it enables us to verify if an education gradient in IVF success is partially driven by systematic differences among less and more educated women.

2.3 IVF in Denmark: Stylized Facts

Our sample includes all Danish women 25 to 45 years of age, who were married or cohabiting with a man, and did not have prior children before seeking the first treatment in 1995-2009. We consider this age group in order to ensure that they completed their education (only 1% of our

[8] While the number of live births is only available until 2005, we can still impute it for 2006 -2009 by examining the birth records in the Statistics Denmark family register for all women in the IVF register. For all fertility treatments, we compute the expected birth date as the start date plus 280 days, which is the expected pregnancy duration. We then check whether the woman has a birth at most 90 days before the expected birth date or at most 21 days after the expected birth date. If a woman had a child during this period, we classify the treatment as a success. However, for women with multiple treatments less than 3 months apart, the above approach gives multiple potential births less than 3 months apart. If this is the case, we classify the last treatment in a sequence as the success and the other treatments in the sequence as failures.

sample was still in school at entry). By doing so, we exclude about 2.5% of treatments of young patients who were 20-24 years old. Since we want to follow women from their first IVF treatment, we exclude all women with treatments in 1995. With this restriction, we drop additionally 1.7% of the treatments. This way, we can start counting initial treatments in 1996, and we classify a treatment as first if the woman did not receive any treatments in 1995.[9]

Our final sample consists of a total of 78,501 initiated treatments (i.e., cycles) in Denmark for the 1996-2009 period. 86.6% of these cycles were to conceive the first child in vitro. For the first child, the median number of cycles per couple is 2, and the maximum is 20. For the second child those numbers are 2 and 18, respectively. Regarding the cycles to conceive the first child, about 80% were performed in the public sector.

Following the law, we consider a treatment to be still eligible for the free quota if in the past the patient received less than three treatments reaching the stage of embryo implantation in a public hospital since the couple entered the sample, conditional on having no previous children. The free treatments can occur only at public hospitals, there is no reimbursement of the expenses if the couple undergoes an IVF treatment in the private sector. Note that the number of free treatments may exceed three, because this upper bound is conditional on a successful embryo transfer. After the initial free treatments, treatments should, according to the law, take place in private clinics. Almost 10% of all treatments in public hospitals should not be free according to our classification. In most cases, these are patients who want to conceive a second child in vitro using the embryos frozen in previous cycles, as mentioned in Section 2.1. We now turn to describe who enters into treatment.

2.4 Characteristics of IVF Patients

In our sample, the majority of IVF patients have a high school degree or some college (49%), followed by college graduates or higher (38%).[10] Interestingly, the distribution of completed years of education among women seeking an IVF treatment to conceive a first child is not remarkably different from that of the childless female population in the same age group (see Figure 2). This might be explained by the fact that Denmark, like other European countries, has a particular

[9]Since our data show the stock of women in treatment during a year, we do not know whether they had treatments before the sample period started. In order to identify the first treatment, we assume that if she enters a fertility treatment that does not result in a child, she either stops the treatment or continues receiving treatments with no break longer than a year.

[10]In 1996 the majority of IVF patients have a high school degree or some college (51%), but this figure goes down in 2009 (43%). In 2009 the majority of IVF patients are college graduates (50%), a group that represented 28% of the IVF sample in 1996. In turn, there is a drop in the number of patients with less than a high school degree who accounted for 21% of the total IVF patients in 1996 but only 7% in 2009. We include time dummies in our analysis to control for this time variation in education across years.

set of institutions that provide universal and free coverage of the IVF procedures through the National Health Service (contrary to the U.S., for instance). This allows us to abstract from issues such as budget constraints or the choice of private medical insurance covering infertility treatments that might result in entrance into treatment.

Panel (a) in Table 1 compares the socioeconomic and demographic characteristics of IVF patient subsamples by education groups, namely high school dropouts (henceforth "$<$ *HS*"), high school graduates or some college (henceforth "*HS*"), and college graduates or higher (henceforth "*College*") seeking the first IVF treatment. Individuals in the *College* group were slightly older when they were first treated.[11] There was almost an equal share of cohabitations and marriages in the *College* group. The less educated ones were slightly more likely to be married (56%). Both individual and spousal income increased with education. The vast majority of the sample was employed, with approximately 92% among highly educated women; that proportion drops to 86% in the *HS* group and then falls to 69% for high school dropouts. There are minor differences in the share of women who were on leave or self-employed between the groups. Paralleling the increase in the propensity to work as education increases, the proportion of women at "home" was 13% in the $<$ *HS* group, 4% in the *HS* group, and 2% in the *College* group. Regarding the distribution of treatments provided in the public sector, about 84% of patients were treated in the public sector the first time, and we did not observe remarkable differences across education groups. That proportion varies from 88% among high school dropouts to 80% among college graduates.[12]

We observed similar differences across education groups when we considered the last treatment seeking the first pregnancy (panel (b), Table 1). Note that a couple might have discontinued IVF treatment either because they had a livebirth or faced a failed implantation or natural miscarriage. Within each group, the proportion of cycles in the public sector slightly decreased because of couples undergoing more than three cycles. Further, the proportion of married couples and (individual and spousal) income increased to some extent, which indicates that married and rich couples were more likely to persist in being treated after a failure.

We next explored whether these more and less educated women were also different in other respects, such as medical conditions, infertility causes, BMI, smoking, etc. Table 2 displays some interesting differences across education groups in terms of services from GPs and their costs.

[11] This is mainly driven by women holding at least a master's degree who are on average 33 years old. College graduates are instead on average 31.8 years old.

[12] A similar figure for the public sector is obtained if we consider all treatments that are eligible to be free: 84% of patients are treated in a public hospital; 88% of the $<$ *HS* group, 84% of *HS* group, and 79% of the *College* group. If instead we count all treatments for the first child: 79% overall; 86% in the $<$ *HS* group, 81% in *HS* group, and 75% in the *College* group.

The number of services from GPs per year tended to decrease with education, 10.3 for the $< HS$ group, 8.6 for the *HS* group, and 7.7 for the *College* group. This differential is also present in the average cost of the GP service (DKK 803 for the least educated group and DKK 597 for the most educated group). Further, there were some directional differences in the diagnoses of infertility causes across education groups (note that doctors may report a woman to have more than one infertility cause). In particular, less educated women were more likely to report a fallopian tube defect, with an incidence of 36% against 21% in the *College* group. On the contrary, male causes, as well as other medical causes and unspecified causes, were more likely to be diagnosed among highly educated women, which may reflect the somewhat higher age at entry. In addition, as one might expect, less educated women were more likely to be diagnosed with a number of other diseases prior to fertility treatment.[13]

Finally, our data-set contains information about smoking, alcohol consumption, and BMI from 2006 to 2009. Table 3 shows large differences across education groups in terms of these three health factors. We find that IVF patients with higher education reported smoking fewer cigarettes in the year before the treatment. The proportion of individuals that reported not smoking any cigarettes at all is 52.4% for the $< HS$ group, 64.5% for the *HS* group, and 67.9% for the *College* group. In contrast, individuals with college or higher degree tended to consume more alcohol prior treatment. For example, the proportion of individuals that reported not drinking alcohol is 44.9% for individuals with less than a high school degree, 39.8% for high school (and some college) and 33.8% for college or higher. More educated individuals also tended to have smaller body sizes according to BMI indicators.

3 The IVF-Education Gradient

To begin our assessment of the relationship between IVF success rate and education, the last row of panel (a) in Table 1 displays the success rate among less and more educated women. The IVF success rate with the first treatment was 20% for the $< HS$ group, 24% for the *HS* group, and 25% for the *College* group. The difference is sharper if we consider success in the last treatment seeking the first pregnancy (panel (b), Table 1): 47%, 54%, and 57% for the $<$ *HS*, *HS*, and *College* groups, respectively. Instead, the average number of treatments is similar across education groups: 2.59 for the $< HS$ group, 2.62 for the *HS* group, and 2.64 for college graduates or higher.

Since highly educated women were slightly older when they underwent the first IVF cycle to

[13] Disease incidence is below 3% in most cases. Two of the diagnoses with the highest incidence were "genitourinary system" and "pregnancy or childbirth", which is understandable since this is a sample who experienced fertility problems and was actively trying to become pregnant.

conceive a child, Table 4 shows the relationship between patient's age, access to IVF in public and private sectors, and success rate. The fraction of first treatments provided by the public sector moderately decreased with age: 89% for women 25-29 years old, 85% for women 30-34 years old, and 77% for women 35-40 years old. The same pattern is displayed if we consider all treatments that were eligible to be free. When we enlarge the sample to all treatments seeking the first successful pregnancy, a large majority of treatments was still provided by the public sector: about 80% (panel (a), Table 4). The data allows us to examine the IVF success rate at the treatment and hospital level. In the latter case, we give equal weight to all hospitals (panel (c), Table 4), whereas in the former case, we place more weight on the high-volume hospitals (panel (b), Table 4). The overall success rate (as measured by the fraction of live births) in the public sector was higher than in the private sector (21.6% versus 17.3% at the treatment level and 22.4% versus 18.1% at the hospital level). Since older women were somewhat more likely to be treated in the private sector, we also examined whether this difference remained when we looked at the distribution of live births in the public and private sectors across age groups. At the treatment level, the success rate was fairly identical across sectors for the mid-range age groups. However, while younger women had higher success rates in the public sector (i.e., 25.8% versus 23%), the reverse was true for older women (2.8% versus 4.9%). At the hospital level, we observe similar patterns.

3.1 Econometric Specification

As documented above, lower and more educated women are different in a number of dimensions (age, income, employment status, medical conditions, BMI, smoking, etc) and, to some extent, sort into different sectors. Thus, an immediate concern is that educational disparities in IVF outcomes may partially reflect these differences. To account for the influence of these systematic differences in individual and clinic characteristics, we estimate the following equation:

$$b_{ijht}^{IVF} = cons + \sum_{s>0} \alpha_s \mathbf{1}_{s_i} + \beta_t + \gamma_h + \beta_t\gamma_h + \eta x_{ij} + \sum_{s>0} \beta_j year_j + \varepsilon_{ij}, \quad (1)$$

where b_{ij}^{IVF} is a dummy variable equal to 1 if a live birth is attained with the IVF treatment j for woman i in the hospital h at year t. s_i is a measure of the individual i's educational attainment, namely (i) less than high school, (ii) high school or some college, or (iii) college or higher. β_t is a year fixed effect, and γ_h is a clinic fixed effect. The vector x_{it} denotes a full set of individual demographic and socioeconomic characteristics, including a second order polynomial in age[14]; marital status; logged female's labor income; logged spousal labor income; a categorical

[14] In our estimation we rescale ages 25-45 to 1-21, respectively. This is done to better capture the non-linearities of the effect of age on the pregnancy probability at the onset from around age 25.

variable for labor market status taking values for "on leave" status, self-employed, employed, out of labor force, and unemployed. Patients' and spouses' incomes are expressed at year 2000 price levels deflated using the Danish Consumer Price Index. ε_{it} is a contemporaneous term reflecting heteroscedastic robust standard errors $N(0, \sigma^2_{\varepsilon,i})$, that we cluster at the individual level, as it is unreasonable to expect IVF outcomes of different cycles from the same woman to be independent.

Note that, while the coverage of infertility treatments for childless couples at a fertile age largely mitigates the potential selection problem in the utilization of these treatments based on education, a positive education gradient in IVF could still be the result of patients sorting into different clinics, as patients across clinics might be affected by unobserved clinic characteristics that are correlated with both individual education and IVF success.[15] In order to account for this confounding factor in the estimation of the education gradient we exploit only the variation of education across patients within a clinic, who essentially faced the same practitioners, description of protocol, equipment, facilities, etc. Before presenting our estimation results, we examine the extent of variation in patients educational attainment that is left after removing hospital and year fixed effects. The overall mean and standard deviation are 13.7 and 2.3, respectively. After removing these fixed effects, we retain more than 90% of the variation (from 2.30 to 2.21), which is reassuring in terms of the precision of our estimates.

Our parameter of interest is α_s, which captures the relative effect of college (or higher education) and high school attainment (or some college) with respect to the reference educational attainment group (i.e., less than high school). Hence, if there is a positive education gradient in IVF, the estimated term α_s will be positive and significant. We next report our results for the benchmark model. We then consider the patient, rather than the cycle, as the unit of observation, and perform a discrete survival analysis. Finally we conduct a number of robustness exercises, and interpret our results.

3.2 Results

First, we estimate a linear probability model (LPM) using information on all women 25 to 45 years of age who underwent an IVF process, as specified in equation (1). Table 5 reports our results. In column (1), we consider all treatments (i.e., cycles) for both first and second births. In column (2) we restrict our attention to treatments of women trying to conceive the first child to see whether the gradient is stronger in this group. For this subsample, we then discard all but

[15] One concern is the presence of disparities in the amount of available resources across education groups, which in turn generates differences in accessibility to expensive medical technologies. If the higher-educated mothers have access to better IVF technology, they will have better success in attaining a live birth simply due to higher productive efficiency. This argument can be stated in general for a wide set of medical technologies; see Grossman (1972); Kenkel (1991); Thompson et al. (2008); and Cutler and Lleras-Muney (2011).

one cycle: the first cycle, which might be viewed as the cleanest because of possible attrition in repeated cycles, in column (3), and the last cycle, which considers every ultimate success, in column (4).[16] In these last two columns we give equal weight to all women, regardless of the number of treatment cycles per woman.

The outcome is clear: There is a large and highly significant education gradient in IVF success rates in all specifications. The IVF success rates of high school and college graduates are markedly higher than those of women without high school degrees (the reference group). Compared to the reference group, patients with high school degrees or some college education have a 2.67 percentage-point higher probability of attaining a live birth through IVF, holding age constant, including year fixed effects, and clinic fixed effects and trends (column 1, Table 5). The estimated coefficient for patients with a college degree is even higher: 4.54.[17] To see this, consider that the average chances of attaining a live birth through IVF are 20.95%, so the education gradient results in a 4.54x100/20.95 = 21.7% higher chance of successful IVF treatment (out of the total chances) for college graduates, and (2.67x100/20.95=)12.7% for women with high school degrees or some college, when compared to individuals without high school degrees.[18]

Interestingly, the gradient is somewhat higher when we consider the treatments to conceive the first child (column 2, Table 5). In particular, regarding the first cycle (column 3, Table 5), the estimate of the gradient is 3.89 percentage-points for the *HS* group, and 5.67 percentage-points for the *College* group. Given that the average chance of attaining a live birth through IVF is 23.82% in their first cycle, the education gradient for college graduates results in a (5.67x100/23.82 =)23.8% higher chance of successful IVF when compared to the reference group, while the education gradient for the *HS* group represents a (3.89x100/23.82=)16.3% higher chance of successful IVF treatment than for individuals without high school. These findings are not an artifact of our measure of education. The results hold true when we divide the population into finer educational groups (i.e., high school dropout, high school degree, trade, some college, college degree, and master or

[16] Both success (live birth) and failure (lack of embryo implantations or natural miscarriage) can be prognostic of dropout. Missmer et al. (2011) document that the proportion of couples discontinuing treatment after a failure increased with cycle number. They do not examine whether attrition is different across education groups. In our sample we observe similar patterns of dropout after a failure across educational groups. For instance, the fraction of women who discontinued treatment after a failure in the first cycle is 18% in the $<$ *HS* group and 16% in both the *HS* and the *College* groups. After failing the third cycle, these fractions rise to 29%, 26%, 25%, for the $<$ *HS*, the *HS*, and the *College* groups, respectively. After failing the fifth cycle, they are 38%, 34%, 31%, for the $<$ *HS*, the *HS*, and the *College* groups, respectively.

[17] Not controlling for individual characteristics changes the estimates slightly but the IVF-education gradient is still large. Patients with high school degrees or some college education have a 2.67 percentage-point higher probability of attaining a live birth through IVF, and patients with a college degree or highar have a 5.06 percentage-point higher probability of attaining a live birth through IVF.

[18] We obtained estimates very close in significance and magnitude when we enlarged the sample to women who we did not observe with a partner.

Ph.D.) as well as when we consider years of schooling. The educational disparities remain when we consider the last trial (column 4, Table 5), i.e., ultimate success or failure.[19] The estimate of the gradient is 7.86 percentage-points for the *HS* group and 13.3 percentage-points for the *College* group. In other words, highly-educated women have a (13.3x100/54.37 =)24.5% higher probability of attaining a live birth and average-educated women a (7.86x100/54.37 =)14.45% higher chance of attaining a live-birth than the low-educated women.

Consistent with the medical literature, we find that age is an important determinant of IVF success. As patients age, the probability of successful IVF births decreases. A 10% increase in individual income is associated with a 4.69 and 5.96 percentage points increase in the IVF success (columns 3 and 4, Table 5), respectively. Spousal income has a negligible and insignificant effect in all cycles except the last one, where patients with higher spousal income have a significantly higher success rate. Further, patients who were employed, self-employed, outside the labor force, and unemployed were less likely to succeed than patients who were in school (i.e., the reference group). On the contrary, women who were on leave had a significantly higher IVF success rate compared to the reference group.[20] Next, we replicate the results in Table 5 when conditioning on male education. The results are reported in Table 6. Strikingly, both female and male educations are significantly and positively associated with IVF success. Further, the estimated coefficients of the female gradient are only slightly smaller than those in the baseline specifications, and their size is almost twice as large as that one of the male gradient in Table 6.

Throughout our analysis, we have focused on a LPM specification. Our results with a logit model imply an almost identical IVF-education gradient (Table 7). For example, at the margin, the estimate of the gradient is 4.43 percentage-points for the *College* group and 2.56 for the *HS* group (column 1, Table 7), against an estimate of 4.54 and 2.67 that we find for the *College* group and the *HS*, respectively, in the baseline specification (column 1, Table 5). Similarly, the gradient remains robust in the other columns of Table 7. We also estimate the conditional probability of delivering at least one live birth at cycle number j given that all cycles before j failed. We allow this probability to differ in education, holding age constant (see Figure 3). The probability of success decreases with the number of cycles for all education types. For instance, this probability drops from 19.5% in the first cycle to 14% in the fourth cycle among $<$ *HS* patients; it drops

[19]The same specifications without clinic fixed effects and trends are in Table A-1. The estimates of the gradient are very similar in size, which seems to suggest that the educational disparities are not due to unobserved clinic-specific time-varying factors or the results of sorting of patients into clinics. Alternatively, it could be that highly educated patients are to some extent more likely to be treated in highly successful clinics where doctors tend to implant less embryos.

[20]We acknowledge that being on leave can be endogenous to having a child in some cases. The reason is that our labor market status variable is measured in November of the year that IVF patients receive treatment. This way, if successful treatment was received, say, in January of the same year, this woman should be on maternity leave in November when labor market status is reported.

from 23.5% in the first cycle to 17.5% in the fourth cycle among *HS* patients; and it drops from 25% in the first cycle to 19% in the fourth cycle among *College* patients. Interestingly, the gap in IVf success across education types is fairly constant throughout the first four cycles. This finding indicates that patients with lower education level do not catch up after repeated cycles.[21]

Finally, note that a failure may be due to a lack of healthy embryos to implant or natural miscarriage after implantation. We next estimate the gradient in those treatments with at least one embryo being implanted. The results are given in Table 8. Strikingly, the estimated coefficients of the gradient are virtually identical to the ones in our baseline specification (Table 5), even when we control for the number of embryos implanted (columns 3 and 5, Table 8). Given that the probability of success, conditional on an embryo transfer, is 28.92 in our sample, these estimates implies that on average college graduates are about 20% more likely to attain a live birth than women who do not have a high school degree. This figure is similar for childless women with a high school degree or two years of college: 13%. This finding seems to suggest that whether a pregnancy will end in miscarriage is not purely idiosyncratic. In fact, whether a pregnancy results in a live birth depends on the grading of the embryo(s), among other factors. Only the best quality embryo(s) are selected, and their quality might be associated with education.[22] Evidence from the medical literature indicates that there are ways to help improve the health of the ovaries and the egg quality. Factors that are relevant for egg quality, and in turn for the embryo, are age, diet, BMI, hormonal issues, stress, alcohol consumption and smoking.[23] Note that also the estimates of the coefficients of age, marital status, and employment status are robust.

This piece of evidence calls into question the validity of using the outcome of IVF as an exogenous source of variation in fertility to identify the effect of a first child on female labor supply (Lundborg et al., 2016). In fact, this putative natural experiment must satisfy the randomness criterion. However, while the IVF outcome is drawn by biological mechanisms, the assumption of randomness is not fully credible in light of our results. Identification of the effect of first child on labor market outcome rests on the assumption that IVF success is not correlated with the error term. Therefore, the description of what is in the error term is critical to assess the reliability of their estimates. Even if Lundborg et al. (2016) control for education, the application of this

[21] In the duration analysis we considered only the first five cycles, because the sample size shrinks considerably afterwards. For instance, only 14% of the patients undergo a fifth cycle.

[22] For instance, using data from three (academic or private) clinics in the greater Boston area, Mahalingaiah et al. (2011) document that patients with a graduate school education have statistically significantly higher peak estradiol levels than patients without a college degree, which in turn affect the odds of cycle cancellation before egg retrieval.

[23] For example, Shah et al. (2011) show that obesity is associated with fewer normally fertilized oocytes, lower estradiol levels, and lower pregnancy and live birth rates. Rossi et al. (2011) find that consumption of as few as four alcoholic drinks per week is associated with a decrease in IVF live birth rate, after controlling for cycle number, cigarette use, body mass index, and age.

instrument is likely to provide biased estimates if IVF success is not orthogonal to unobservable factors that could affect labor market outcomes. Consider for example personality traits that are correlated with education: some medical evidence indicates that personality traits and ability to cope with stressful situations may affect the outcome of IVF and, at the same time, an emerging literature in labor economics documents that personality traits are associated with employment status and wages, and this relationship is not fully mediated by education. See, e.g., Heckman et al. (2006); Almlund et al. (2011); Fletcher (2013), and references therein.

4 Additional Evidence

Educational disparities in IVF success rates extend beyond age, marital status, individual and spousal income, labor market status, the clinic in which the woman is treated, the number of embryos transferred, and the cycle number (Section 3). Here we explore the robustness of our results to other alternative mechanisms that could account for the education gradient in IVF success. For instance, disparities in unhealthy behaviors (such as smoking and drinking) and health problems experienced before the treatment could be held accountable for the education gradient in IVF success rates. We also show robustness to alternative education specifications and eligibility of free treatments. Finally, we discuss disparities in IVF productive efficiency as a rationale for the education gradient in IVF.

4.1 Health Status and Behaviors

Table 2 and Table 3 show that more and less educated women display some differences in infertility causes, health problems experienced before IVF, smoking, drinking, and BMI, which the medical literature considers "risk factors" to achieving a successful pregnancy. Hence, we examine whether the educational disparities simply reflect these differences. To control for health status, we incorporate pre-existing medical conditions in our model, such as the number of GP services in the past year, the total medical expenditures associated with GP services, the patient's infertility diagnostic information, and whether the patient has been diagnosed with any serious disorder or disease before undergoing an IVF treatment (see section 2.4). First, we explore how the coefficient of the gradient changes as we introduce infertility causes, GP services and medical conditions in our baseline regression (column 3, of Table 5). We find that adding these controls increases the education gradient in the first cycle, especially for the *College* group (column 1, Table 9). Specifically, *College* patients are associated with a 6.63 (instead of 5.67) percentage-point higher probability of attaining a live birth compared to $<$ *HS* patients. For *HS* patients, the estimate increases from 3.89 to 4.49-percentage points.[24]

Regarding infertility causes, there is no significant association between IVF success rate and cervical defects, male causes and unspecified causes. In contrast, we observe that for those women who undergo infertility treatment because of a defect of the fallopian tube the probability of IVF success drops of 2.53 percentage points; and for those patients with "other causes" of infertility this probability drops of 3.14 percentage points. Note that while the former cause of infertility is more prevalent in the $< HS$ group, the latter one is more prevalent in the *College* group, and might be related to the quality of the eggs becase these patients are slightly older when they enter into treatment. The fact that the absolute value of the coefficient of "other causes" is the highest among all infertility causes may partially explain why we observe that the education gradient in the *College* group increases. The estimated coefficients of the average number of GP services and of their monetary cost are close to zero.

Information on behavioral factors such as smoking, alcohol consumption, and BMI is available only for 2006-2009. Hence, we first replicate our results for this time span (column 2, Table 9). Note that the education gradient in column (2) is higher than in column (1), which indicates that the educational disparities may become larger over time. Then we compare these results with the ones obtained when we also include the number of cigarettes smoked, the number of units of alcohol consumption per week, and BMI. We find that the size of education gradient has a small decrease from 5.93 percentage points to 5.34 percentage points for *HS* patients, and a sharper decrease from 8.72 percentage points to 7.5 percentage points for *College* patients (column 3, Table 9). When including also alcohol consumption, the gradient is somewhat higher perhaps because highly educated women reported to drink more (column 4, Table 9). Perhaps not surprisingly, not smoking, as well as not drinking, is positively associated with IVF success.[25]. We obtain the same robust results if, instead of considering only the first cycle for the first child, we enlarge the sample to all cycles for both first and second child. See Table A-2 in the appendix.

Our results are robust to alternative education specifications. In particular, the education gradient in IVF success, we find that it is monotonically increasing in educational attainment also when we divide the population into finer educational groups (the baseline group is still the $< HS$ group): 5.28 for high school graduates, 5.76 for women with two years of college, 6.39 for college graduates, and 7.36 for women with a master or Ph.D. degree (column 1, Table 10). The significance and magnitude of these estimates are fairly identical when we restrict our attention to treatments that reached the embryo implantation stage (column 3, Table 10). Finally, we show

[24]Whether we used a dummy for each diagnosis given at hospitals during the year prior to treatment, or an indicator equal to 1 if the patient has been diagnosed with any disease did not alter the robustness of the results.

[25]All specifications include indicator for missing information on BMI, smoking and alcohol consumption

that one more year of education is associated with a 0.8 percentage points higher probability of a IVF success (columns 2 and 4, Table 10).

We next restrict our attentions to those treatments that were eligible to be free because attrition is limited in this case.[26] This also helps rule out issues associated with potential financial constraints. When we restrict the sample to the treatments eligible to be free, the sample size shrinks from 67,974 to 57,172 IVF cycles, but the IVF-education gradient remains significantly positive and slightly large in magnitude (column 1, panel (a), Table 11), most likely caused by the exclusion of ineligible women above 40 who are predominantly highly educated and have low fertility. These results are robust to focusing on the first or last cycle (columns 2 and 3, panel (a), Table 11).

To summarize, the evidence provided in this section makes a compelling case that education itself, rather than individual characteristics, health related behaviors, and clinic characteristics (which are all correlated with education), contributes to explaining success in IVF.

4.2 Disparities in IVF Productive Efficiency

An important dimension of IVF outcomes is that we can study whether the education disparities in IVF success increase or decrease with success. To explore this dimension, we further restrict our attention to women who had a child through IVF within the free-eligible treatments, and sought a second pregnancy later on (panel (b), Table 11). We select the women this way to be able to follow the same woman from the first to the second child. The existence of an education gradient for the first pregnancy would imply that, on average, it takes the highly-educated patients less IVF treatments to have a child than the patients with lower educational attainment, even when we condition on being "relatively fast" in succeeding in the first IVF birth (i.e., within the first three trials conditional on embryo transfer). Our results show that this is indeed the case. We find that *College* patients are associated with a significant 4.71 percentage-points higher probability of attaining a live birth at any given treatment compared with $<$ *HS* patients; furthermore, *HS* patients are associated with a 5.48 percentage-points higher probability compared to high school dropouts (column 1, panel (b), Table 11). Next, we explore the possibility that the less-educated might catch up with the more educated by studying the outcome of the second IVF child. We

[26] The attrition rate, however, is not very different across education groups in our sample, especially in the first four cycles. For instance, the fraction of women who undergo a new cycle after failing the first one is 82% in the $<$ *HS* group and 84% in both the *HS* and the *College* groups. After failing the second cycle, these fractions drop to 79%, 80%, and 81%, for the $<$ *HS*, the *HS*, and the *College* groups, respectively. After failing the third cycle, these fractions drop to 71%, 74%, and 75%, for the $<$ *HS*, the *HS*, and the *College* groups, respectively. After failing the fourth cycle, these fractions drop to 62%, 68%, and 72%, for the $<$ *HS*, the *HS*, and the *College* groups, respectively.

find that this is indeed the case. Now, the education gradient drastically declines to about 1.7 percentage-points for both education groups and it is not significant in either group (column 2, panel (b), Table 11). The fact that the education disparities in the second IVF child disappear suggest that the less-educated patients can and do catch up in terms of success probability in IVF treatments. We observe a similar pattern when we consider just the first cycle for the first and second birth, respectively in columns (3) and (4) in panel (b) of Table 11.

The fact that the higher-educated are faster at succeeding in achieving a favorable health outcome has received alternative explanations in health economics. Grossman (2006) distinguishes between "allocative efficiency" and "productive efficiency" mechanisms. "Allocative efficiency" refers to the notion that the individuals with higher levels of education choose different health inputs because they face different prices and have access to different resources. This typically occurs with the adoption of novel medical technologies and newly drugs approved by the FDA, as they face lower costs of searching for higher-quality treatment (Lleras-Muney and Lichtenberg, 2005). In the case of the utilization of IVF treatments, however, we find an education gradient even when we exploit variation *within* a clinic (where patients faced the same IVF inputs), which seems to rule out this argument. Instead, our results point into the direction of "productive efficiency", i.e., that highly educated individuals have better health outcomes than lower educated ones even when they all face the same prices and constraints. Within a clinic, all IVF patients face the same strict protocol and IVF inputs. In particular, the rigors of completing a cycle of IVF entail strict adherence to an intense schedule of appointments, blood tests, ultrasound tests, and procedures, and patients compliance with medications (see Section A in the appendix). Therefore, a better knowledge of how to use the newly acquired information about the IVF technology, i.e., higher ability to manage similar IVF inputs, can determine the organizational capital that yields higher "IVF productive efficiency" by the more educated individuals. Further, the evidence that the education gradient vanishes when seeking a second pregnancy supports the hypothesis that while women with higher educational attainment are more likely to attain a live birth, the less educated ones can acquire this skill after they experience a first success.

5 Conclusion

In this paper, we investigate the education gradient associated with a well-established medical technology, IVF. The unique structure of the administrative Danish register allowed us to estimate this gradient using comparisons across patients within clinics, and to control for a wide range of individual characteristics, pre-treatment medical conditions, infertility causes, number of embryos implanted, body size, and unhealthy behaviors such as past smoking and drinking. It is noteworthy that the potential selection into treatment is mitigated by the fact that, in Denmark, IVF patients are treated for free in the first three cycles reaching the stage of embryo implantation.

We found that highly educated women do better in these treatments. Specifically, women with a college degree are about 24% more likely to attain a live birth than high school dropouts in the first cycle, and women with high school degree achieve similar results (i.e., they are 16% more likely to have a succesful pregnancy than high school dropouts). That is, there is a large and highly significant education gradient in IVF success. Similar findings were obtained when we consider the last IVF cycle that women undergo, which ultimately measures success. In this case, highly educated women have a 24% higher probability of attaining a live birth (and average-educated women a 14% one) than lowly-educated women. Indeed, our estimated hazard rates show that the gap remains fairly constant throughout the first four cycles. Finally, educational disparities are present even when we control for embryo(s) being implanted. This result suggests caution when using the outcome of ART or IVF as an exogenous source of variation in fertility to identify the effect of a first child on female labor supply (Cristia, 2008; Lundborg et al., 2016). In fact, while this putative natural experiment arises from biological mechanisms, the assumption of randomness is not fully credible in light of our results.

Our findings open a new set of research questions. As long as access to IVF technology may delay motherhood, women career and fertility choices are likely to be influenced by the determinants of IVF success, which are the object of our study. The fact that we find striking educational disparities in IVF success may contribute to explain changes in selection into motherhood and disparities in labor-force participation and occupational upgrading. We are currently pursuing this line of research.

References

Adda, J., Dustmann, C., and Stevens, K. (2016). The career costs of children. *Journal of Political Economy*, in press.

Almlund, M., Duckworth, A. L., Heckman, J., and Kautz, T. (2011). Personality psychology and economics. *Handbook of the Economics of Education*, 4:1–181.

Bitler, M. and Schmidt, L. (2012). Utilization of Infertility Treatments: The Effects of Insurance Mandates. *Demography*, 49(1):125–149.

Buckles, K. (2008). Understanding the returns to delayed childbearing for working women. *American Economic Review*, 98(2):403–07.

Caucutt, E., Guner, N., and Knowles, J. (2002). Why do women wait? matching, wage inequality, and the incentives for fertility delay. *Review of Economic Dynamics*, 5(4):815–855.

Connolly, M., Hoorens, S., and Chambers, G. M. (2010). The costs and consequences of assisted reproductive technology: An economic perspective. *Human Reproduction Update*, 16(6):603–613.

Cristia, J. (2008). The effect of a first child on female labor supply: Evidence from women seeking fertility services. *Journal of Human Resources*, 43(3):487–510.

Cutler, D. M. and Lleras-Muney, A. (2011). Education and Health. Working Paper.

Danish Health Insurance (2013). Webpage for the danish health insurance (https://www.sygeforsikring.dk/default.aspx?id=226).

Dansk Fertilitetsklinik (2016). Ivf treatment guide (ivf vejning).

de Mouzon, J., Goossens, V., Bhattacharya, S., Castilla, J., Ferraretti, A., Korsak, V., Kupka, M., Nygren, K., Andersen, A. N., EIM, and ESHRE (2010). Assisted reproductive technology in europe, 2006: results generated from european registers by eshre. *Human Reproduction*, 00(0):1–12.

Fletcher, J. M. (2013). The effects of personality traits on adult labor market outcomes: Evidence from siblings. *Journal of Economic Behavior and Organization*, 89:122 – 135.

Goldin, C. and Mitchell, J. (2016). The new lifecycle of womens employment: Disappearing humps, sagging middles, expanding tops. NBER Working Papers 22913, National Bureau of Economic Research, Inc.

Goldin, C. and Olivetti, C. (2013). Shocking Labor Supply: A Reassessment of the Role of World War II on Women's Labor Supply. *American Economic Review*, 103(3):257–62.

Goldman, D. P. and Smith, J. P. (2002). Can patient self-management help explain the ses health gradient? *Proceedings of the National Academy of Sciences of the United States of America*, 99(16):10929–10934.

Grossman, M. (1972). *The Demand for Health: A Theoretical and Empirical Investigation*. New York: Columbia University Press.

Grossman, M. (2006). Education and nonmarket outcomes. volume 1, chapter 10, pages 577–633. Elsevier, 1 edition.

Heckman, J., Stixrud, J., and Urzua, S. (2006). The effects of cognitive and noncognitive abilities on labor market outcomes and social behavior. *Journal of Labor Economics*, 24(3):411–482.

Jones, L. E., Schoonbroodt, A., and Tertilt, M. (2010). Fertility Theories: Can They Explain the Negative Fertility-Income Relationship? In *Demography and the Economy*, NBER Chapters, pages 43–100. National Bureau of Economic Research, Inc.

Kenkel, D. (1991). Health Behavior, Health Knowledge and Schooling. *Journal of Political Economy*, 99.

Leung, M.-Y., Groes, F., and Santaeulàlia-Llopis, R. (2016). The Relationship between Age at First Birth and Mother's Lifetime Earnings: Evidence from Danish Data. *PLoS ONE*, 1(11).

Lillard, D. R., Plassmanna, V., Kenkela, D., and Mathiosa, A. (2007). Who kicks the habit and how they do it: Socioeconomic differences across methods of quitting smoking in the USA. *Social Science & Medicine*, 64:2504–2519.

Lleras-Muney, A. and Lichtenberg, F. (2005). The Effect Of Education On Medical Technology Adoption: Are The More Educated More Likely To Use New Drugs? *Annales dEconomie et Statistique*, 79/80.

Lundborg, P., Plug, E., and Rasmussen, A. W. (2016). Fertility effects on female labor supply: Iv evidence from ivf treatments. *American Economic Review*, forthcoming.

Mahalingaiah, S., Berry, Hornstein, M. D., Cramer, D. W., and Missmer, S. A. (2011). Does a womans educational attainment influence in vitro fertilization outcomes? *Fertility and Sterility*, 95(8):26182620.

Miller, A. (2011). The effects of motherhood timing on career path. *Journal of Population Economics*, 24(3):1071–1100.

Ministry of Health (1997). Law on artificial insemination (lov om kunstig befrugtning i forbindelse med lægelig behandling, diagnostik og forskning m.v.). Law.

Ministry of Health (2006). Law on artificial insemination (lov om ændring af lov om kunstig befrugtning i forbindelse med lægelig behandling, diagnostik og forskning m.v.). Law.

Ministry of Health (2012). Official webpage for information on fertility treatment (https://www.sundhed.dk/borger/sundhed-og-livsstil/graviditet-foedsel-barsel/barnloesheds-listeside/kopi-af-behandling-barnloeshed/).

Ministry of Health (2013). *Choice of Hospital (Sygehusvalg)*. Ministeriet for Sundhed og Forebyggelse.

Missmer, S. A., Pearson, K., Ryan, L., Meeker, J., Cramer, D., and Hauser, R. (2011). Analysis of multiple-cycle data from couples undergoing in vitro fertilization: methodologic issues and statistical approaches. *Journal of Epidemiology*, 22(4):497–504.

Olivetti, C. (2014). The Female Labor Force and Long-Run Development: The American Experience in Comparative Perspective. In *Human Capital in History: The American Record*, NBER Chapters, pages 161–197. National Bureau of Economic Research, Inc.

Rosenzweig, M. R. and Schultz, T. P. (1989). Schooling, Information and Nonmarket Productivity: Contraceptive Use and Its Effectiveness. *International Economic Review*, 30(2):457–77.

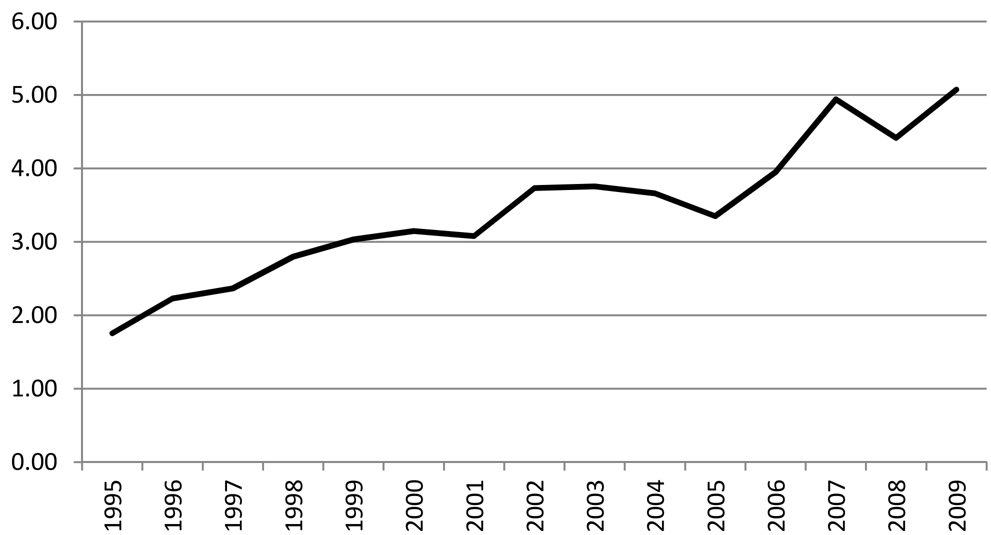
Rossi, Berry, Hornstein, Cramer, Ehrlich, and Missmer. (2011). Effect of alcohol consumption on in vitro fertilization. *Obstet Gynecol.*, 117(1):136–142.

Schmidt, L. (2007). Effects of Infertility Insurance Mandates on Fertility. *Journal of Health Economics*, 26(3):431–446.

Shah, D., Missmer, S., Berry, K., Racowsky, C., and Ginsburg, E. (2011). Effect of obesity on oocyte and embryo quality in women undergoing in vitro fertilization. *Obstet Gynecol.*, 118(1):63–70.

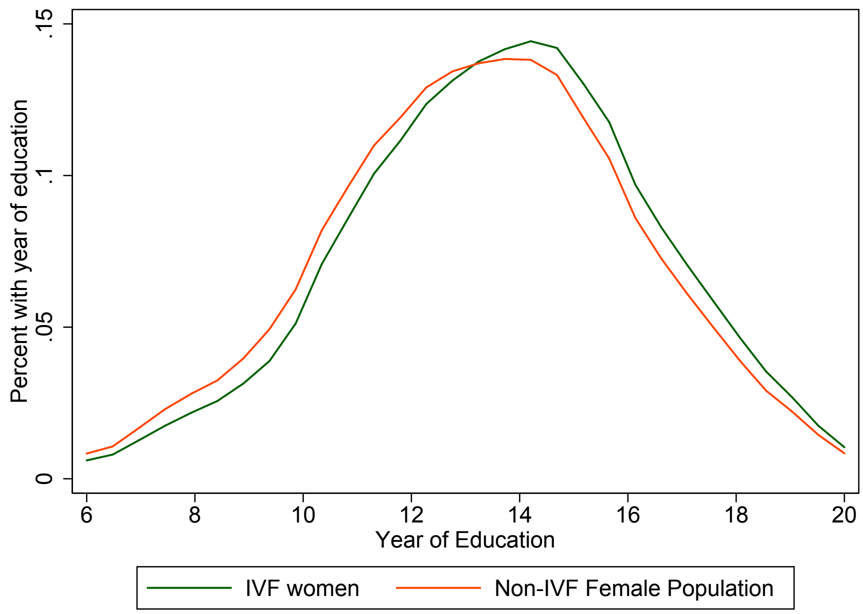
Thompson, V., Cavazos-Rehg, P., Tate, K., and Gaier, A. (2008). Cancer information seeking among african americans. *Journal of Cancer Education*, 23:92–101.

Figure 1: IVF Children (%), Fraction of All Births: Denmark (1995-2009)



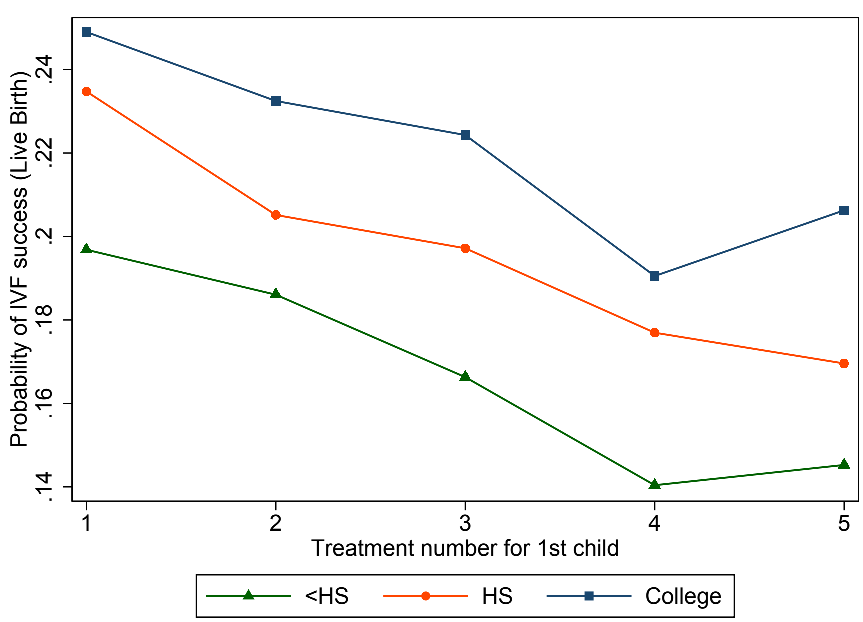
Notes: The fraction of IVF children (%) is computed as the number of births from the IVF register over number total births in the population in a given year.

Figure 2: Distribution of Years of Education



Notes: The samples for both IVF and non-IVF populations are childless women conditional on being married or cohabiting. See our discussion in section 2.4

Figure 3: Hazard Rates by Education



Notes: We report the outcome of a logit regression with education and number of treatment interacted (and controlling for education and number of treatments and age) and then plotted the prediction of the successrate for each treatment number in the different education categories at the average age of education. See our discussion in section 3.2.

Table 1: Demographic Characteristics of IVF Patients

Education	< *HS*	*HS*	*College*
(a) First Treatment:			
Age	31.41	31.36	32.19
	(3.97)	(3.80)	(3.88)
Married (%)	56.2	54.0	52.7
Patient's income	180,328	231,528	286,745
	(74,443)	(89,596)	(123,252)
Spousal income	263,856	324,845	361,319
	(134,881)	(589,665)	(758,122)
Employment status (%):			
On leave	2.62	1.20	0.64
Self-employment	3.15	3.16	1.78
Employed	69.2	85.7	92.0
Unemployed	11.4	4.21	2.17
In school	1.10	1.29	1.14
Out of labor force	12.5	4.46	2.28
Treated in public hospital (%)	87.7	84.5	79.8
Live births (%)	20.2	24.1	24.6
Observations	3,174	12,802	9,933
(b) Last Treatment:			
Age	32.26	32.13	32.85
	(4.13)	(3.94)	(4.04)
Married (%)	60.2	59.5	57.9
Patient's income	181,843	234,224	292,091
	(77,411)	(90,297)	(125,004)
Spousal income	269,275	330,127	366,434
	(141,879)	(590,260)	(357,044)
Employment status (%):			
On leave	3.02	1.50	0.97
Self-employment	3.48	3.43	1.84
Employed	69.37	85.50	91.80
Unemployed	10.33	4.03	2.05
In school	0.81	1.24	1.09
Out of labor force	13.0	4.29	2.25
Treated in public hospital (%)	84.9	82.3	76.3
Live births (%)	47.0	54.4	56.6
Number of total treatments	2.59	2.62	2.64
Observations	3,079	12,721	10,109

Notes: In terms of education groups, we denote IVF patients with less than high school as < *HS*, high school or some college as *HS*, and college or higher degree as *College*. Entries are means conditional on first treatment in panel (a) and on last treatment in panel (b). Standard deviations in parentheses. Income is in DKK, deflated by CPI to year 2000. Employment status is measured the year prior to treatment.

Table 2: Medical Conditions of IVF Patients by Education Groups

Variable	$< HS$	*HS*	*College*
General practitioner (GP) services:			
Average number of GP services	10.31	8.62	7.67
Average cost of GP services	803	661	597
Infertility causes (%):			
Cervical defect	1.00	1.55	1.95
Ovulation defect	11.5	11.2	12.9
Fallopian tube defect	36.0	24.7	20.6
Male causes	36.7	40.7	42.7
Other causes	16.7	23.6	28.9
Unspecified causes	17.9	22.1	21.6
Disease Diagnosis (%):			
Infectious diseases	0.64	0.43	0.39
Neoplasms	0.24	0.23	0.24
Blood diseases	0.15	0.10	0.09
Endocrine diseases	1.20	0.91	0.84
Mental Illness	0.18	0.18	0.14
Nervous system	0.88	0.53	0.45
Eye diseases	0.36	0.41	0.46
Ear diseases	0.47	0.25	0.32
Circulatory system	0.59	0.65	0.59
Respiratory system	1.02	0.65	0.59
Digestive system	2.44	1.81	1.43
Skin diseases	1.16	0.79	0.69
Musculoskeletal system	3.90	2.34	1.79
Genitourinary system	30.06	28.83	26.88
Pregnancy or childbirth	11.90	13.12	14.55
Prenatal diseases	0.05	0.02	0.03
Malformations chromosomal	0.21	0.30	0.32
Abnormal laboratory findings	3.77	2.91	2.57
Injuries	10.31	7.68	6.40
Factors for health contact	18.66	17.55	17.27

Notes: In terms of education groups, we denote IVF patients with less than high school as $< HS$, high school or some college as *HS*, and college or higher degree as *College*. Examples of general practitioner (GP) services are a consultation, a blood test, a vaccination, which are measured the year prior to treatment. A patient can have many infertility causes. Disease diagnosis are indicator if a patient has been given the diagnosis the year prior to treatment.

Table 3: Smoking, Alcohol Consumption, and BMI by Education Groups

Variable	$< HS$	*HS*	*College*
Cigarettes smoked (%):			
$\#$ of cigarette $= 0$	52.4	64.6	68.0
$1 \leq \#$ of cigarette ≤ 5	5.1	3.1	2.4
$6 \leq \#$ of cigarette ≤ 10	7.9	3.1	1.4
$\#$ of cigarette ≥ 11	8.7	2.8	1.0
Missing	25.9	26.4	27.2
Alcohol consumption per week (%):			
$\#$ of units $= 0$	45.0	39.8	33.8
$1 \leq \#$ of units ≤ 3	13.8	17.9	22.1
$4 \leq \#$ of units ≤ 5	2.2	4.2	5.7
$\#$ of units ≥ 6	2.6	2.9	4.3
Missing	36.5	35.2	34.0
BMI (%):			
BMI$<$20	7.4	9.1	11.1
20$\leq$BMI$<$25	35.3	38.1	44.1
25$\leq$BMI$<$30	21.9	19.3	14.7
BMI$\geq$30	11.8	9.2	5.0
Missing	23.6	24.3	25.1

Notes: In terms of education groups, we denote IVF patients with less than high school as $< HS$, high school or some college as *HS*, and college or higher degree as *College*. Number of cigarettes smoked and units of alcohol consumption are self reported during each treatment. BMI is measured at the fertility clinic/hospital. *HS* denotes high school. The sample is restricted to years 2006-2009 for which information on smoking, alcohol consumption, and BMI is available.

Table 4: IVF Treatments and Age (First Child)

		Age			
	All	25-29	30-34	35-40	41+
(a) Treatments in the public sector:					
Only first treatment (%)	84.6	88.8	85.5	76.6	-
Only free-eligible treatments (%)	83.1	87.9	84.3	75.7	-
All (%)	79.6	87.5	83.1	73.8	3.9
(b) IVF success rate: Treatment level					
Public Sector	21.6	25.9	22.4	15.5	2.8
Private Sector	17.3	23.0	22.2	14.1	4.9
(c) IVF success rate: Hospital level					
Public Sector	22.4	26.6	23.8	14.8	1.2
Private Sector	18.1	23.2	26.0	11.2	3.9

Notes: The unit of observation is a treatment in panel (b), and the hospital in panel (c).

Table 5: Education Gradient in IVF (Live Birth)

	(1)	(2)	(3)	(4)
Treatments:	All	All	First	Last
Seeking pregnancy for:	1st and 2nd child	1st child	1st child	1st child
HS and some college	0.0267***	0.0282***	0.0389***	0.0786***
	(0.00480)	(0.00501)	(0.00818)	(0.00971)
College and higher degree	0.0454***	0.0483***	0.0567***	0.133***
	(0.00507)	(0.00531)	(0.00872)	(0.0102)
Age	-9.63e-05	-0.00240	-0.000149	0.00174
	(0.00138)	(0.00146)	(0.00234)	(0.00254)
Age square	-0.000750***	-0.000604***	-0.000748***	-0.00194***
	(7.39e-05)	(7.99e-05)	(0.000138)	(0.000143)
Married	-0.00733**	-0.00906***	-0.00484	-0.0458***
	(0.00311)	(0.00327)	(0.00533)	(0.00596)
Log total income	0.000934	0.00122	0.00469**	0.00596**
	(0.00136)	(0.00145)	(0.00232)	(0.00290)
Log spousal income	-0.000260	-0.000392	-9.70e-05	0.00433*
	(0.00124)	(0.00136)	(0.00230)	(0.00262)
Employment status:				
On leave	0.0821***	0.0993***	0.0730*	0.0999***
	(0.0217)	(0.0250)	(0.0379)	(0.0369)
Self-employment	-0.0177	-0.0239	-0.0260	-0.0431
	(0.0184)	(0.0193)	(0.0307)	(0.0326)
Employed	-0.0338**	-0.0400**	-0.0566**	-0.0657**
	(0.0158)	(0.0168)	(0.0263)	(0.0281)
Out of labor force	-0.0595***	-0.0616***	-0.0665**	-0.111***
	(0.0169)	(0.0179)	(0.0285)	(0.0308)
Unemployed	-0.0574***	-0.0588***	-0.0629**	-0.0954***
	(0.0171)	(0.0181)	(0.0288)	(0.0314)
Constant	0.341***	0.251***	0.0191	0.464***
	(0.0639)	(0.0927)	(0.144)	(0.144)
Observations	78,501	67,974	25,909	25,909
R-squared	0.027	0.028	0.029	0.122

Notes: Robust standard errors are in parentheses. They are clustered at the individual level in columns (1) and (2). *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. HS denotes high school. Age is measured as starting from 1 to better capture the nonlinearities occurring from age 25 to 45. Employment status reference category is "in school". All specifications include clinic fixed effect, clinic trends and year fixed effects.

Table 6: Education Gradient in IVF (Live Birth) with Spousal Education Control

	(1)	(2)	(3)	(4)
Treatments:	All	All	First	Last
Seeking pregnancy for:	1st and 2nd child	1st child	1st child	1st child
HS and some college	0.0236***	0.0247***	0.0352***	0.0679***
	(0.00486)	(0.00506)	(0.00829)	(0.00979)
College and higher degree	0.0382***	0.0402***	0.0490***	0.110***
	(0.00530)	(0.00555)	(0.00910)	(0.0106)
Spousal HS and some college	0.0152***	0.0174***	0.0192***	0.0537***
	(0.00435)	(0.00454)	(0.00736)	(0.00852)
Spousal College and higher degree	0.0252***	0.0286***	0.0283***	0.0822***
	(0.00509)	(0.00534)	(0.00870)	(0.00991)
Age	-0.000327	-0.00265*	-0.000461	0.00104
	(0.00138)	(0.00146)	(0.00234)	(0.00254)
Age Square	-0.000739***	-0.000592***	-0.000731***	-0.00190***
	(7.39e-05)	(7.99e-05)	(0.000138)	(0.000143)
Married	-0.00765**	-0.00940***	-0.00505	-0.0468***
	(0.00311)	(0.00327)	(0.00533)	(0.00596)
Log total income	0.000834	0.00114	0.00470**	0.00595**
	(0.00136)	(0.00145)	(0.00232)	(0.00289)
Log spousal income	-0.00116	-0.00145	-0.00106	0.00147
	(0.00126)	(0.00138)	(0.00232)	(0.00264)
Employment status:				
On leave	0.0862***	0.104***	0.0775**	0.111***
	(0.0217)	(0.0250)	(0.0379)	(0.0370)
Self-employment	-0.0150	-0.0205	-0.0233	-0.0351
	(0.0184)	(0.0193)	(0.0307)	(0.0326)
Employed	-0.0306*	-0.0363**	-0.0536**	-0.0564**
	(0.0159)	(0.0168)	(0.0264)	(0.0282)
Out of labor force	-0.0558***	-0.0572***	-0.0625**	-0.0986***
	(0.0169)	(0.0179)	(0.0285)	(0.0308)
Unemployed	-0.0531***	-0.0538***	-0.0586**	-0.0823***
	(0.0171)	(0.0182)	(0.0289)	(0.0314)
Constant	0.339***	0.249***	0.0133	0.448***
	(0.0637)	(0.0921)	(0.145)	(0.142)
Observations	78,501	67,974	25,909	25,909
R-squared	0.027	0.028	0.029	0.124

Notes: Robust standard errors are in parentheses. They are clustered at the individual level in columns (1) and (2). *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. HS denotes high school. Age is measured as starting from 1 to better capture the nonlinearities occurring from age 25 to 45. Employment status reference category is "in school". All specifications include clinic fixed effect, clinic trends and year fixed effects.

Table 7: Education Gradient in IVF (Live Birth): Logit Specification

	(1)	(2)	(3)	(4)
Treatments:	All	All	First	Last
Seeking pregnancy for:	1st and 2nd child	1st child	1st child	1st child
HS and some college	0.0256***	0.0271***	0.0370***	0.0766***
	(0.00478)	(0.00495)	(0.00806)	(0.00967)
College and higher degree	0.0443***	0.0470***	0.0546***	0.131***
	(0.00509)	(0.00532)	(0.00869)	(0.0102)
Age	0.00642***	0.00478***	0.00593**	0.00873***
	(0.00152)	(0.00162)	(0.00261)	(0.00289)
Age Square	-0.00124***	-0.00116***	-0.00127***	-0.00238***
	(9.38e-05)	(0.000103)	(0.000175)	(0.000174)
Married	-0.00732**	-0.00920***	-0.00467	-0.0464***
	(0.00309)	(0.00324)	(0.00530)	(0.00597)
Log total income	0.00131	0.00161	0.00555*	0.00630**
	(0.00162)	(0.00175)	(0.00304)	(0.00309)
Log spousal income	-0.000310	-0.000471	-0.000238	0.00394
	(0.00135)	(0.00147)	(0.00248)	(0.00269)
Employment status:				
On leave	0.0683***	0.0807***	0.0615*	0.105***
	(0.0179)	(0.0199)	(0.0315)	(0.0403)
Self-employment	-0.0154	-0.0206	-0.0227	-0.0466
	(0.0168)	(0.0174)	(0.0279)	(0.0341)
Employed	-0.0327**	-0.0376***	-0.0537**	-0.0709**
	(0.0140)	(0.0145)	(0.0231)	(0.0296)
Out of labor force	-0.0613***	-0.0616***	-0.0659**	-0.117***
	(0.0157)	(0.0163)	(0.0262)	(0.0321)
Unemployed	-0.0580***	-0.0572***	-0.0606**	-0.102***
	(0.0157)	(0.0164)	(0.0263)	(0.0326)
Observations	78,501	67,974	25,903	25,909
Pseudo R-squared	0.0269	0.0277	0.0253	0.0906

Notes: The partial effects are evaluated at the mean. Robust standard errors are in parentheses. They are clustered at the individual level in columns (1) and (2). *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. HS denotes high school. Age is measured as starting from 1 to better capture the nonlinearities occurring from age 25 to 45. Employment status reference category is "in school". Logit specifications include clinic fixed effect and year fixed effects.

Table 8: Education Gradient in IVF (Live Birth) upon Embryo Implantation

	(1)	(2)	(3)	(4)	(5)
Treatments with Embryo Implantation:	All	First	First	Last	Last
HS and some college	0.0282***	0.0377***	0.0348***	0.0770***	0.0703***
	(0.00567)	(0.00894)	(0.00910)	(0.0115)	(0.0118)
College and higher degree	0.0485***	0.0571***	0.0553***	0.131***	0.129***
	(0.00595)	(0.00950)	(0.00966)	(0.0120)	(0.0123)
Age	0.0002	0.0008	-2.78e-05	0.0085***	0.0079***
	(0.00159)	(0.00251)	(0.00257)	(0.00286)	(0.00295)
Age square_sq	-0.0008***	-0.0009***	-0.0009***	-0.0022***	-0.0022***
	(8.57e-05)	(0.000148)	(0.000152)	(0.000166)	(0.000172)
Married	-0.0084**	-0.0035	-0.0025	-0.0377***	-0.0305***
	(0.00358)	(0.00569)	(0.00577)	(0.00676)	(0.00691)
Log total income	0.0009	0.0040	0.0042	0.0082**	0.0059*
	(0.00158)	(0.00263)	(0.00269)	(0.00338)	(0.00353)
Log spousal income	-0.0002	0.0003	0.0007	0.0063**	0.0064**
	(0.00141)	(0.00242)	(0.00244)	(0.00294)	(0.00302)
Employment status:					
On leave	0.0969***	0.101***	0.110***	0.104***	0.0972**
	(0.0240)	(0.0393)	(0.0404)	(0.0401)	(0.0412)
Self-employment	-0.0124	-0.0138	-0.0215	-0.0406	-0.0622
	(0.0206)	(0.0317)	(0.0321)	(0.0362)	(0.0378)
Employed	-0.0288	-0.0411	-0.0419	-0.0559*	-0.0720**
	(0.0176)	(0.0270)	(0.0274)	(0.0307)	(0.0322)
Out of labor force	-0.0534***	-0.0553*	-0.0527*	-0.0825**	-0.0951***
	(0.0190)	(0.0294)	(0.0299)	(0.0342)	(0.0358)
Unemployed	-0.0535***	-0.0518*	-0.0493	-0.0852**	-0.102***
	(0.0192)	(0.0299)	(0.0304)	(0.0347)	(0.0361)
Two embryos implanted			0.112***		0.154***
			(0.00637)		(0.00872)
Three (or more) embryos implanted			0.127***		0.0894***
			(0.0181)		(0.0192)
Constant	0.385***	0.0279	-0.00282	0.538***	0.643**
	(0.0725)	(0.143)	(0.157)	(0.194)	(0.297)
Observations	66,614	24,935	24,209	19,449	17,707
R-squared	0.028	0.032	0.044	0.121	0.146

Notes: Robust standard errors are in parentheses. They are clustered at the individual level in Column (1). *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. HS denotes high school. All specifications include clinic fixed effect, clinic trends and year fixed effects. Our sample consists of the treatments reaching the embryo implantation stage (first child). The sample size in column (3) is slightly smaller than in column (2) because the number of embryos is missing in some treatments.

Table 9: Education Gradient in IVF (Live Birth) Conditional on Health Status and Behavior

	(1) All years	(2) 2006-2009	(3) 2006-2009	(4) 2006-2009
HS and some college	0.0449***	0.0593***	0.0534***	0.0569***
	(0.00815)	(0.0176)	(0.0178)	(0.0178)
College and higher degree	0.0663***	0.0872***	0.0750***	0.0810***
	(0.00870)	(0.0179)	(0.0183)	(0.0183)
Infertility causes:				
Cervical defect	-0.0152	-0.00391	-0.00212	-0.00326
	(0.0207)	(0.0255)	(0.0253)	(0.0253)
Ovulation defect	-0.0182*	-0.0234	-0.0212	-0.0255
	(0.00973)	(0.0276)	(0.0278)	(0.0281)
Fallopian Tube defect	-0.0253***	-0.0458	-0.0418	-0.0438
	(0.00915)	(0.0334)	(0.0335)	(0.0336)
Male causes	-0.00519	0.00115	0.00961	0.0106
	(0.00746)	(0.0120)	(0.0121)	(0.0121)
Other causes	-0.0314***	-0.0327	-0.0342	-0.0375
	(0.00911)	(0.0296)	(0.0297)	(0.0299)
Unspecified causes	-0.0150	-0.0257	-0.0330	-0.0374
	(0.0101)	(0.0339)	(0.0340)	(0.0342)
Cigarettes smoked per day:				
$\#$ of cigarettes $= 0$			0.0507**	0.0477*
			(0.0242)	(0.0244)
$1 \leq \#$ of cigarettes ≤ 5			0.0119	0.0133
			(0.0320)	(0.0320)
$6 \leq \#$ of cigarettes ≤ 10 ,			0	0
			(7.20e-09)	(6.65e-09)
Alcohol consumption per week:				
$\#$ of unit $= 0$				0.0623***
				(0.0214)
$1 \leq \#$ of unit ≤ 3			0.0216	
				(0.0211)
$4 \leq \#$ of unit ≤ 5				0.0274
				(0.0257)
BMI<20			0.0726***	0.0781***
			(0.0217)	(0.0217)
$20 \leq$ BMI≤ 25			0.0328*	0.0394**
			(0.0168)	(0.0170)
$25 \leq$ BMI≤ 30			0.0113	0.0171
			(0.0182)	(0.0183)
Average number of GP services	0.00951***	-0.00466**	-0.00481***	-0.00471***
	(0.00108)	(0.00182)	(0.00181)	(0.00180)
Average cost of GP services	-4.20e-05***	4.48e-05**	4.81e-05**	4.54e-05**
	(1.33e-05)	(2.10e-05)	(2.09e-05)	(2.09e-05)
Constant	-0.00233	-1.315	-1.255	-1.206
	(0.147)	(0.846)	(0.892)	(0.915)
Past Disease(s)	Yes	Yes	Yes	Yes
Observations	25,909	7,544	7,544	7,544
R-squared	0.039	0.036	0.043	0.045

Notes: Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. All specifications include the controls, clinic fixed effect, clinic trends and year fixed effects of the baseline specification. General practitioner (GP) services (e.g., consultation, blood test, vaccination, etc.) and diseases (see Table 3 for a classification of diagnosis) are recorded the year prior to treatment. Reference group for cigarettes is more than 10, reference group for alcohol consumption is more than 5, reference group for BMI is above 30. Estimates for missing values of cigarettes, alcohol and BMI are suppressed. Our sample consists of the first treatments of first child.

Table 10: Education Gradient in IVF (Live Birth): Different Specifications of Education

	(1)	(2)	(3)	(4)
Education Specification:	6 Categories	Linear	6 Categories	Linear
Conditional on embryo transfer:	No	No	Yes	Yes
High School	0.0528***		0.0513***	
	(0.0115)		(0.0131)	
Vocational School	0.0407***		0.0411***	
	(0.00850)		(0.00993)	
2 years College	0.0576***		0.0544***	
	(0.0126)		(0.0141)	
Bachelor	0.0639***		0.0647***	
	(0.00912)		(0.0105)	
Master or PhD	0.0736***		0.0732***	
	(0.0109)		(0.0123)	
Years of Education		0.00800***		0.00807***
		(0.00117)		(0.00132)
Age	0.000211	0.000235	0.000173	0.000190
	(0.00234)	(0.00234)	(0.00261)	(0.00261)
Age Squared	-0.000737***	-0.000733***	-0.000783***	-0.000777***
	(0.000138)	(0.000138)	(0.000153)	(0.000153)
Married	-0.00315	-0.00274	-0.00233	-0.00194
	(0.00532)	(0.00532)	(0.00595)	(0.00594)
Log Total Income	0.00411*	0.00403*	0.00530**	0.00520**
	(0.00236)	(0.00235)	(0.00266)	(0.00265)
Log spousal Income	-0.000513	-0.000410	-0.000124	-3.26e-05
	(0.00228)	(0.00228)	(0.00243)	(0.00244)
Employmnet Status	Yes	Yes	Yes	Yes
GP Services	Yes	Yes	Yes	Yes
Infertility Causes	Yes	Yes	Yes	Yes
Past Disease(s)	Yes	Yes	Yes	Yes
Clinic FE and Trends	Yes	Yes	Yes	Yes
Constant	0.00230	-0.0610	0.0525	-0.00990
	(0.147)	(0.147)	(0.149)	(0.149)
Observations	25,909	25,909	22,472	22,472
R-squared	0.039	0.039	0.046	0.045

Notes: Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. Age is measured as starting from 1 to better capture the non linearities occurring from age 25 to 45. Observations in Columns (3) and (4) are treatments that reached the embryo implantation stage. Our sample is restricted to 1st child and 1st treatment.

Table 11: Education Gradient in IVF (Live Birth): Conditional on Free Quota Eligibility

(a) First Child (Any Sector)

	(1)	(2)	(3)
Treatments	All	First	Last
Seeking pregnancy for:	1st child	1st child	1st child
HS and some college	0.0339***	0.0465***	0.0681***
	(0.00547)	(0.00835)	(0.00961)
College and higher degree	0.0579***	0.0675***	0.114***
	(0.00588)	(0.00901)	(0.0101)
Observations	57,172	25,155	26,322

(b) First Versus Second Pregnancy (Any Sector)

	(1)	(2)	(3)	(4)
Treatments	All	All	First	First
Seeking pregnancy for:	1st child	2nd child	1st child	2nd child
HS and some college	0.0548***	0.0166	0.0534***	0.0208
	(0.0181)	(0.0184)	(0.0300)	(0.0248)
College and higher degree	0.0471**	0.0180	0.0522*	0.0190
	(0.0189)	(0.0189)	(0.0317)	(0.0259)
Observations	6,229	7,815	3,399	3,399

Notes: Robust standard error, clustered at the individual level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. HS denotes high school. The specification uses socio-econ characteristics and health controls as in previous Table 9, column 1, including the clinic fixed effect, clinic trends and year fixed effects. Column (1) in Panel (B) refers to treatments of patient-couples who are eventually successful with their first child in any sector before exceeding their first three free attempts and whom we later observe attempting a second IVF child.

Online Appendix

A The IVF Procedure

The IVF procedure that women have to go through generally involves three phases. The first phase is the diagnosis of why the couple is infertile, which involves an analysis of the sperm quality and female fertility. All women who are in our sample of IVF-treated women have undergone the clarification procedure.

The second phase is strict and complex. It consists of the aspiration of oocytes (egg retrieval), the insemination, and the embryo transfer. This involves both medical interventions and patient's strict adherence to treatment. We can break this phase into six consecutive steps (Dansk Fertilitetsklinik, 2016).[27] In a first step, the patient will start a down-regulation of follicle stimulation hormones (FSH) two weeks prior to the ovarian stimulation process. The down-regulation improves the control on the future ovarian stimulation (e.g., prevents premature ovulation) and requires the application of two different nose sprays. One of the sprays needs to be applied twice per day and one four times per day.[28] The second step is the ovarian stimulation process that starts with the menstrual period. This process refers to hormone stimulation with FSH through daily injections that must be taken at the same time every evening. During this process nasal sprays are applied the same number of times (four) per day, though in less quantity. Ovarian stimulation is monitored with regular (three-to-five) blood and ultrasound tests.[29] The third step consists of an injection to release the eggs around ten days after the stimulation begins. This injection releases the eggs precisely forty hours after its application. It is very important that the patient manages to follow procedure and takes the injection at the time determined by the doctor. The fourth step is the egg retreival, and it is performed by doctors. The fifth step is insemination. This is a purely medical procedure without patient involment which may lead to at least one healthy embryo to be transferred on the basis of the morphological grading of the embryos.[30] The sixth step is the embryo transfer, which takes place approximately two-three days after the eggs retrieval, if there were healthy embryos to implant. Doctors assess the quality of the embryos on the basis of some aspects of their microscopic appearance: Cell number, cell regularity, degree of fragmentation, granularity, etc.

The third phase spans from the embryo transfer to the potential birth of the child. In the two weeks following the transfer, patients must place one tablet three times a day, or apply a gel twice daily, in the vigina to ensure the mucosa matures correctly, and then take a pregnancy test. Patient must then follow a standard healthy life style condusive to a succesful pregnancy.

[27] The second phase of the IVF procedure can either be "long" or "short". For concreteness, we focus on the description of the "long" procedure with six steps that embeds the "short" one. We follow the description provided by the oldest fertility clinics in Denmark (Dansk Fertilitetsklinik, 2016).

[28] Alternatively, the patient injects herself with one daily Lupron injection in the belly at night.

[29] The last day of stimulation, FSH injections are complemented with a human chorionic gonadotropin (HCG) injection to support the normal development of an egg in a woman's ovary.

[30] Blastocyst culture helps select the best quality embryos for transfer and reduces multiple pregnancy risks.

Table A-1: Education Gradient in IVF (Live Birth) without Clinic FE and Clinic trends

	(1)	(2)	(3)
Treatments:	All	First	Last
Seeking pregnancy for:	1st and 2nd child	1st child	1st child
HS and some college	0.0266***	0.0366***	0.0781***
	(0.00483)	(0.00817)	(0.00974)
College and higher degree	0.0461***	0.0530***	0.136***
	(0.00507)	(0.00864)	(0.0102)
Age	-0.000628	-0.000511	0.00185
	(0.00138)	(0.00225)	(0.00251)
Age square	-0.000701***	-0.000780***	-0.00198***
	(7.25e-05)	(0.000127)	(0.000138)
Married	-0.00613**	-0.00658	-0.0474***
	(0.00310)	(0.00533)	(0.00598)
Log total income 0	0.000981	0.00427*	0.00579**
	(0.00138)	(0.00232)	(0.00292)
Log spousal income	-0.000323	-0.000952	0.00303
	(0.00126)	(0.00229)	(0.00261)
Employment status:			
On leave	0.0866***	0.0774**	0.0963***
	(0.0217)	(0.0377)	(0.0371)
Self-employment	-0.0145	-0.0211	-0.0451
	(0.0185)	(0.0306)	(0.0328)
Employed	-0.0319**	-0.0508*	-0.0711**
	(0.0160)	(0.0262)	(0.0282)
Out of labor force	-0.0582***	-0.0633**	-0.122***
	(0.0170)	(0.0283)	(0.0309)
Unemployed	-0.0552***	-0.0590**	-0.103***
	(0.0172)	(0.0287)	(0.0315)
Constant	0.264***	0.269***	0.684***
	(0.0275)	(0.0459)	(0.0542)
Observations	78,501	25,909	25,909
R-squared	0.018	0.018	0.107

Notes: Robust standard errors are in parentheses. They are clustered at the individual level in Column (1). *** p<0.01, ** p<0.05, * p<0.1. HS denotes high school. Age is measured as starting from 1 to better capture the nonlinearities occurring from age 25 to 45. Employment status reference category is "in school". Specification includes year fixed effects.

Table A-2: Education Gradient in IVF (Live Birth) conditional on Health Status and Behaviors (All Treatments)

	(1) All years	(2) 2006-2009	(3) 2006-2009	(4) 2006-2009
HS and some college	0.0328***	0.0324***	0.0289***	0.0306***
	(0.00481)	(0.0100)	(0.0101)	(0.0102)
College and higher degree	0.0549***	0.0587***	0.0522***	0.0557***
	(0.00507)	(0.0102)	(0.0104)	(0.0105)
Average number of GP services	0.00986***	-0.00243**	-0.00248**	-0.00246**
	(0.000728)	(0.00101)	(0.00101)	(0.00101)
Average cost of GP services	-4.27e-05***	3.29e-05***	3.41e-05***	3.32e-05***
	(8.60e-06)	(1.15e-05)	(1.16e-05)	(1.16e-05)
Infertility causes:				
Ovulation defect	0.00534	-0.0178	-0.0144	-0.0146
	(0.00584)	(0.0177)	(0.0178)	(0.0177)
Fallopian Tube defect	-0.00198	-0.0430**	-0.0384*	-0.0387*
	(0.00528)	(0.0203)	(0.0203)	(0.0202)
Cervical defect	0.00529	-0.0150	-0.0127	-0.0131
	(0.0130)	(0.0154)	(0.0154)	(0.0154)
Male causes	0.0252***	0.0151**	0.0188***	0.0193***
	(0.00416)	(0.00705)	(0.00707)	(0.00707)
Other causes	-0.0449***	-0.0308*	-0.0296	-0.0303
	(0.00498)	(0.0186)	(0.0186)	(0.0186)
Unspecified causes	-0.00276	-0.0518**	-0.0520**	-0.0528**
	(0.00602)	(0.0207)	(0.0207)	(0.0207)
Cigarettes smoked per day:				
$\#$ of cigarettes $= 0$			0.0222	0.0211
			(0.0139)	(0.0140)
$1 \leq \#$ of cigarettes ≤ 5			0.00660	0.00832
			(0.0183)	(0.0184)
Alcohol consumption per week:				
$\#$ of unit $= 0$				0.0285**
				(0.0114)
$1 \leq \#$ of unit ≤ 3				0.0115
				(0.0113)
$4 \leq \#$ of unit ≤ 5				0.00483
				(0.0136)
BMI<20			0.0419***	0.0441***
			(0.0123)	(0.0123)
$20 \leq$ BMI≤ 25			0.0270***	0.0303***
			(0.00953)	(0.00957)
$25 \leq$ BMI≤ 30			0.0120	0.0153
			(0.0102)	(0.0103)
Past Disease(s)	Yes	Yes	Yes	Yes
Constant	0.283***	0.617*	0.695*	0.705*
	(0.0652)	(0.372)	(0.386)	(0.388)
Observations	78,501	23,860	23,860	23,860
R-squared	0.042	0.037	0.040	0.041

Notes: Robust standard error clustered at the individual level are in parentheses. *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. The sample includes all treatments seeking both first and second child. See Table 9 for the description of the specifications and variables included.