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Patient education and the impact of new medical research

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ABSTRACT

We examine the impact that medical research published in peer-reviewed journals has on the practice of medicine. We exploit the release of a recent *New England Journal of Medicine* article which demonstrated that the risks of attempting a vaginal birth after having a previous C-section birth (VBAC) were higher than previously thought. We find that immediately following this article, the national VBAC rate dropped by 16% and this change was largest among more educated mothers, particularly those with a graduate degree.

1. Introduction

Consumers have access to a number of information sources when making medical decisions. These sources include physician or hospital medical report cards, direct-to-consumer advertisements, warning labels placed on medications, FDA drug withdrawals, and medical studies. Vast sums of public money are spent on medical research that produces new medical information, as well as on the collection and dissemination of quality reports about health care providers to the public. In theory, providing more information will allow patients to receive the most appropriate and cost-effective treatment. However, we do not adequately understand how new medical research affects medical decisions (Phelps, 1992; Lee et al., 1995; Weingarten, 1997).

Past economic studies find some evidence that people are responsive to new information when making medical decisions. Azoulay (2002) finds that the sales of prescription drugs increase in response to both new scientific evidence and increased marketing. Pope (2006) finds that non-emergency patients are more likely to attend hospitals that receive a higher ranking in US News and World Report, and Cutler et al. (2004) find that hospital patient volume responds to medical report cards. Wosinska (2005) finds that DTC advertising of prescription drugs increases compliance with drug therapy and Avery et al. (2007) find that DTC advertising of nicotine replacement therapies leads to more smokers seeking to quit, sometimes even without the use of advertised pharmacotherapies.

It is surprising that we do not adequately understand how information from new medical studies affects medical decisions since so much public funding and human effort is devoted to providing this type of information. For example, there are 5000 medical journals indexed on Medline. Many of the published studies involve decisions between two treatments that are already available, often at the same cost. If one treatment is objectively better and information can lead people to the appropriate treatment, this could lead to an increase in healthy outcomes with little additional cost to society.

Most of the small body of economic studies that look at consumer response to new medical information have not examined whether the response differs by education. Exceptions include Lleras-Muney and Lichtenberg (2006), who find an education gradient in how quickly people use a drug after it has been approved by the FDA, and Mathios (2000) who finds no relationship between the drop in demand for salad dressings with higher fat content in response to federal law requiring nutritional labels and the average education of the customers at a given store location.

We examine the response to medical findings published in July 2001 in the *New England Journal of Medicine* (Lydon-Rochelle et al., 2001) that found an increased risk of having a vaginal birth after a caesarean (VBAC). The article was reported by National Public Radio

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on July 3, 2001, and was carried by newspapers across the country under the headline "Labor Risky after Cesarean." Using US birth certificate data, we find that in a three-month period following the release of the article, the national VBAC rate dropped by 16% (from 19% of those with prior caesarean deliveries giving birth vaginally for their current birth, to 15.9%). In several states, the VBAC rate dropped over 30%. This change was largest among younger and more educated mothers. The NEJM article also indicated that VBACs were particularly risky if the labor was induced. We find similar large drops in the probability that women with previous C-sections had their labor induced, with the largest change again concentrated among younger and more educated mothers.

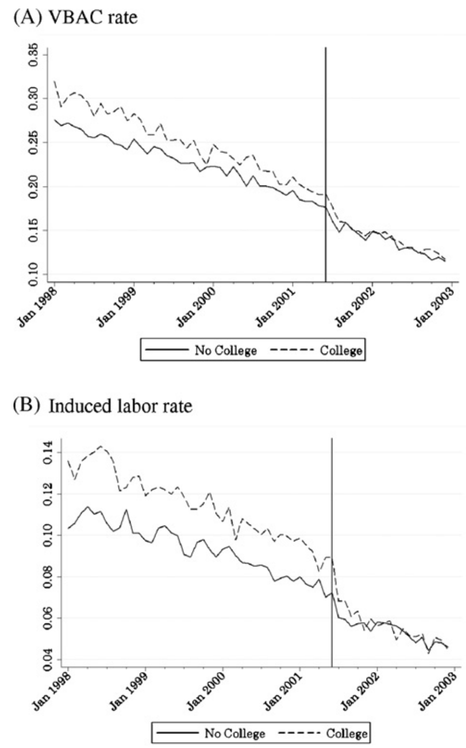
2. VBACs in the US

In 2000, 22.9% of all births in the US were caesarean section (C-section). Among those births to mothers who have had a prior C-section, 79.4% will be delivered by C-section. In fact, until the development of the low traverse incision in the 1970s, the US medical profession adopted a policy that all women who had experienced a previous caesarean would automatically receive a caesarean for all subsequent births. In layman's terms, this policy came to be known by the mantra "once a caesarean, always a caesarean." In 1981, the national VBAC rate was only 3% (Harer, 2002).

The major concern with allowing women with a previous C-section to attempt a VBAC is the increased risk that the uterus will rupture near the scar site of the incision. In the event of a uterine rupture, the baby must be delivered immediately by C-section. If not, the rupture cuts off the blood supply to the baby and can potentially kill the mother if the bleeding is not stopped. There is also some concern that if the uterus cannot be properly repaired, the mother will require a hysterectomy (thus preventing future births). From a policy perspective, one concern about the rise in the caesarean rate is the additional healthcare costs that it involves. Keeler and Brodie (1993) found that in 1989, the physician's charge alone was on average $500 more to perform a C-section than a vaginal birth. Gruber et al. (1999) find that this difference depends on the patient's insurance status, with physicians receiving $561 more to perform a C-section for patients with private insurance and only $127 more for patients with Medicaid.

These types of cost savings led many managed healthcare organizations in the 1990s to adopt pro-VBAC practices. In 1995, the American College of Obstetricians and Gynecologists (ACOG) released guidelines that suggested that women with only one previous C-section who had a lower transverse uterine incision should be encouraged to have a VBAC. As a result the VBAC rate reached its highest point of 28.3% in 1996 (Menacker and Curtin, 2001). In 1993, Los Angles County University of Southern California Medical Center adopted a policy that any mother who had the low-risk factors mentioned in the ACOG guidelines would have to have a VBAC. This policy led to 49 lawsuits and a payout of $24 million by 1997 with millions more expected to be paid from cases in which the baby died during the procedure (Harer, 2002). These types of legal concerns led to a steady decline in the VBAC rate starting in 1997.

The downward trend in VBAC rates since 2000 is shown in Panel A of Fig. 1, which plots the rate in monthly increments for the years 2000–2002, separately for women with at least a four-year college degree ("college") and those without any college education ("no college"). Over this period, the VBAC rate dropped from around 23% in January 2000 to 12% in December 2002, a 48% decrease. Fig. 1 also shows that the VBAC rate had been traditionally higher among college-educated women than among women with no college education until July 2001, at which point both rates declined



Source: National Center for Health Statistics (2000-2002). The sample consists of women who completed a college degree ("college") and women with no more than a high school diploma ("no college"). We omit all of the mothers with just some college education to provide a clearer contrast.

Fig. 1. National VBAC rate and induced labor rate by education level of mother (A) VBAC rate and (B) induced labor rate.

sharply and converged. The VBAC rate decreased more sharply among college-educated mothers than among mothers without a college degree. Panel B in Fig. 1 shows a similar pattern for whether the mother had her labor artificially induced, though the educational gaps before July 2001 were much larger.

The major drop in the VBAC rate directly followed the release of a *New England of Medicine* article in July 2001 (Lydon-Rochelle et al., 2001), showing that mothers with a previous C-section were more likely to experience a uterine rupture if they attempted a trial of labor (0.58%) than if they had an elective repeat C-section (0.16%). The article also indicated that mothers who had their labor induced were even more likely to experience a uterine rupture (0.77%), especially if they were induced with the hormone prostlandins (2.45%). We use the change in the VBAC rate following the publication of this article to examine how the impact of new medical research differs according to the education of the patient.

In 2002, an additional article published in the *Journal of the American Medical Association* by Smith et al. (2002) came to similar conclusions as the July 2001 article about the relative risk of attempting a trial of labor. While not the focus of this paper, one of our additional checks examines the impact of this second article.

3. Conceptual framework and testable hypotheses

We motivate our analysis of the differences in response by socioeconomic status with a simple conceptual discussion. We assume that patients and physicians jointly decide on the method of child delivery (although our study will not be able to distinguish the patient response from a physician response as we only observe the outcome of the joint decision), taking into consideration the costs and benefits of each procedure. Patients and physicians may have preferences (practice patterns) that are formed over time, but are updated in response to new information. As with other medical news, we expect that the response to Lydon-Rochelle et al. (2001) will vary based on many factors, including the strength of prior preferences on the part of the decision makers, the pressures of insurers, and peer group effects. A full investigation of these competing response pathways would require richer data than birth certificates contain. However, economic theory suggests that socioeconomic distinctions, such as educational attainment, may also influence health behavior. Grossman (1972) asserts that education may have an allocative effect on health production partly through the incorporation of information.

Grossman's theory has been tested in a number of studies that find evidence to support it. For example, Lleras-Muney and Lichtenberg (2006) find that more highly educated people are quicker to adopt drugs recently approved by the FDA. This finding holds, after controlling for the income and insurance status of the individual, thus netting out the indirect effects of education through increased access (something which we also do by looking at a low cost decision, such as having labor induced). They support their findings with survey data from the National Science Foundation, showing that people with a college degree were more likely to understand the nature of scientific inquiry, and they were more likely to state that they were interested and well-informed about new medical discoveries. In a similar vein, we hypothesize that those with more education could incorporate new medical information more quickly in child birth decisions. As earlier noted, our methodology is unable to discern whether this occurs through the mother's direct absorption of new medical research via media or other informational channels, through the sorting to providers who are more informed about new medical information or more willing to adjust their practices, or if the change comes through other mechanisms. In each of these plausible circumstances, education plays an allocative role in improving health, an issue to which we return in the discussion.

We test our hypothesis that better educated patients will more quickly be affected by new medical information by comparing the VBAC and induced labor rates before and after the release of the NEJM article, comparing women of higher and lower education levels, controlling for other individual characteristics that are determinants of birth procedures. Specifically, we estimate equations of the following form:

$$P(Y_i = 1) = \beta_0 + \beta_1 \cdot \text{post}_i + \beta_2 \cdot \text{education}_i + \beta_3 \cdot \text{education}_i \cdot \text{post}_i + X_{i\cdot\gamma} + e_i$$

Y is an indicator for whether the mother experienced a VBAC (or alternatively had her labor induced), among those women who have had a prior C-section and thus are candidates for a VBAC. Post refers to births occurring in the three-month period following the Lydon-Rochelle et al. (2001) article with the omitted category being those births during the three-month period prior to the release of the article (we exclude those births that occurred in July 2001, since the article was released mid-month).

This specification assumes that there was no knowledge of the article prior to July 2001. If information about the findings of the NEJM article had been circulating prior to the publication of the article, then our analysis would offer a conservative estimate of the effect. The NEJM, however, restricts media subscribers from reporting on upcoming articles from the journal until the day before the publication of the article. Media subscribers who break the embargo risk losing advanced access to NEJM research in the future.[1]

Education is measured as a set of four indicators (with less than high school degree being the omitted group) and X is a set of our covariates, including state or county fixed effects. X also includes an interaction between the post-period and all other maternal characteristics (excluding the medical risk factors), allowing those characteristics to have different influences on birth procedures over time. The key estimate of interest is β_3, which shows whether the impact of the article on higher educated mothers' differs from the impact on lower educated mothers.

All of the results presented in our tables are based on a linear probability model. We have also run our models using a fixed effect logit specification, though as Ai and Norton (2003) point out, the interpretation of interaction effects in non-linear models can often be misleading. We apply the Ai and Norton (2003) methodology to our fixed effect logit models and find that the educational differences are even larger when using this method. We also run the fixed effect logit specification for each of the education groups separately. This allows the effect of all of the other characteristics including the state fixed effects to vary by education. We find the pattern of the response being larger for more educated mothers to be the same as the linear probability model results that we report.

4. Data

Our analysis uses US Natality Data from the National Vital Statistics System of the National Center for Health Statistics (NCHS). These data comes from birth certificates that are filed with vital statistics offices in each state. We restrict our sample to all full-term births that occurred after 37–43 weeks of gestation (a restriction similar to past studies, e.g. Smith et al., 2002), and to mothers who have had a prior C-section and are thus eligible to attempt a VBAC. We focus on the three-month periods immediately before and after July 2001. Our sample contains 82,432 births to mothers with previous C-sections in the pre-period (April–June) and 87,811 in the post-period (August–October).

Table 1 provides the full set of controls used in our analysis, along with basic summary statistics for both the pre- and post-periods. Maternal education is reported in 17 categories on the natality files, which we collapse down to five groups: less than high school degree, high school degree, some college, four-year college degree, and graduate-school degree. We divide the mothers into four groups based on their race/ethnicity: non-Hispanic white, black, Hispanic, and other race. We include controls for the mother's age (in years), the birth order of the child (linear), binary indicators for whether the mother is married and whether it is a plural birth (i.e. twins, triplets, etc.). We also include controls for the 16 medical risk factors recorded in the natality data, such as whether the mother has diabetes or chronic hypertension (both of which are associated with lower VBAC rates).

The second two columns in Table 1 provide the probability of a VBAC among particular subgroups. For example, it is very unlikely (only a 4–5% chance) that a mother with a plural birth will have a VBAC, but more likely (28–31%) for a woman who has had a previous pre-term or small-for-gestation baby. Table 2 expands on the differences by education in the pre- and post- periods and provides some initial descriptive analysis of the changes that occurred in the VBAC and induced labor rates for each of the education groups between the pre- and post- periods. In the pre-period there is a

[1] The lead author of the NEJM article told us that the research was presented at a few conferences prior to the release of the NEJM article, though these presentations were to a public health audience and not clinicians.

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Table 1
Summary statistics of mother's characteristics for three months before and after July 2001.

Characteristics	Mean [SD]		P (VBAC|characteristic = 1)	
	Pre	Post	Pre	Post
Education				
High school drop-out	0.169	0.182	0.199	0.178
High school degree	0.312	0.321	0.178	0.151
Some college	0.242	0.235	0.181	0.150
Four year college degree	0.170	0.163	0.199	0.167
Graduate degree	0.106	0.099	0.197	0.154
Age	30.04 [5.58]	30.03 [5.64]		
Married	0.761	0.751	0.188	0.158
Birth order	2.65 [0.94]	2.67 [0.95]		
Plural birth	0.019	0.020	0.051	0.043
Race				
White	0.627	0.601	0.195	0.160
Black	0.141	0.147	0.180	0.162
Hispanic	0.182	0.199	0.168	0.147
Other race	0.050	0.053	0.196	0.179
Risk factor				
Cardiac disease	0.007	0.007	0.235	0.180
Lung disease	0.014	0.014	0.239	0.187
Diabetes	0.050	0.051	0.142	0.107
Genital herpes	0.011	0.011	0.231	0.177
Hydramnios	0.012	0.010	0.213	0.172
Hemoglobinopathy	0.001	0.001	0.188	0.162
Chronic hypertension	0.012	0.011	0.135	0.104
Pregnancy-associated hypertension	0.028	0.025	0.162	0.122
Eclampsia	0.002	0.002	0.146	0.155
Incomplete cervix	0.003	0.003	0.189	0.182
Previous infant of 4000+ g	0.026	0.026	0.234	0.205
Previous preterm or small-for-gestation baby	0.023	0.022	0.319	0.284
Renal disease	0.003	0.003	0.229	0.218
Rh sensitization	0.007	0.007	0.213	0.163
Uterine bleeding	0.005	0.005	0.236	0.151
N	82,432	87,811		

Note: Sample includes all births in the US for April–June and August–October 2001 to mothers with a previous C-section.

U-shaped pattern between education and the VBAC rate of mothers without a high school degree are most likely to have a VBAC, mothers with some college are least likely to have a VBAC, but only slightly less than mothers who have completed college. However, the lower educated women are also less likely to receive any type of specific medical intervention in labor. The second panel in Table 2 shows that less educated women are much less likely to have their labor induced.

When we look at the changes in these rates between the pre- and post-period, we find that the largest changes (both in absolute terms and in percentage change) occurred among the mothers with the highest level of education. The changes were particularly high for the set of women with a graduate degree, who saw a 22% drop in the VBAC rate and a 28% drop in the rate of induced labor. The corresponding changes for women with less than a high school degree were only 11% and 16%.

Table 2
VBAC and labor induction rates for three months before and after July 2001.

	N	Pre	Post	Change	%Change	*t*-Stat
(A) VBAC						
Graduate school	17,383	0.1972	0.1545	−0.0427	−0.2165	7.40
College degree	28,377	0.1991	0.1674	−0.0317	−0.1592	6.92
Some college	40,632	0.1814	0.1504	−0.031	−0.1709	8.40
HS degree	53,924	0.1782	0.1508	−0.0274	−0.1538	8.59
Drop-out	29,927	0.1993	0.1775	−0.0218	−0.1094	4.81
Overall	170,243	0.1910	0.1601	−0.0309	−0.1620	16.07
(B) Labor was induced						
Graduate school	17,383	0.0861	0.0618	−0.0243	−0.2822	6.13
College degree	28,377	0.0897	0.0675	−0.0222	−0.2475	6.93
Some college	40,632	0.0903	0.0699	−0.0204	−0.2259	7.60
HS degree	53,924	0.0808	0.0616	−0.0192	−0.2376	8.69
Drop-out	29,927	0.0685	0.0577	−0.0108	−0.1577	3.86
Overall	170,243	0.0831	0.0637	−0.0194	−0.2302	15.28

Notes: The pre and post-period each refer to the three-month window before and after July 2001, the date of publication of Lydon-Rochelle et al. (2001). The sample consists of all US births during these two periods to mothers with a previous C-section.

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Table 3
Response of VBAC and labor induction rates to Lydon-Rochelle et al. (2001).

	VBAC		Induced labor	
Post	−0.0557***	−0.0581***	−0.0304***	−0.0425***
	[0.0103]	[0.0131]	[0.0082]	[0.0096]
Post·HS degree	−0.0085	−0.0116*	−0.0097**	−0.0105**
	[0.0054]	[0.0062]	[0.0042]	[0.0044]
Post·some college	−0.0139**	−0.0136*	−0.0113**	−0.0109**
	[0.0063]	[0.0072]	[0.0048]	[0.0050]
Post·college degree	−0.0169**	−0.0186**	−0.0145***	−0.0145**
	[0.0072]	[0.0078]	[0.0053]	[0.0057]
Post·graduate school	−0.0270***	−0.0249***	−0.0174***	−0.0169***
	[0.0078]	[0.0090]	[0.0051]	[0.0057]
Post·age	0.0013***	0.0012***	0.0006**	0.0008***
	[0.0004]	[0.0004]	[0.0003]	[0.0003]
Post·married	0.0014	0.0021	0.0021	0.0017
	[0.0049]	[0.0054]	[0.0029]	[0.0036]
Post·order	−0.0021	−0.0011	0.0003	0.0025
	[0.0023]	[0.0027]	[0.0013]	[0.0017]
Post·plural birth	0.0179**	0.0162	0.0050	0.0077
	[0.0077]	[0.0126]	[0.0101]	[0.0105]
Post·black	0.0190***	0.0177***	0.0045	0.0023
	[0.0046]	[0.0055]	[0.0047]	[0.0052]
Post·hispanic	0.0104	0.0128**	0.0045	0.0048
	[0.0087]	[0.0058]	[0.0037]	[0.0040]
Post·other race	0.0197**	0.0266**	0.0068	0.0089
	[0.0076]	[0.0108]	[0.0062]	[0.0060]
HS degree	−0.0033	−0.0014	0.0089**	0.0099***
	[0.0047]	[0.0053]	[0.0035]	[0.0035]
Some college	0.0116**	0.0101	0.0203***	0.0195***
	[0.0055]	[0.0069]	[0.0047]	[0.0038]
College degree	0.0462***	0.0431***	0.0254***	0.0243***
	[0.0067]	[0.0071]	[0.0054]	[0.0046]
Graduate school	0.0527***	0.0474***	0.0246***	0.0236***
	[0.0072]	[0.0072]	[0.0049]	[0.0046]
Age	−0.0067***	−0.0072***	−0.0021***	−0.0021***
	[0.0005]	[0.0004]	[0.0003]	[0.0002]
Married	0.0140***	0.0112***	0.0044*	0.0049*
	[0.0038]	[0.0043]	[0.0023]	[0.0029]
Order	0.0716***	0.0692***	0.0156***	0.0131***
	[0.0064]	[0.0035]	[0.0023]	[0.0017]
Plural birth	−0.1720***	−0.1670***	−0.0487***	−0.0522***
	[0.0135]	[0.0112]	[0.0072]	[0.0079]
Black	−0.0170***	−0.0193***	−0.0050	−0.0025
	[0.0061]	[0.0059]	[0.0042]	[0.0050]
Hispanic	−0.0097	−0.0055	−0.0208***	−0.0164***
	[0.0093]	[0.0056]	[0.0047]	[0.0035]
Other	0.0201***	0.0167**	−0.0187***	−0.0172***
	[0.0071]	[0.0078]	[0.0052]	[0.0049]
Constant	0.1795***	0.2085***	0.0867***	0.0939***
	[0.0117]	[0.0112]	[0.0059]	[0.0073]
Fixed effects	State	County	State	County
Observations	170,243	133,994	170,243	133,931
R-squared	0.056	0.073	0.029	0.053

Notes: Results displayed are from two linear probability models of the form of Eq. (1). The time period is limited to three months before ("pre") and three months after ("post") Lydon-Rochelle et al. (2001). Standard errors are in brackets. Asterisks (*, **, and ***) indicate significance at the 10%, 5%, and 1% levels, respectively.

The regression analysis in the next section follows this same before-and-after approach, but adjusts the comparisons for the medical risks and county characteristics that may differ across mothers with different levels of education. For example, women with at least a college degree are more likely to have a plural birth (twins or triplets), but less likely to have diabetes or pregnancy-associated hypertension.

5. Results

In Table 3, we present the results from our primary regression specification that tests whether the impact of the release of the new medical research differed by maternal characteristics, such as age, education, race, marital status (a proxy for material well-being), number of previous births, and whether the mother carried multiple fetuses (i.e. twins, triplets, etc.). The time period of the study is limited to three months before and three months after the publication of the study by Lydon-Rochelle et al. (2001), thus capturing the short-term effects. The first column results are from a model that includes state fixed effects to control for the legal climate at the state level that influences the viability of attempting a VBAC (e.g. the prevalence of managed care and differences in Medicaid reimbursement policies for vaginal vs. Cesarean deliveries, as well as medical norms and preferences). The VBAC rate differed widely across states during the pre-period, with some states, such as Vermont, having a VBAC rate of over 40% and other states, such as Nevada, having a VBAC rate of only 15%.

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The second column in Table 3 includes fixed effects for the county in which the mother delivers her baby. This captures differences in the attitudes and practices towards VBACs in a more narrowly defined area than the entire state. Most medical malpractice cases are based on common community practices, so VBAC rates across counties within the same state also vary widely. The county fixed effects also controls for some of underlying unobservable differences in mothers in different counties that might influence their propensity to experience a VBAC. This also captures differences in quality of healthcare between richer and poorer counties. The sample size drops from 170,343 to 133,994 when including county fixed effects, because county identifiers are not reported in natality data for counties with a population less than 100,000. Thus, this also reflects estimates from a more urban population.[2]

As a second-dependent variable, we look at whether labor was induced, which Lydon-Rochelle et al. (2001) found led to the highest medical risk for women with a previous C-section. As Table 2 shows, labor induction occurs at a lower frequency among women with the least education in the pre-2001 period, a pattern that does not generally hold for VBACs. Looking at induced labor provides an example of a low cost medical procedure for which the educational pattern in the pre-period differs from the educational pattern of the VBAC rate in the same period.

The results show that the drop in the VBAC rate was greatest among women with the most education and those who were younger, with some evidence that non-white mothers experienced a smaller response. When using county fixed effects, women with graduate degrees experienced a change in their VBAC rate that is 2.5 percentage points greater than the change among women who did not finish high school. The overall change in the VBAC rate was 3.0 percentage points, highlighting just how large the educational gaps are. Though the changes are of a smaller magnitude, similar patterns exist among women with lower levels of education, with the response following a monotonic pattern in both the likelihood of having a VBAC and of having labor induced.

We also find that younger mothers experienced a larger change in response to the new medical research than their older counterparts. Holding education constant, an age gap of 21 years leads to a difference in the VBAC rate equivalent to the gap between a mother with a graduate degree and a mother who did not complete high school. These age differences in the impact of new information are similar to patterns in the adoption of new technologies, such as the Internet (Goldfarb and Prince, 2008). We find no significant differential impact based on the mother's marital status or number of previous children, but there is some evidence that the VBAC rate of non-white mothers experienced a smaller change.

To ensure that our results are not driven merely by preexisting time trends, we implement a set of placebo tests similar in nature to that of Bertrand et al. (2004). We replicate the analysis from Table 3 for every possible three-month interval between April 1998 and September 2002 (42 separate regressions). While we observe significant drops in the VBAC rate in these months (there is a downward trend over the whole period), the only two points in time in which we find a significant difference in the change in the VBAC rate based on the mothers' education occurred on July 2001 (the article examined in this paper) and May 2002 (the JAMA article that confirmed the earlier results).

We also carry out a falsification test in which we conduct our original analysis (using the original pre/post timing measures as in Table 3) on first-time mothers and mothers who have had a previous child but have not had a previous C-section. The results found in Lydon-Rochelle et al. (2001) pertained only to the risks faced by women with a previous C-section, and make no recommendations about the advisability of having a first-time C-section.

Table 4 provides the results for three of the placebo tests and two falsification tests. It shows that in only one case (which is well within what we would expect with 40 coefficients) is there a significant coefficient on the interaction between the post-period and maternal education. This means that while the VBAC and C-section rate were changing across each of these periods, there were no systematic differences in the change based on the mothers' education. This provides evidence that the differential impact in July 2001 is not simply picking up a time trend that always differed by education.

The placebo test involving first-time mothers helps to illustrate that more educated mothers seem less likely to deliver by C-section even as first-time mothers. This helps shed light on the higher VBAC rate among more educated mothers pre-2001, suggesting that this may reflect higher educated mothers perceiving more utility from avoiding repeat C-sections, absent risk information on VBACs.

Finally, we extend our analysis to include multiple three-month time periods, both before and after the release of the NEJM article, so that we can observe the effects of the July 2001 article beyond the immediate period. We divide the mothers into two educational groups, based on whether or not the mother has a four-year college degree. We carry out the same analysis as before, but now include indicator variables for the four three-month periods before and after July 2001. Thus, our analysis extends from July 2000 to July 2002, allowing us to comment on the immediate as well as medium range impact (Table 5).

The coefficients on the main effects for each period show that the risk-adjusted VBAC rates declined across every period in our analysis, with the biggest drop occurring in the period immediately after July 2001. The interactions between college graduates and the time periods before July 2001 indicate that there was already a differential trend in the VBAC rate, such that the VBAC rates were starting to converge prior to the release of the article. However, the largest change in these educational gaps occurred in the first three months after the article, with the educational gap slightly smaller in the following months. The initial change in labor took a little longer to develop, with the largest gap in the educational differences occurring four to six months after the release of the article, with the educational gaps slowly decreasing in the following months.

6. Possible mechanisms

There are at least three mechanisms that explain why more educated mothers display a larger and quicker change in response to new medical information. First, more educated mothers may be better able to access and act on new information.[3] Second, more educated mothers may go to doctors that are more responsive to the new information. Third, education may just be a proxy for income and social class which provides access

[2] We also carry out an analysis where we include just state fixed effects for the sample of patients for which we have county identifiers (the more populous counties), and find that the results are very similar to the results using county fixed effects. This indicates that differences between our results using state and county fixed effects are due to differences between small and large counties (as we cannot include county fixed effects for smaller counties), rather than due to the decision of which level of fixed effect we use.

[3] Using data for 2001 from the Simmons National Consumer Survey, we found that women with college or more education were much more likely than women with less than high school to report having listened to a news program on the radio during the last week (1.35% vs. 9%).

Table 4
Placebo and falsification tests.

	Placebo #1: February 2001	Placebo #2: July 2000	Placebo #3: October 2000	Falsification test #1: prior birth but no prior C-section	Falsification test #2: first-time mothers
Outcome: vaginal birth					
Post	−0.0218	−0.0380***	−0.0061	0.0048	0.0030
	[0.0139]	[0.0142]	[0.0148]	[0.0044]	[0.0062]
Post·HS degree	0.0006	−0.0105	0.0010	0.0008	0.0010
	[0.0067]	[0.0071]	[0.0075]	[0.0020]	[0.0033]
Post·some college	0.0082	−0.0023	−0.0016	0.0019	0.0005
	[0.0071]	[0.0075]	[0.0086]	[0.0024]	[0.0040]
Post·college degree	0.0027	−0.0063	−0.0060	−0.0005	−0.0037
	[0.0089]	[0.0088]	[0.0103]	[0.0025]	[0.0042]
Post·graduate school	0.0029	−0.0155	−0.0026	0.0008	−0.0035
	[0.0096]	[0.0111]	[0.0116]	[0.0029]	[0.0051]
Post·age	0.0002	0.0016***	−0.0002	0.0000	0.0001
	[0.0005]	[0.0004]	[0.0005]	[0.0002]	[0.0003]
N	128,255	127,977	128,944	1,080,387	490,968
Outcome: induce labor					
Post	0.0016	−0.0173*	−0.0047	0.0107**	0.0117*
	[0.0099]	[0.0102]	[0.0110]	[0.0045]	[0.0064]
Post·HS degree	−0.0032	−0.0031	−0.0087	−0.0011	−0.0038
	[0.0051]	[0.0053]	[0.0062]	[0.0025]	[0.0034]
Post·some college	0.0054	−0.0039	−0.0115*	−0.0004	0.0007
	[0.0052]	[0.0057]	[0.0062]	[0.0033]	[0.0046]
Post·college degree	−0.0053	0.0022	−0.0046	0.0004	0.0003
	[0.0063]	[0.0063]	[0.0075]	[0.0031]	[0.0045]
Post·graduate school	−0.0037	−0.0045	−0.0071	0.0040	0.0024
	[0.0071]	[0.0075]	[0.0084]	[0.0036]	[0.0050]
Post·age	−0.0003	0.0004	0.0004	−0.0002	−0.0004
	[0.0003]	[0.0003]	[0.0003]	[0.0002]	[0.0002]
N	128,185	127,892	128,863	1,079,948	490,774

Notes: Standard errors in brackets. The placebos are the three months before and after the indicated months and are limited to women with a previous C-section. Each regression includes the same set of additional controls as Table 3 along with county fixed effects.
* Significant at 5%.
** Significant at 1%.

to the doctors who are better able to respond to the information.

Distinguishing between these explanations is important in terms of understanding the relative benefit of public health policy geared at either informing the public about new medical knowledge (through public awareness campaigns), helping patients find the right doctor (through increased access or medical report cards), or increasing access to quality medical providers through subsidized health care.[4]

Child birth provides a situation that potentially makes many of these mechanisms more salient than other medical procedures. Pregnancy is a medical condition that is readily visible to other people and provides a natural point of conversation that allows others to share information they have learned through media sources. Pregnant women are also likely to have friends recently pursuing the same medical procedure and thus have more access to information through these peer networks. Finally, the degree to which women can foresee the timing of this particular medical procedure gives them much more time to sort to doctors than for other medical procedures.

Epstein and Nicholson (2005) offer some evidence for how physician treatment patterns evolve, in the case of C-sections. They find that, although there is some learning from peers and from residency programs, there is still a large component of practice patterns that are unexplained. Epstein et al. (2008) investigate the matching between physicians and patients, shedding light on sorting in OB markets. They exploit the fact that births performed on weekends reveal physician characteristics since there is reduced ability to sort based on the on-call schedule of weekends; they then use that information to see whether patients who have the ability to sort (week day deliveries should reflect sorting) have done so, within the practice. They find evidence that patients appear to sort, and that the extent of sorting is greater within multi-practioner groups.

While we are unable to separate the relative magnitude of the channels mentioned above, future research could disentangle these various channels using hospital discharge records with physician identifiers and information on the patients' education and birth procedures. If the educational gaps in the response to new medical research are due to the decisions of patients, then among the patients going to a particular doctor we would observe a larger response among the more educated patients. If instead the differential response is due to more educated mothers sorting into doctors who are more responsive to the new medical research, then we would expect to see doctors with the larger response to the new medical research would attract more educated patients and that lower educated patients who happened to have a responsive doctor would experience a similar response as the more educated patients being attended by the same doctor.[5]

[4] These channels are very similar to those described by Glied and Lleras-Muney (2008) as mechanisms through which technological innovations may affect the relationship between education and health.

[5] We were able to use data from the CMS Medicare hospital cost reports for 2001 to construct the fraction of hospitals in each county that were teaching hospitals. Our results are the same whether we include this measure as an additional control or interact this measure with each of the education groups. We do find some evidence that the educational gaps in the change in VBAC rates was larger in counties with a higher fraction of teaching hospitals.

Table 5
Response of VBAC and induced labor rates using multiple leads and lags.

	VBAC		Induced labor	
College·period (*t* − 4)	0.0042	0.0058	0.0019	0.0028
	[0.0042]	[0.0053]	[0.0033]	[0.0038]
College·period (*t* − 3)	0.0021	0.0032	0.0069	0.0075*
	[0.0049]	[0.0058]	[0.0045]	[0.0041]
College·period (*t* − 2)	0.0037	0.0027	0.0035	0.0033
	[0.0056]	[0.0055]	[0.0030]	[0.0037]
College·period (*t* + 1)	−0.0102**	−0.0092*	−0.0058*	−0.0050
	[0.0039]	[0.0048]	[0.0033]	[0.0033]
College·period (*t* + 2)	−0.0068	−0.0080*	−0.0099***	−0.0101***
	[0.0045]	[0.0048]	[0.0030]	[0.0033]
College·period (*t* + 3)	−0.0110**	−0.0087*	−0.0088***	−0.0076**
	[0.0045]	[0.0049]	[0.0030]	[0.0031]
College·period (*t* + 4)	−0.0089**	−0.0087*	−0.0065*	−0.0066**
	[0.0035]	[0.0045]	[0.0032]	[0.0033]
Period (*t* − 4)	0.0458***	0.0519***	0.0163*	0.0126
	[0.0126]	[0.0125]	[0.0095]	[0.0093]
Period (*t* − 3)	0.0334**	0.0429***	0.0096	0.0026
	[0.0151]	[0.0153]	[0.0109]	[0.0103]
Period (*t* − 2)	0.0108	0.0190	−0.0018	−0.0087
	[0.0140]	[0.0138]	[0.0097]	[0.0097]
Period (*t* + 1)	−0.0592***	−0.0637***	−0.0355***	−0.0484***
	[0.0097]	[0.0122]	[0.0079]	[0.0095]
Period (*t* + 2)	−0.0740***	−0.0825***	−0.0426***	−0.0459***
	[0.0105]	[0.0131]	[0.0079]	[0.0090]
Period (*t* + 3)	−0.0893***	−0.0893***	−0.0443***	−0.0527***
	[0.0106]	[0.0128]	[0.0100]	[0.0096]
Period (*t* + 4)	−0.0985***	−0.1026***	−0.0497***	−0.0623***
	[0.0090]	[0.0128]	[0.0099]	[0.0100]
Fixed effects	State	County	State	County
Observations	578,726	458,142	576,994	456,645
R-squared	0.056	0.073	0.026	0.043

Notes: Each period consists of three consecutive months. The omitted group is the set of three months immediately before July 2001. Each regression includes the same set of additional controls as Table 3.

7. Conclusion

We study the impact that medical research has on the use of birth procedures by exploiting the release of a *NEJM* article that brought new information to light on the risks of vaginal birth after a previous C-section (VBAC). Our results indicate that it was the more educated women who experienced the largest change in treatment in response to the new medical information. While the absolute risks at stake in a VBAC procedure are fairly small in magnitude (less than 1% chance of uterine rupture), our results show that knowledge of even this small difference is enough to change medical behavior.

This finding builds on theory and an existing literature by showing that the impact of new medical technology differs by education. This differential influence of both new research and new technology might help explain the educational gaps in health that occur in the US. Future research is needed to explore the mechanisms by which these educational differences occur, investigating the relative role of the physicians and patients in making decisions in response to new medical advances.

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