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Iron Deficiency and Schooling Attainment in Peru[†]

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Do nutritional deficiencies contribute to the intergenerational persistence of poverty by reducing the earnings potential of future generations? To address this question, we made available supplemental iron pills at a health center in rural Peru and encouraged adolescents to take them via media messages. School administrative data provide novel evidence that reducing iron deficiency results in a large and significant improvement in school performance and aspirations for anemic students. Our findings demonstrate that combining low-cost outreach efforts and local supplementation programs can be an affordable and effective method of reducing rates of adolescent iron deficiency anemia. (*JEL* I21, I23, I26, J24, J31, Q51, Q53)

One of the fundamental questions in development economics is whether a significant fraction of the world's poor are caught in nutrition-based poverty traps that make them likely to remain poor over generations. In particular, the poor are frequently deprived of the micronutrients they need to function at their physical optimum, which may affect their short-run or long-run earnings potential through reduced productivity at work or in school. Although empirical evidence suggests limited potential for calorie-based poverty traps in less developed countries (largely because calorie consumption is sufficient in most regions of the world), it is possible that deficits of specific micronutrients contribute to cycles of poverty.

One potential culprit is underconsumption of the micronutrient iron. An estimated 50 percent of women and children in developing countries are believed to suffer from iron deficiency anemia (IDA), and adolescents are a particularly vulnerable subpopulation (World Health Organization 2011a).[1] Iron deficiency, which decreases the circulation of oxygen in the blood, reduces aerobic capacity and

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[1]This is because iron needs are especially high during periods of physical growth. The highest rates of IDA are found among children under 5 and pregnant women, followed by female adolescents between 12 and 15 (World Health Organization 2011a).

hence may contribute to lower earnings among malnourished individuals.[2] It is also believed to result in lower cognitive function, memory, and attention span, and as a result, may significantly increase the cost of human capital accumulation in impoverished settings, and hence contribute directly to intergenerational poverty traps.[3] That is, if IDA significantly lowers the return to schooling, it may be impossible for parents who are too poor to afford an iron-rich diet to pull their children out of poverty by investing in their human capital.

Although it is difficult to firmly establish the existence of a nutrition-based poverty trap, we can learn whether there is potential for IDA to contribute to the intergenerational persistence of poverty by investigating whether reducing IDA has a causal effect on human capital attainment. If it does, this would indicate that returns to schooling investment are significantly lower for anemic individuals, which could trap families in a low-human-capital equilibrium over generations in settings where iron is costly to obtain.[4] Indeed, a number of studies provide evidence that iron-deficient children and adolescents, particularly those who qualify as anemic, perform worse on cognitive tests (Luo et al. 2011, Pollitt et al. 1985, Hutchinson et al. 1997, Webb and Oski 1973, and Halterman et al. 2001). In addition, there is strong evidence that lower scores on tests of memory, learning, and attention can be improved or even reversed with short-term iron supplementation.[5] This evidence has motivated the World Health Organization (WHO) to recommend that countries with endemic anemia adopt costly large-scale Weekly Iron and Folic Acid Supplementation (WIFS) programs for children and adolescents, and several countries have embarked on such efforts over the past decade.[6]

However, while the benefit of supplementation on cognitive functioning has been well-established with clinical trials, the contribution of these findings to our understanding of poverty persistence is less straightforward, and depends on one key outstanding question. Namely, does reducing iron deficiency have a large enough effect on cognition to result in tangible increases in human capital accumulation? Although the tests employed in experimental studies of iron supplementation are often similar to scholastic achievement tests, the benefits of supplementation on human capital accumulation may be far lower than the benefits on cognitive functioning measured in clinical settings. If in real life anemic students are motivated to engage in

[2] Specifically, iron deficiency affects physical activity through two pathways. First, as hemoglobin levels decline, the maximum amount of oxygen that the body can use (aerobic capacity) declines. Second, as iron stores are depleted, the amount of oxygen available to muscles declines, reducing endurance, and the heart must work harder to produce the same amount of activity.

[3] Iron is important for brain and central nervous system (CNS) activity because it is the key component of the many enzymes that involve essential oxidation reduction reactions, synthesis of neurotransmitters, catabolism of neurotransmitters, and synthetic processes such as the production of myelin.

[4] Although iron-rich diets are more expensive than calorie-equivalent low-iron diets in most settings including Peru, it is also true that iron supplements are inexpensive. Hence, IDA should not form the basis of a traditional poverty trap as long as supplementation is a feasible alternative. In practice, iron supplements are not sold on the private market in developing countries, so almost all private consumption of iron occurs through consumption of iron-rich food.

[5] See, for instance: Seshadri et al. (1982); Pollitt et al. (1985); Soemantri, Pollitt, and Kim (1985); Groner et al. (1986); Kashyap and Gopaldas (1987); Seshadri and Gopaldas (1989); Soemantri (1989); and Bruner et al. (1996). One large study in Thailand could not replicate the beneficial effects of iron supplementation found in other settings (Pollitt et al. 1989, Sungthong et al. 2004).

[6] See http://www.wpro.who.int/publications/docs/FORwebPDFFullVersionWIFS.pdf for a detailed overview of six such programs.

compensatory behaviors or exert extra effort in order to maintain rates of school progression, differences in performance captured in a clinical setting—where there is little incentive to exert effort on cognitive tests—will overstate improvements in actual schooling outcomes or learning that would result from reducing IDA. Put differently, it may be the case that family background and expectations of academic achievement are such overwhelming determinants of academic success that small changes in cognitive capacity have little effect on human capital attainment, even when such differences can be captured in a clinical trial.

The answer to this question is not only important for evaluating the returns to costly supplementation efforts such as WIFS, but is critical for understanding the myriad of ways in which micronutrient deficiencies contribute to poverty and underdevelopment. Previous research has shown the detrimental effect of iron deficiency on adult labor force productivity (Thomas et al. 2006),[7] but to date there is no rigorous evidence that IDA is an important contributing factor to low rates of human capital accumulation and hence an important source of intergenerational persistence of poverty in developing countries.[8]

A second outstanding question in the literature is how to make weekly supplementation programs for adolescents feasible in resource-constrained settings. The evidence from clinical studies indicates that iron supplementation is cost-effective as long as it reaches those who are anemic. Yet targeting is difficult to achieve given that diagnosis through blood tests is rarely feasible in impoverished settings. Furthermore, adolescents are a difficult population to reach for preventive care given their infrequent contact with health professionals. This fact has motivated many policymakers to favor expensive doorstep policy approaches that deliver pills directly to adolescents. These policies are out of reach for many local governments and likely not even cost-effective. Meanwhile, little effort has gone into evaluating whether supplement programs can be made affordable with simple interventions that encourage adolescents to actively seek preventive health services offered through a public clinic. Since iron is only beneficial for those who suffer from IDA, there is a particular need to establish whether streamlined approaches can reach enough of those in need on a high-enough frequency basis to be efficacious.

Our study addresses both of these gaps in the current literature by providing iron supplements through a village health clinic in rural Peru, and implementing a simple, scalable classroom-based media program that encourages adolescents to take up the supplements. The goals of the study were two-fold: to evaluate the contribution of low dietary iron intake to human capital attainment by measuring the causal effect of reducing adolescent anemia on school performance, and to assess whether adolescents in disadvantaged settings could be encouraged to take advantage of preventive health programs offered through the village clinic with a low-cost intervention. With

[7] There is also a substantial nonexperimental empirical literature that tests for the existence of nutrition-based poverty traps. For a comprehensive review see Strauss and Thomas (1998).

[8] Although there is speculation that IDA is an important contributing factor to maternal, perinatal, and child mortality, causal evidence on the impact of IDA on health status is similarly lacking (Stoltzfus, Mullany, and Black 2004). A number of papers provide evidence that other measures of health status influence schooling attainment. For an overview of this literature, see Alderman and Bleakley (2013). Bobonis, Miguel, and Puri-Sharma (2006) provide experimental evidence that a combination of iron supplements and deworming drugs improves school participation among anemic students in India. There are also a number of nonexperimental studies linking anemia to school performance.

respect to the first objective, our study breaks new ground by tracking administrative records of school performance and progression, in addition to clinical assessments of anemia and cognitive function, and thereby provides rigorous evidence on the causal influence of IDA on human capital accumulation.

Our study demonstrates that by introducing a low-cost encouragement intervention, supplementation programs offered through a public clinic can be effective in reaching anemic adolescents in impoverished settings. Although targeting is far from perfect, a sufficient number of iron deficient adolescents take up pills at a high enough frequency to observe a significant reduction in rates of IDA. Those who respond to promotional videos are disproportionately high-achieving yet poor and low-aspiring students, which abates concern that only the least needy adolescents will respond to an information campaign.

Among anemic students, the reduction in IDA is 50 percent larger when media messages are added to the supplementation program, which suggests that direct-to-patient marketing is an essential compliment to any clinic-level distribution scheme targeting adolescents. Our analysis of take-up also reveals that adolescents are significantly more likely to seek iron supplements when a sibling is exposed to promotional messages even conditional on own media exposure. This indicates that the benefits of media messages are further multiplied through spillover effects within families.

Our clinical test results corroborate previous evidence on the impact of IDA on cognitive functioning, with the gains concentrated among visualization and analytical skills. More importantly, administrative data from schools provide strong evidence that the improvements in cognitive skills are substantial enough to have a significant influence on school performance and learning. For students who were anemic at baseline, an average of 10 100 milligram (mg) iron pills taken over 3 months improves average test scores by 0.4 standard deviations and likely increases the probability of grade progression.

In addition, we provide novel evidence on the positive influence of iron supplementation on aspirations of upward mobility. In particular, iron supplementation is associated with a 16 percent improvement in previously anemic students' aspirations for the future. This result suggests that small changes in own ability are salient and that aspirations adapt quickly to changes in performance, which is encouraging for interventions that target older children and young adults. It also suggests that human capital gains are likely to be compounded by improvements in intrinsic motivation to succeed in school among those who benefit from reductions in IDA. More fundamentally, our results suggest that returns to schooling are lower for impoverished students simply because they are nutrient deprived, which implies a non-convexity in the returns to schooling with respect to income. Both results indicate that learning deficits from IDA have the potential to generate a nutrition-based poverty trap.

I. Study Design

A. *Setting*

Our study took place among all 219 students of 1 rural secondary school in the Cajamarca district of Peru during the 2009 school year. The burden of iron deficiency

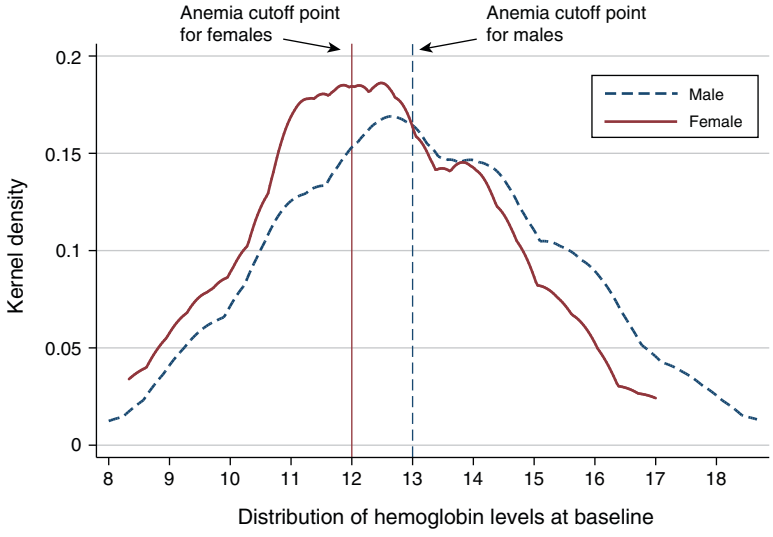

FIGURE 1. HEMOGLOBIN DENSITY AT BASELINE RELATIVE TO ANEMIA CUTOFF, BY GENDER

is high throughout the developing world, and Peru is no exception: A 2008 study by UNICEF found that 39 percent of adolescents in rural Peru are affected by anemia (UNICEF 2008).[9] Among students in our study, 42 percent of boys and 41 percent of girls were anemic at the onset of the study. Figure 1 shows the distribution of hemoglobin (Hg) levels among male and female students at baseline, along with the anemia cutoff points. The figure shows a high fraction of both male and female students below the cutoff for anemia, but also high densities of students slightly above both cutoff points, indicating that, while not necessarily anemic, the majority of both boys and girls in the study are vulnerable to iron deficiency.[10, 11]

Overall, Cajamarca is one of the lowest performing districts in Peru based on UNICEF's childhood development index (UNICEF 2008). With respect to schooling achievement, 91 percent of adolescents in Cajamarca have skills at least 1 grade below the basic level for their age-appropriate grade in math, which is 5 percentage points worse than the national average (UNICEF 2008). The students who participated in our study ranged in age from 11 to 19, and encompassed 5 secondary school grade levels. The distribution of students across grades is shown in Figure 2. Forty-eight percent of the sample was female, and there were slightly more males than females in most grade levels.[12] Consistent with overall district performance,

[9] In contrast, in the United States, only approximately 9 percent of females aged 12–19 years were anemic between 2003 and 2006 (Cogswell et al. 2009), and the Center for Disease Control's National Health and Nutrition Examination Survey (NHNES) suggests that less than 7 percent of nonpregnant women of reproductive age in the United States are anemic (de Benoist et al. 2008).

[10] Prior to our experiment, iron supplements were not readily available through public or private clinics or stores, and there were no reports in our baseline survey of individuals consuming iron pills.

[11] It is also worth noting that the same pattern of a concentration of individuals slightly above the cutoff point occurs in other contexts, including populations with lower anemia prevalence, such as the distribution described for Caucasian women in the United States by Johnson-Spear and Yip (1994).

[12] The males in the school were also approximately six months older than the females, a difference which was significant in a standard *t*-test.

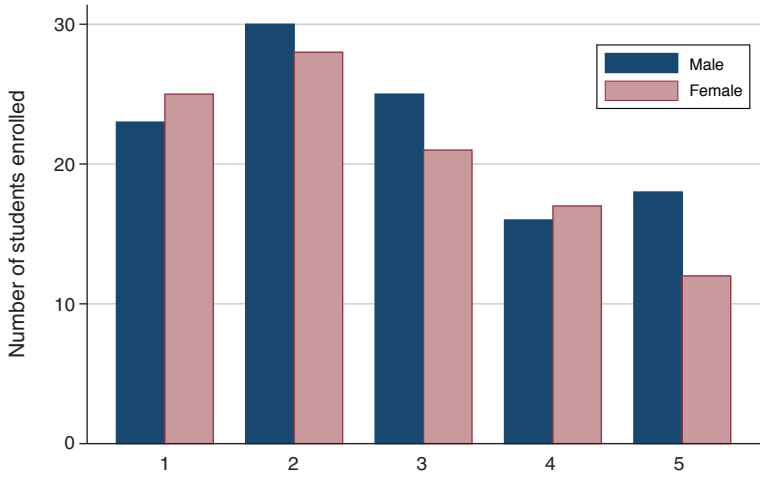

FIGURE 2. SCHOOL ENROLLMENT BY GRADE AND GENDER

in our study school dropout rates before high school completion (grade 5) are relatively high: in the class that graduated in 2010, less than half of students on the roster in their first year even entered their fourth year of school.[13] Males and females drop out in roughly equivalent proportions.

B. *Experiment*

Our efforts to reduce anemia among adolescents in our study involved stocking the village clinic with iron supplements for ten weeks from October to December 2009, and training the local staff to distribute one iron pill free of charge to any adolescent who requested one in person on any day of the study.[14, 15] The nurse was also trained to discuss the benefits of iron supplementation for anemic individuals, although she did not provide any diagnostic services to better target pills towards those who were or were likely to be anemic. The health center was located in the

[13] Similar dropout rates were found in adjacent classes.

[14] To record take-up, the nurse had access to a computerized database that contained all students' IDs, pictures, and names. In addition, she was told to make the pill available to anyone not in the database who fell into that age category.

[15] Pills were made available at the clinic through May 2010, but encouragement activities ceased at the end of the school year in December 2009. Because encouragement activities were not resumed after summer break (December–March), our analysis focuses on the short-run impact on anemia and academic outcomes of ten weeks of access to iron supplements, a length of time over which anemia has been shown to fall with weekly supplementation in previous studies. Although pill consumption was recorded during summer break, there was no careful record keeping during the summer. That said, there was a noticeable decline in pill consumption on the days for which data were recorded. For example, an average of 54.8 students traveled to the village clinic daily to receive the iron supplements during the last week of classes in December. By the first week of January (about 2 weeks later), the daily average dropped to 6.4. We attribute this sudden decline largely to the fact that students no longer had a reason to travel close to the clinic daily while school was not in session, rather than any abrupt change in attitude or other such factor.

village center, 0.3 kilometers from the school, and was open from 10 AM to 5 PM Monday through Saturday.[16]

Our collaboration with a public health clinic meant that iron pills had to be made equally available to all adolescents in the village. Hence, in order to create experimental variation, the study used an encouragement design that randomly varied students' exposure to promotional materials emphasizing the benefits of supplementation and encouraging them to visit the clinic daily to take an iron pill. In particular, over the course of the ten-week study, students were exposed multiple times to one of the following three videos that lasted one to two minutes: the first video showed a popular soccer player encouraging iron supplements to maximize energy; the second showed a doctor encouraging iron supplements for overall health; and the third "placebo" video did not mention iron at all and instead featured a dentist encouraging oral hygiene.[17] The first two videos served both to explain the benefits of iron to the children, and to remind them to take the iron pills. Each video lasted between 70 and 100 seconds, and on average students viewed the same one of the three videos 5.75 times over the 10-week period. Appendix Figure A1 shows the distribution of video sessions across the entire sample.[18]

The videos were shown in conjunction with a school program that provided students free access to the Internet during scheduled sessions in the classroom after school hours.[19] Videos were shown to students upon logging into the computer and before they could access the Internet, so there was strong incentive for students to sit through the videos.[20] Within each grade, students were randomly assigned to one of the three videos, with one-third assigned to each. Randomization was achieved at the student level by assigning each student a unique login code that triggered one of the three videos to be shown upon each login.

Throughout the analysis, students shown the first two videos are considered to be in the treatment group, and students shown the third video are considered to be in the control group.[21] Students were also assigned to different intensities of exposure by randomly varying the number of computer sessions they could attend. However, since the difference across treatment and control video groups in terms of take-up of pills is relatively constant across degrees of exposure (Figure 3), in this analysis we differentiate treatment only by the content of the video, grouping together all students assigned to the iron videos into the treatment group and all students

[16] We monitored the presence of a nurse through her logins on the laptop, which revealed that she was continuously present during business hours throughout the study period.

[17] In particular, the treatment was block randomized across grades. Within each grade, one-third was randomly assigned to watch the placebo video, one-third assigned to watch the soccer video, and one-third assigned to watch the physician video.

[18] Extensive computer logs tracked both logins and site access of each student, making it possible to calculate the number of sessions attended by each student and, consequently, the number of times they viewed the encouragement videos and the amount of time they spent on the computers.

[19] The sessions, which included an on-site computer instructor to help students, were scheduled after school and on Saturdays. Students were randomly assigned to particular sessions of 20 students each, and the schedule was posted on the school bulletin board.

[20] Every student had a headset to watch the videos individually.

[21] One of the tables included in our online Appendix compares the characteristics of students assigned to both treatment videos (i.e., the one with the soccer player and the physician) and to the placebo (i.e., oral hygiene) video. Overall, the three groups were similar across various demographic and socioeconomic characteristics, as well as in terms of their baseline grades and hemoglobin levels.

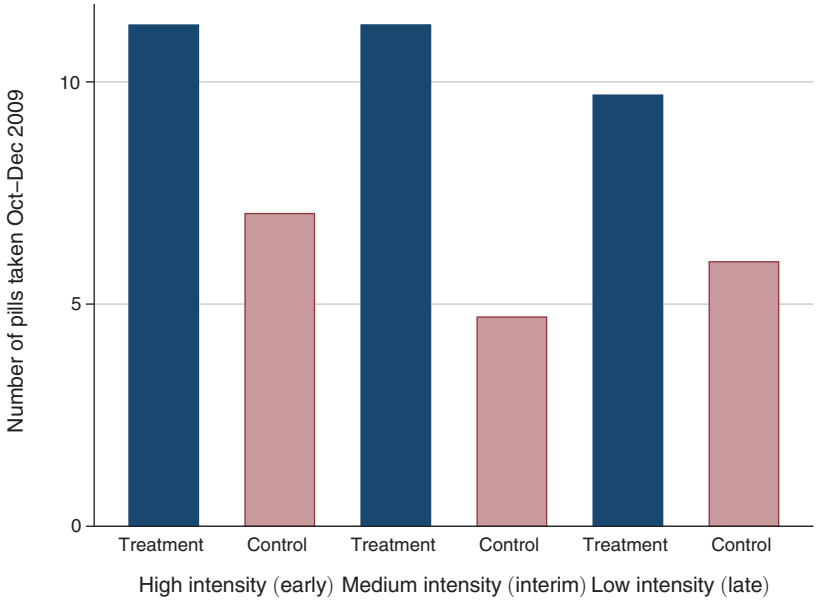

FIGURE 3. PILL TAKE-UP BY NUMBER OF VIDEO SESSIONS

assigned to the placebo video into the control group.[22] As there was no difference across treatment and control in terms of the number of computer sessions attended, we can safely infer that our experimental manipulation isolates the influence of public health messaging and not of computer activity more generally (Appendix Figure A1).

Data for the experimental analysis come from baseline and follow-up surveys conducted one month prior to and ten weeks after the onset of supplementation efforts, and academic records from the 2009 school year.[23] Both baseline and follow-up involved a questionnaire administered individually to each student that included questions on academic aspirations and perceptions, subjective health, and daily activities, and a separate questionnaire administered to the household head of each student (or closest relative living in the same home) that largely captured information on family background and socioeconomic status.[24]

In addition, students in our study played video games designed to measure cognitive ability. The Wii game, *Big Brain Academy: Wii Degree*, encompassed five distinct tests of cognitive ability: identification, memorization, analysis, computation,

[22] The most logical explanation for the fact that increased exposure did not lead to significant differences in the take-up of pills is that there is some threshold number of times observing a public health method above which the message has no additional influence on behavior.

[23] The baseline survey was administered in August 2009 and the follow-up survey was conducted in December 2009, and academic records are from December 2009.

[24] To obtain informed consent, before the collection of the baseline survey data, parents were gathered in the school and explained the basic objectives of the study. A physician explained that we would collect blood samples to measure nutrition, along with the minimal risk involved in this procedure. The following day, consent forms for participation were delivered to students at school, who were asked to bring them back with parents' signature (whether affirmative or negative). Only two students failed to return the consent form, and were excluded from the study.

and visualization. The games were played by students while they were at school in December 2009. Finally, anthropometric data were collected from each study subject at baseline (September 2009) and follow-up (December 2009) by the nurse at the health clinic, including height, weight, abdominal circumference, and blood hematocrit levels, a common means of determining anemia.[25]

Table 1 presents summary statistics from our sample of students. Overall, the students come from relatively impoverished households as indicated by household income, maternal education, electrification, and household size. Still, it is worth noting that the sample is fairly representative of *rural* Peru in terms of overall poverty and anemia.[26]

Table 1 also reveals that random assignment to the experimental arms achieved comparison groups that are balanced on observable baseline characteristics. Importantly, three key outcomes in the study—iron deficiency, academic grades, and perceptions of upward mobility—are almost identical across treatment and control groups at baseline. Only 1 out of 18 variables—height—is imbalanced across treatment and control at a level approximating statistical significance, and the difference is small in magnitude and negative in sign (individuals assigned to the treatment group are shorter), indicating it would bias downward rather than upward experimental estimates of the causal effect of iron supplements on health.[27]

An F-test of joint significance confirms that the two samples are balanced on observables at baseline. The difference is likely related to a more striking difference in means across the two groups that is large in magnitude although statistically insignificant: there is a 9 percentage point difference in the fraction of males across the two groups. Although the difference is presumably the unlikely product of random assignment, because gender is an important determinant of anemia and grade attainment, in all regression specifications we include gender as a control variable (though the results are virtually identical when we do not). Furthermore, the sample is balanced on all observables among the subsample of students that are anemic at baseline (column 4 in Table 1), among whom we expect the treatment effects to be concentrated.

[25] To streamline fieldwork procedures, the investigators chose to employ simple and portable devices that measure hemoglobin (HemoCues), but do not provide ferritin or transferrin measures.

[26] Table A1 compares the sample in our study to other high school students in rural Peru. In general, the students in our sample have either similar characteristics or are slightly worse off than other students in Peru (e.g., they have less educated mothers, are shorter, have lower hemoglobin levels, and have a larger student-teacher ratio).

[27] In particular, if the height difference reflects underlying differences in socioeconomic status, we would expect those in the treatment group to have lower and not higher school performance in the absence of the intervention. Furthermore, the height imbalance is fully explained by the gender imbalance—controlling for gender, there is no significant difference across control and treatment groups with respect to height and the point estimate is very close to zero. In fact, controlling for gender, several of the differences become even smaller, including weight, anemia status, and first quarter grades. With respect to the household socioeconomic status measures, while some of the insignificant differences may seem nontrivial in magnitude, it is worth noting that there is no discernible pattern—e.g., income in the treatment group is lower, but access to electricity and mother's education is higher. Of course, it is worth noting that our sample size is small, which increases concern over random differences across experimental groups at baseline.

Table 1—Summary Statistics by Treatment Status

Variable	Treatment	Control	Difference T–C			Observations
			All	Anemic	Non-anemic	(T/C)
Male	0.483	0.597	−0.115	−0.086	−0.135	143/72
	(0.501)	(0.494)	(0.072)	(0.114)	(0.094)	
Age (months)	180.164	181.871	−1.708	−3.988	−0.133	143/72
	(20.773)	(22.742)	(3.100)	(5.362)	(3.732)	
Distance to school (hours)	0.704	0.746	−0.0420	0.075	−0.118	137/71
	(0.679)	(0.704)	(0.101)	(0.146)	(0.137)	
Baseline hemoglobin level	12.716	13.042	−0.326	−0.080	−0.364	141/72
	(2.151)	(2.229)	(0.315)	(0.251)	(0.285)	
Baseline anemia status	0.420	0.403	0.0170	N/A	N/A	143/72
	(0.495)	(0.494)	(0.071)			
Height (cm)	148.063	150.536	−2.473	−2.749	−2.201	140/72
	(8.726)	(9.223)	(1.290)	(2.152)	(1.592)	
Weight (kg)	46.400	47.879	−1.479	−0.0390	−2.426	141/72
	(9.011)	(8.119)	(1.263)	(2.04)	(1.602)	
No. members in household	5.804	5.764	0.040	−0.017	0.070	143/72
	(1.885)	(2.059)	(0.281)	(0.457)	(0.356)	
2009 first quarter grades	12.151	11.917	0.234	0.327	0.178	143/72
	(1.141)	(1.108)	(0.163)	(0.237)	(0.221)	
Grade at baseline	2.692	2.764	−0.072	−0.043	−0.094	143/72
	(1.349)	(1.337)	(0.194)	(0.346)	(0.227)	
Monthly income (100 S/.)	7.665	8.340	−0.675	0.161	−1.319	143/72
	(9.223)	(7.408)	(1.251)	(2.716)	(0.942)	
Mother's years of educ.	3.465	3.319	0.145	−0.079	0.293	142/72
	(3.116)	(2.577)	(0.426)	(0.76)	(0.497)	
Owns land	0.832	0.847	−0.015	−0.097	0.041	143/72
	(0.375)	(0.362)	(0.054)	(0.085)	(0.069)	
Father present in HH	0.748	0.833	−0.085	−0.078	−0.090	143/72
	(0.436)	(0.375)	(0.06)	(0.095)	(0.078)	
Size of house (m^2)	110.217	103.653	6.564	4.620	7.884	143/72
	(125.529)	(60.452)	(15.646)	(26.161)	(19.48)	
Index of Perceived Upward Mobility[a]	1.659	1.629	0.031	0.159	−0.052	138/70
	(0.52)	(0.569)	(0.079)	(0.128)	(0.100)	
Has sibling	0.427	0.444	−0.0180	−0.099	0.039	143/72
	(0.496)	(0.5)	(0.072)	(0.112)	(0.094)	
Total Computer Time (hours)[b]	7.860	7.625	0.235	−0.004	0.408	143/72
	(5.784)	(5.837)	(0.838)	(1.353)	(1.074)	
Household electricity	0.750	0.690	0.060	0.069	0.053	140/71
	(0.435)	(0.466)	(0.065)	(0.097)	(0.087)	
Joint *F*-test (Wald test)			14.55	16.92	16.93	

Note: Standard errors are in parentheses.

[a] Index of Perceived Upward Mobility is an index of whether the student plans to leave their hometown after graduation, and whether they plan to continue their education after graduation.

[b] Total Computer Time refers to the number of hours the student spent on a computer through the program.

C. *Take-Up of Iron*

Throughout the distribution period, the nurse who distributed pills in the clinic carefully tracked each student's name and unique ID, the date of the visit, the time of the visit, and whether the student was given an iron pill. Overall, the experiment

Table 2—Number of Pills Taken

	Pills taken			≥ 500 mg iron	
	(1)	(2)	(3)	(4)	(5)
Treatment	4.732		4.237	0.177	0.219
	(1.515)		(1.465)	(0.0715)	(0.0937)
Treatment: Soccer		3.949			
		(1.760)			
Treatment: Physician		5.484			
		(1.742)			
Male student			−2.411		
			(1.390)		
Monthly income (100 S/.)			−0.0175		
			(0.0809)		
Distance to school (hours)			−4.063		
			(1.033)		
Age (months)			−0.133		
			(0.0590)		
Anemic at baseline × treatment					−0.0980
					(0.146)
Anemic at baseline					−0.000767
					(0.121)
Observations	215	215	215	215	215
Control mean	5.944	5.944	5.944	0.417	0.417

Notes: Full sample from study. Standard errors are in parentheses.

was successful in distributing iron pills to study subjects, although take-up was far from universal. On average, students received 9.3 pills over the course of the study. Seventy-six percent of students went to the clinic at least once to receive an iron pill, and 53 percent went at least 5 times, and so received at least 500 mg of iron over 10 weeks. Thus, we estimate that at least half of the sample received enough iron to improve health status and potentially improve cognition. Although below the official recommended dose, several studies conducted among school-aged children have demonstrated the efficacy of an intermittent iron supplementation schedule of at least 60 mg per week for 8 weeks (Schultink et al. 1995).[28]

Furthermore, as shown in Table 2, although the manipulation was relatively subtle, our encouragement design was successful in generating significant differences across experimental arms in take-up of iron pills. On average, students assigned to the treatment took roughly 80 percent more pills than the control group, a difference that was strongly significant with and without controls (column 1, column 3). Furthermore, approximately 42 percent more students in the treatment group took at least 500 mg of iron over the course of the study, a level that has been demonstrated in previous studies to reverse iron deficiency among the anemic.[29] As shown in Table 2,

[28] Efficacy of weekly supplementation of iron has demonstrated an improvement in iron stores in adolescence in many settings, including Peru (Beaton and McCabe 1999). For instance, 120 mg of iron per week was shown to reduce iron deficiency among Peruvian adolescent girls in a far less anemic subpopulation (Zavaleta, Respicio, and Garcia 2000).

[29] A study of female Indonesian adolescents in Indonesia also found improved hemoglobin concentrations following administration of 480 mg of iron over a two-month period (Angeles-Agdeppa et al. 1997).

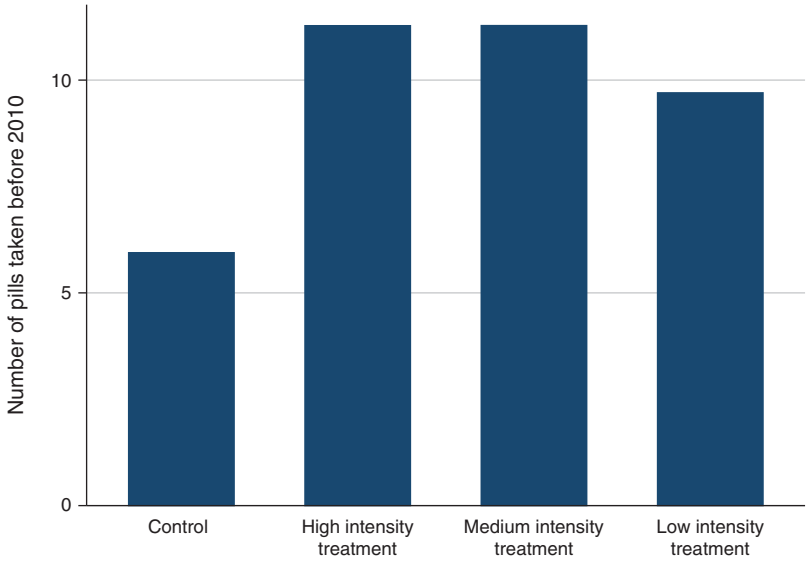

FIGURE 4. PILL TAKE-UP BY EXPOSURE INTENSITY

column 4, among the treatment group, 60 percent of students took at least 500 mg of iron, while among the control group that number was only 42 percent.[30] Column 5 shows that anemic students were equally as likely as non-anemic students to take this level of supplementation in both treatment and control, which makes sense given that students were not informed about the results of their hemoglobin tests.

These results demonstrate that regularly watching short videos that focused on the benefits of iron and reminded children to take the iron pills led to a significant increase in the number of pills taken. However, the exact content of the videos did not seem to make a difference. As seen in column 2, the average difference in take-up between the two treatment videos was close to zero, although we cannot rule out potential compositional changes in the set of responders that depend on video content. In addition to treatment exposure, we observe that age, gender, and distance to town center, but not income, are strong predictors of take-up (column 3). In particular, older girls living close to the clinic are most likely to seek iron pills, the first two factors contributing positively to the program's ability to achieve optimal self-targeting without screening for anemia.

D. *Econometric Specification*

In the analysis that follows, we estimate a model with the following basic linear regression:

$$Y_i = a + \beta_1 T_i + \omega \mathbf{X}_i + e, \tag{1}$$

[30] It is, of course, possible that even lower levels of iron supplementation are effective in reducing anemia among those close to the threshold or improving health outcomes among those well below the cutoff, but very low levels of supplementation have not been evaluated in clinical studies.

where Y_i is the outcome of interest[31]; T_i is a binary variable for assignment to the treatment group; and X_i is a set of controls.

A key feature of our empirical analysis is to look separately at the effect of supplementation on students who are anemic versus non-anemic at baseline, as is standard in the literature. This is because, for all outcomes, we anticipate no treatment effects on the non-anemic subpopulation who—based on evidence from existing studies—should receive no benefit from additional iron intake, especially with regard to cognitive outcomes.[32] In particular, we estimate regressions for both the sample of students who were and were not anemic at baseline and test directly whether outcomes change *only* for those who were anemic at baseline. We also test whether the effect of the treatment differed between the subsamples.

In accordance with the WHO guidelines on anemia, the threshold level of hematocrit at or below which a student is considered to be in the anemic subsample differs for male and female participants. Male students are considered anemic at 13g/cc hemoglobin or below, whereas female students are considered anemic at 12g/cc hemoglobin or below (WHO 2001). To account for any slight imbalances and increase the precision of our treatment effect estimates, all regressions control for gender and grade, which are first-order determinants of both anemia and schooling outcomes. In addition, we present regression results for all outcomes with and without the following additional control variables for socioeconomic status, measured at baseline: total household labor income, whether the household has access to electricity, and mother's years of schooling. Since performance measures can be influenced by differences in grading standards or practices across teachers (although teachers vary little within subjects in the school in which the study was conducted), in all regressions we also include class fixed effects.

II. Results and Discussion

A. *Anemia and Cognitive Function*

We begin by exploring the impact of treatment on reductions in iron deficient anemia and related improvements in cognitive functioning, the channel through which supplementation has the potential to improve school performance. The first outcome of interest is a dummy indicator of whether a student was anemic according to hemoglobin tests measured at endline (Table 3). As expected, media messages did not have an impact on the rate of anemia of those who were not anemic at baseline (columns 2 and 4). However, we do find that they reduced anemia among those who suffered from IDA at baseline (columns 1 and 3). In particular, previously anemic students exposed to the treatment were approximately 34 percent less likely to be anemic at the time of the follow-up survey.

[31] Throughout the analysis, we will focus on the impact of our intervention on students' cognitive function, grades, grade promotion, and perceived upward mobility. Table A2 presents the summary statistics for these outcomes in the treatment and control groups.

[32] Several studies show that the provision or encouragement of iron pills only substantively affects those who are already anemic. These include: Falkingham et al. (2010); Bobonis, Miguel, and Puri-Sharma (2006); Soemantri (1989); Gera et al. (2007); and Thomas et al. (2006).

TABLE 3—ANEMIA

	(1)	(2)	(3)	(4)
Treatment	−0.202	0.020	−0.212	0.009
	(0.105)	(0.091)	(0.106)	(0.091)
Male student	0.017	0.075	−0.004	0.093
	(0.105)	(0.089)	(0.108)	(0.089)
Monthly income (100 S/.)			−0.006	−0.002
			(0.004)	(0.009)
Electricity in home			0.203	−0.095
			(0.130)	(0.095)
Mother's years of schooling			−0.004	0.036
			(0.015)	(0.017)
Wald test (Prob > χ^2)		0.1016		0.0996
Sample	Anemic	Non-anemic	Anemic	Non-anemic
Observations	89	126	89	126
Control mean	0.586	0.419	0.586	0.419

Notes: Wald test for equality across columns. Standard errors are in parentheses.

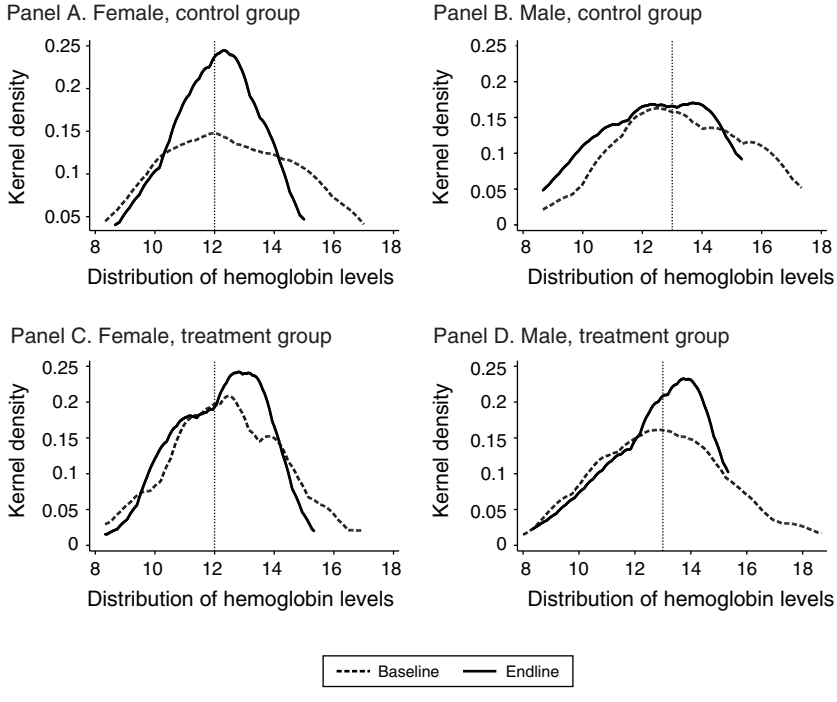

FIGURE 5. DISTRIBUTION OF HEMOGLOBIN LEVELS AT BASELINE AND ENDLINE BY GENDER AND TREATMENT

Note: Vertical dashed lines represent the anemia cutoff points for females and males.

TABLE 4—COGNITIVE FUNCTION

	(1)	(2)	(3)	(4)
Treatment	86.639	−11.616	80.765	−13.820
	(40.980)	(29.868)	(39.675)	(29.343)
Male student	110.789	53.370	102.739	56.716
	(40.975)	(29.370)	(40.263)	(29.024)
Monthly income (100 S/.)			−0.653	1.162
			(1.599)	(2.769)
Electricity in home			59.011	73.435
			(48.032)	(30.668)
Mother's years of schooling			17.540	7.769
			(5.758)	(5.432)
Wald test (Prob > χ^2)		0.0621		0.0565
Sample	Anemic	Non-anemic	Anemic	Non-anemic
Observations	87	121	87	121
Control mean	405.786	496.952	405.786	496.952

Notes: Wald test for equality across columns. Standard errors are in parentheses.

This result is consistent in magnitude to the effects of the intervention on take-up of iron pills. Figure 5 shows the distributions of hemoglobin levels at baseline and endline across control and treatment groups by gender. Average hemoglobin levels decreased in both control and treatment groups, consistent with descriptive studies of seasonality in hemoglobin levels, which document significantly lower rates of Hb during the summer months (our study took place beginning in the spring and ending in the summer).[33] However, the size of the decrease is markedly different across treatment and control groups: while the reduction in the control group was −0.79, hemoglobin levels in the treatment group reduced by only −0.28 on average. This translates into a positive effect of the treatment on the rate of anemia.

We do not find any significant treatment effect on self-reported measures of physical health (Appendix Table A3) that were collected at follow-up, including days of school missed due to illness and endurance (number of minutes individual can run). Effects of iron supplements on physical health may be particularly hard to detect due to measurement error (including a high rate of missing data) inherent in the self-reported nature of these data.

We next examine the influence of iron supplementation on cognitive functioning. As described in Section IB, cognitive ability is measured as the sum of a student's score on the cognitive Wii game, with performance increasing in score.[34] Once again, the treatment had no significant impact among those who were not anemic at baseline (Table 4, columns 2 and 4). However, there is strong evidence of improvements in cognitive functioning among those who were iron deficient at baseline. As shown in columns 1 and 3, among the anemic subsample, treatment was associated with a

[33] For instance, see Ronnenberg et al. (2000).

[34] In particular, we recorded individual scores for five different tasks performed in Wii Brain Academy. Because the weights for each task are not obvious, we simply added the five scores such that every task is given the same weight in the overall score. Seven individuals, including two anemic individuals, were absent on the day that games were played, and thus are excluded from the regressions.

21 percent increase in cognitive test scores. This pattern of results is consistent with the fact that the vast majority of studies do not find cognitive improvements from increasing iron levels in non-iron-deficient participants. Appendix Tables A4, A5, and A6 show that these improvements were concentrated in games measuring analysis and visual identification skills, while there is no significant effect of treatment on scores in mathematics or memory games. Our findings of improvement in visual identification skills and the absence of findings on improvements of mathematical skills are broadly consistent with results from clinical studies on the impact of iron supplementation on cognitive abilities (Bruner et al. 1996, Lambert et al. 2002).[35]

Treatment effect estimates for both anemia and cognitive functioning are robust to the inclusion of family background controls.

B. *School Performance*

As described earlier, the main caveat of these and similar results in the literature on supplementation is that it is unclear the extent to which these changes in cognitive test scores are associated with improvements in school performance. Hence, we next examine the central outcome of interest in this study—whether these potentially small changes in cognitive functioning impact academic achievement. Our measure of academic achievement is a standardized average of a student's grades from the fall semester in the following subjects: math, foreign language, social sciences, science, and communications. The other five school subjects—art, religion, physical education, vocational education, and human relations—are excluded from the grade index due to the fact that grades in these subjects are based largely on attendance and assignment completion, and hence are not anticipated to be influenced by cognitive ability.[36] As such, the excluded subjects form the basis of a placebo check in which we verify that there is indeed zero effect of treatment on grades in these subjects.

Given that the end of the study period coincided with the end of the 2009 academic year, we also measure grade promotion by whether a student who was enrolled in school at the end of the 2009 academic year proceeded to the next grade at the onset of the 2010 academic year, roughly three months after the study period ended. Although dropout during the school year is high, the vast majority of students who complete the academic year reenroll the following academic year (that is, dropout is concentrated during the first half of the academic year), so a reasonably accurate measure of promotion can be constructed from school records in 2010.

Table 5 suggests that the increased take-up of iron pills does not have any impact on the subsample that was not originally iron deficient (columns 2 and 4). However, consistent with all previous results, treatment has a large and significant impact on

[35] One caveat is that cognitive test categories employed in the existing literature do not perfectly map into cognitive categories distinguished by the various Wii games. In the existing literature, the most consistent results are positive effects on verbal skills and visual identification, while there is little evidence of effects on IQ, math, or vocabulary.

[36] The results are robust to including human relations—which include some ambiguous content such as writing assignments—in the set of subjects that are sensitive to cognitive ability. However, consistent with the prediction that achievement in this subject is unrelated to cognitive ability, grades in human relations have zero (0.007) correlation with cognitive test scores, unlike all other subjects, in which grades are positively correlated with cognitive tests. The only other exception is vocational education, which has a negative correlation with cognitive test scores.

TABLE 5—GRADES AND PROMOTION OUTCOMES

	Grades[a]				Promoted			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment	0.455	−0.098	0.434	−0.102	0.114	0.044	0.105	0.042
	(0.218)	(0.183)	(0.215)	(0.187)	(0.057)	(0.048)	(0.058)	(0.049)
Male student	−0.283	−0.497	−0.338	−0.484	0.073	−0.071	0.065	−0.076
	(0.217)	(0.178)	(0.218)	(0.183)	(0.057)	(0.047)	(0.059)	(0.048)
Monthly income (100 S/.)			−0.010	0.002			−0.002	−0.002
			(0.009)	(0.018)			(0.002)	(0.005)
Electricity in home			0.171	−0.101			0.089	−0.016
			(0.264)	(0.196)			(0.072)	(0.053)
Mother's years of schooling			0.082	0.031			0.009	0.006
			(0.031)	(0.034)			(0.008)	(0.009)
Wald test[b] (Prob > χ^2)	0.0349		0.0310		0.4005		0.4100	
Sample	Anem	Non-anem	Anem	Non-anem	Anem	Non-anem	Anem	Non-anem
Observations	89	126	89	126	86	120	86	120
Control mean[c]	11.179	11.733	11.179	11.733	0.862	0.902	0.862	0.902
Control SD[c]	0.965	1.346	0.965	1.346				

Note: Standard errors are in parentheses.

[a] Average grades of five subjects (math, foreign language, social science, science, and communications) in the third and fourth quarters of 2009. Averages have been standardized to the control group: $(Y_i - \mu_Y)/\sigma_Y$.

[b] Wald test for equality across columns.

[c] Control mean and standard deviation of the original (nonstandardized) grades.

grades for students who are anemic at baseline. Average grades of the treated anemic subsample improved over 0.45 standard deviations (columns 1 and 3) and the result is statistically significant. Although we did not make any predictions as to which subjects would be improved by the treatment, a post hoc breakdown is available in Appendix Tables A7, A8, and A9. The improvements were concentrated in English (foreign language), science, and social science classes, although the coefficients on treatment are positive across all subjects.[37] Reassuringly, there is no indication of a treatment effect of iron supplementation among the subpopulation of non-anemic students, who provide a form of quasi-control group in that they should not experience any physiological benefits from greater iron availability. This provides evidence against Hawthorne effects contributing to the change in outcomes, which is always a concern in unblinded experiments.

Anemic students exposed to promotional videos were also considerably more likely to be promoted to the next grade level in 2010 (columns 5 and 7 in Table 5). Although the difficulty of not observing progression in those who leave school complicate our data,[38] we take these results as suggestive (if not conclusive) that the

[37] Our results might be concentrated in three of the five subjects due to differences in grading standards across teachers. This is unlikely because teachers did not know which students were assigned to the treatment and control groups. However, to account for this possibility, we estimate regressions including teacher-level indicator variables. Appendix Table A10 suggests that differences in teacher standards do not drive our results: they are robust to controlling for teacher effects.

[38] Grade progression is gleaned from class records from the 2010 academic year. Students in grade five who completed all four quarters of the year and do not appear in the roster in 2010 are assumed to have progressed. Nine students (three anemic) below grade four fail to reenroll and are thus treated as missing, as it is difficult to determine whether they would have progressed had they not dropped out. However, since there is no significant treatment

intervention made students more likely to progress to the next grade. Based on the control mean, anemic students are less likely than non-anemic students to advance to the next grade (86 percent versus 90 percent). However, anemic students in the treatment, whose likelihood of grade promotion increased by 11 percent on account of iron supplements, achieved a rate of promotion slightly higher than non-anemic students.[39]

The results presented in Table 5 are based on an intent-to-treat specification. Although we take 500 mg as the "sufficient dose" to induce improvement in various cognitive and educational outcomes based on previous studies, we also cannot rule out the possibility that smaller doses may also have an impact on anemic studies. Roughly 80 percent of treated students who suffered from IDA at baseline took at least 100 mg of iron (1 pill) over the course of the study; roughly 53 percent of treated students who suffered from IDA at baseline took at least 500 mg of iron (5 pills). Thus, we estimate that the average treatment effect on the treated would be in the range of 0.58 standard deviations and 0.9 standard deviations improvement in average grades. These implied effects are large, although perhaps not implausibly so; regardless, given the large confidence intervals, we also cannot rule out more moderate effects of supplements on performance.

C. *Aspirations*

Our final outcome of interest is the impact of iron supplementation on students' aspirations for the future.[40] We construct a measure of perceived upward mobility based on two outcomes from the student survey: whether a student intended to leave his or her home town after high school; and whether a student intended to continue in either college or technical school following graduation from secondary school. The index takes on a value of 0, 0.5, or 1 based on students' answers to these two questions. At baseline, 82 percent of students reported planning to leave town after high school, 83 percent of students reported planning to attend college or technical school, and 68 percent report both.

The regression results reported in Table 6 reveal that iron supplementation also brought about a significant increase in perceived upward mobility. Consistent with the previous pattern of results, the effect is small and insignificant among students that were not anemic at baseline (columns 2 and 4). However, among previously

effect on whether students leave school at the end of the 2009 school year (Appendix Table A11), this assumption is unlikely to bias the results. Moreover, the results are robust to calculating based on grades whether each of these nine individuals appears eligible to progress to the next grade, and to assuming that students that completed grade five but who failed at least one class do not progress.

[39] It is possible that anemic students who received iron supplements were rewarded for greater effort rather than better performance in school, but given the exam-based grading practices in this environment, we think it is safe to assume that higher grades reflect better performance on tests.

[40] Note that given the large set of outcomes variables, we also report an omnibus test of joint significance in Appendix Table A13, for all outcomes, the results of which suggest that our interpretation of the effects of the program on the anemic subsample are legitimate. We also estimate *p*-values adjusted for the Family-Wise Error Rate (FWER) for the four families of outcomes: cognitive ability, grades, grade promotion, and aspirations. Our results for cognitive ability and aspirations remain significant (among the anemic subsample) at conventional levels when the SEs are adjusted to account for the FWER, while the results on grades and promotion become insignificant. Although one interpretation is that this deems our results on grades invalid, it is worth noting that FEWR adjustments are quite demanding given the small scale of our intervention. This table is reported in the online Appendix.

Table 6—Upward Mobility

	Index of perceived upward mobility			
	(1)	(2)	(3)	(4)
Treatment	0.175	0.008	0.170	0.025
	(0.062)	(0.058)	(0.064)	(0.058)
Male student	0.045	−0.054	0.048	−0.058
	(0.061)	(0.055)	(0.066)	(0.056)
Monthly income (100 S/.)			0.001	0.005
			(0.002)	(0.005)
Electricity in home			0.013	−0.151
			(0.082)	(0.060)
Mother's years of schooling			−0.003	0.006
			(0.009)	(0.010)
Wald test (Prob > χ^2)	0.0537		0.0935	
Sample	Anemic	Non-anemic	Anemic	Non-anemic
Observations	81	121	81	121
Control mean	0.660	0.775	0.660	0.775

Notes: Wald test for equality across columns. Standard errors are in parentheses.

Table 7—Upward Mobility Outcomes

	Leave hometown				Continue school			
	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Treatment	0.289	0.008	0.297	0.032	0.065	0.048	0.049	0.053
	(0.110)	(0.090)	(0.115)	(0.088)	(0.075)	(0.062)	(0.078)	(0.063)
Male student	0.023	−0.083	0.028	−0.101	0.060	−0.018	0.055	−0.011
	(0.109)	(0.087)	(0.117)	(0.086)	(0.075)	(0.060)	(0.080)	(0.061)
Monthly income (100 S/.)			0.001	0.005			0.001	0.006
			(0.004)	(0.008)			(0.003)	(0.006)
Electricity in home			−0.066	−0.295			0.113	−0.021
			(0.142)	(0.093)			(0.099)	(0.066)
Mother's years of schooling			0.002	−0.011			−0.008	0.019
			(0.017)	(0.016)			(0.011)	(0.011)
Wald test (Prob > χ^2)	0.0484		0.0601		0.8752		0.9708	
Sample	Anem	Non-anem	Anem	Non-anem	Anem	Non-anem	Anem	Non-anem
Observations	82	124	82	124	82	122	82	122
Control mean	0.462	0.667	0.462	0.667	0.846	0.854	0.846	0.854

Notes: Wald test for equality across columns. Standard errors are in parentheses.

anemic students, treatment results in a 27 percent increase in expectations for the future and the effect is significant at the 1 percent level (columns 1 and 3). However, only one of the individual measures—leaving town—is significant on its own, as shown in Table 7 (columns 1 and 3). While it is possible that the information provided in the videos reinforced supplement-takers' beliefs about the returns to iron pills and hence contributed to changes in their perceptions of economic mobility, the fact that changes in beliefs are only experienced by anemic students who take pills (and anemia is likely to be unobservable to the student) suggests that at least some of the effect is a response to real improvements in cognition or academic achievement.

This result is striking because it indicates that not only are small differences in own cognitive ability immediately salient to individuals, but that aspirations for the future adapt almost immediately to changes in ability. One could imagine that self-confidence is far more entrenched and reinforced by parental and teacher expectations and perceptions of ability, which are unlikely to adjust quickly to treatment exposure. If aspirations are an important determinant of achievement, this suggests that small differences in cognitive ability have the potential to help individuals attain economic mobility even when the reversal occurs relatively late in life when individual identity is fairly well formed.

This result contributes to a growing body of work documenting influences on individual aspirations for the future. Overall, the literature on aspiration formation has focused mainly on the effect of direct or indirect encouragement from role models (Beaman et al. 2012, Miller and Connolly 2013, Vakis and Macours 2014, and Nguyen 2008). This study thus provides novel evidence that improvements in one's own health can lead to immediate improvements in aspirations of future mobility.

D. *Peer Effects*

The design of the intervention also randomized the assignment of students' siblings into the treatment and control groups, thus creating exogenous variation in the assignment of siblings to the treatment. In Appendix Table A12, we restrict the sample to students who have siblings in the same school (43 percent of all the students in the sample) and compare the characteristics of those whose siblings were assigned to the treatment and control group. In the anemic subsample, those who had siblings in the treatment group lived closer to the school and weighed more at baseline. However, there are no statistically significant differences in most dimensions.

As shown in Table 8, we also see evidence of spillover effects of the media messages within households.[41] Students who had a sibling randomly assigned to the intervention experienced a significant improvement in grades relative to those whose sibling was not *over and above* the direct benefit they experienced from being exposed to the messages themselves. While we do not find statistically significant effects among students that were not previously anemic (columns 2 and 4 in Table 8), there is a large and positive impact on the subset of students with iron deficiencies at baseline (columns 1 and 3 in Table 8).[42]Among the anemic subsample, having a sibling treated had almost the same effect on grade attainment as did being treated alone, and was additive to one's own exposure to media messages.[43] This impact is also reflected in analogous regressions on anemia at endline (unreported): having a

[41] There may also be important peer effects among friends and neighbors, but we cannot observe those links in our data. Spillovers within classrooms are also possible, but there are too few classrooms in our data to investigate this empirically.

[42] Our results are robust to controlling for the above-mentioned baseline imbalances between those who had siblings in the treatment group and those who did not in the regressions (not reported). However, we cannot completely rule out the possibility that these groups differ on some unobservable dimension, which may relate to the size of the estimates.

[43] However, it is worth pointing out that the estimates are not precise enough to rule out substantially smaller indirect (peer) effects relative to the direct effects.

Table 8—Grade[a] Outcomes with Siblings

	(1)	(2)	(3)	(4)
Treatment	0.430	−0.057	0.410	−0.061
	(0.206)	(0.190)	(0.190)	(0.198)
Male student	−0.318	−0.502	−0.363	−0.487
	(0.221)	(0.179)	(0.231)	(0.180)
Has sibling	−0.514	−0.343	−0.447	−0.328
	(0.204)	(0.258)	(0.238)	(0.258)
Has sibling in treatment	0.672	0.391	0.479	0.380
	(0.238)	(0.272)	(0.236)	(0.276)
Monthly income (100 S/.)			−0.009	0.002
			(0.006)	(0.017)
Electricity in home			0.204	−0.099
			(0.255)	(0.259)
Mother's years of schooling			0.078	0.028
			(0.027)	(0.033)
Wald test[b] (Prob $> \chi^2$)	0.0722		0.0677	
Sample	Anemic	Non-anemic	Anemic	Non-anemic
Observations	89	126	89	126
Control mean[c]	11.342	11.697	11.342	11.697
Control SD[c]	0.982	1.451	0.982	1.451

Note: Standard errors are in parentheses.

[a]Average grades of five subjects (math, foreign language, social science, science, and communications) in the third and fourth quarters of 2009. Averages have been standardized to the control group: $(Y_i - \mu_Y)/\sigma_Y$.

[b]Wald test for equality across columns.

[c]Control mean and standard deviation of the original (nonstandardized) grades.

sibling exposed to promotional videos is associated with a 31 percent reduction in anemia at follow-up, although the effect is noisily estimated.[44]

This result suggests that not only are siblings sharing information about the media messages they receive (such that being exposed directly is indistinguishable from having a sibling exposed), but they are also increasing the likelihood of pill take-up through other channels such as encouraging one another to go to the clinic. This pattern implies that promotional videos are not only cheap on a per capita basis, but have a multiplier effect that makes them even more cost-effective. That is, one individual's exposure to a promotional message is equivalent to exposing more than one individual to that message by way of positive take-up externalities. These are likely to be particularly important among adolescents, whose decision to visit a clinic may be highly dependent on the take-up behavior of friends or siblings.

The results are consistent with a number of other findings in the literature that document significant positive peer effects on education outcomes, although the mechanism we highlight is different than that most often discussed in the literature on sibling spillovers.[45] While most of the existing literature emphasizes learning from peers, our results indicate that peer effects on pill take-up in this setting operate

[44]Some of the higher overall treatment effect estimates are due to the fact that this subsample of students with siblings at school are relatively worse off in terms of family background, as is reflected in the significant negative coefficient estimate on the indicator for "Has Sibling."

[45]For example, see Baird et al. (2014); Barrera-Osorio et al. (2011); Garces, Thomas, and Currie (2002); and Qureshi (2011) for evidence from various settings.

mainly through reducing transportation costs or encouraging imitation, which we deduce from the fact that sibling effects are equally large regardless of whether the second sibling has been exposed to the same information.

E. *Selective Take-Up*

Our results show that simple low-cost promotional materials can dramatically increase the take-up of iron pills made available through a public clinic. While only 42 percent of students who were not exposed to video messages promoting iron supplementation took up the minimum dose suspected to have an impact (500 mg) over the course of the study, 59 percent of those exposed to the videos took at least this much iron over the 10-week period. Among anemic students, the rate rose from 41 percent to 53 percent.

These rates mean that resource-constrained governments that are unable to deliver iron supplements directly to adolescents can achieve very high coverage simply by reminding students of the benefits of supplementation on a regular basis. This intervention could be scaled up fairly cheaply by providing video materials to be shown in classrooms, as was done in our experiment, through television spots aired at moments of prime adolescent viewership, or in public Internet kiosks.

Back-of-the-envelope calculations comparing an encouragement-type program against a doorstep program in the style of WIFS, clearly show the cost-effectiveness of a media-based encouragement design. Our estimates suggest that an encouragement program along the lines of the one evaluated by this study would reduce the cost per case of anemia prevented by over 90 percent, and that the cost of an encouragement program per student would be less than a twelfth of that of a doorstep program.[46]

Since the program achieved high but not universal coverage, one important question is whether media messages improve or worsen the targeting of supplements to those who have the potential to benefit. That is, what type of students are encouraged by media messages to take up iron pills on a high enough frequency basis to potentially matter for school performance? We can learn something about selection into treatment from a simple comparison of baseline observable characteristics across those who do and do not take up iron pills in the treatment versus the control group, which reveals how the average characteristics of responders changes when we include those who are influenced to take up pills from the clinic on account of media messages.

Table 9 presents means of a range of household and individual characteristics across all four subgroups, and the last column of the table shows the significance of the difference-in-difference in means. For ease of comparison, we divide the sample somewhat arbitrarily into those who took more than 500 mg of iron over the course of the study and those who took less than that, which attains a reasonably balanced

[46] Calculating the costs of a doorstep program are based on the details provided about WIFS in WHO (2011b). We assume that the encouragement program requires substantially less time from a trained health professional, incurs no cost of delivering pills to schools, and consumes fewer pills, but, conversely, leads to less reduction in anemia. These calculations hold even assuming that a doorstep program reduces anemia at nearly double the rate of an encouragement design.

Table 9—Five or Fewer Pills versus More than Five

Variable	Treatment group			Control group			
	≤ 5 pills mean	> 5 pills mean	Diff	≤ 5 pills mean	> 5 pills mean	Diff	Diff-in-diff
Male	0.565	0.420	0.145	0.617	0.560	0.057	0.088
	(0.500)	(0.497)	(0.084)	(0.491)	(0.507)	(0.123)	(0.149)
Age (months)	184.474	176.864	7.610	181.969	181.688	0.281	7.329
	(20.197)	(20.724)	(3.459)	(20.766)	(26.522)	(5.669)	(6.389)
Distance to school (hours)	0.854	0.591	0.263	0.827	0.587	0.241	0.022
	(0.807)	(0.541)	(0.115)	(0.785)	(0.487)	(0.175)	(0.207)
Baseline hemoglobin level	12.617	12.792	−0.175	13.326	12.507	0.820	−0.994
	(2.383)	(1.968)	(0.367)	(2.322)	(1.977)	(0.547)	(0.653)
Baseline anemia status	0.484	0.370	0.114	0.362	0.480	−0.118	0.232
	(0.504)	(0.486)	(0.083)	(0.486)	(0.510)	(0.122)	(0.148)
Height (cm)	149.049	147.301	1.748	151.830	148.104	3.726	−1.978
	(8.210)	(9.083)	(1.485)	(8.625)	(9.982)	(2.256)	(2.660)
Weight (kg)	47.126	45.846	1.280	48.902	45.956	2.946	−1.666
	(8.805)	(9.182)	(1.533)	(8.132)	(7.895)	(1.993)	(2.615)
Number members in household	5.806	5.802	0.004	5.574	6.120	−0.546	0.550
	(1.990)	(1.813)	(0.319)	(2.061)	(2.048)	(0.509)	(0.584)
2009 first quarter grades	11.900	12.343	−0.443	11.974	11.808	0.166	−0.610
	(1.132)	(1.117)	(0.190)	(0.977)	(1.335)	(0.275)	(0.335)
Grade at baseline	2.855	2.568	0.287	2.745	2.800	−0.055	0.342
	(1.377)	(1.322)	(0.227)	(1.375)	(1.291)	(0.333)	(0.403)
Monthly income (100 S/.)	8.704	6.870	1.834	7.148	10.583	−3.436	5.270
	(13.039)	(4.459)	(1.554)	(5.706)	(9.587)	(1.801)	(2.581)
Mother's years of education	2.952	3.862	−0.911	3.085	3.760	−0.675	−0.236
	(2.557)	(3.452)	(0.524)	(2.636)	(2.454)	(0.637)	(0.879)
Owns land	0.774	0.877	−0.102	0.830	0.880	−0.050	−0.052
	(0.422)	(0.331)	(0.063)	(0.380)	(0.332)	(0.090)	(0.111)
Father present in HH	0.758	0.741	0.017	0.830	0.840	−0.010	0.028
	(0.432)	(0.441)	(0.074)	(0.380)	(0.374)	(0.094)	(0.125)
Size of house (m^2)	115.581	106.111	9.470	110.468	90.840	19.628	−10.159
	(131.359)	(121.544)	(21.242)	(62.628)	(55.058)	(14.887)	(32.529)
Index of Perceived Upward Mobility[a]	1.672	1.649	0.023	1.543	1.792	−0.248	0.271
	(0.539)	(0.507)	(0.089)	(0.622)	(0.415)	(0.141)	(0.163)
Has sibling	0.419	0.432	−0.013	0.447	0.440	0.007	−0.020
	(0.497)	(0.498)	(0.084)	(0.503)	(0.507)	(0.125)	(0.150)
Total Computer Time (hours)[b]	6.371	9.000	−2.629	6.617	9.520	−2.903	0.274
	(4.653)	(6.313)	(0.954)	(5.281)	(6.449)	(1.413)	(1.699)
Household electricity	0.787	0.722	0.065	0.674	0.720	−0.046	0.111
	(0.413)	(0.451)	(0.074)	(0.474)	(0.458)	(0.116)	(0.135)
Joint *F*-test (Wald test)		40.84			40.84		
Observations	62	81		47	25		

Note: Standard errors are in parentheses.

[a] Index of Perceived Upward Mobility is an index of whether the student plans to leave their hometown after graduation, and whether they plan to continue their education after graduation.

[b] Total Computer Time refers to the number of hours the student spent on a computer through the program.

distribution of students across the four subgroups. Three main compositional effects stand out from this exercise. First, we observe that, although in the control group responders come from similar socioeconomic backgrounds as nonresponders, in the

treatment group pill-takers are significantly poorer than those who do not take iron pills, indicating that responders are relatively poor. Interestingly, however, they are also relatively high performers in terms of school grades at baseline, but have relatively low aspirations for the future. Hence, while treatment does not succeed in encouraging those who are disproportionately anemic to seek supplements, it also does not influence only those who are sufficiently iron replete. In this sense (reaching the relatively poor), the intervention manages to achieve some degree of positive self-targeting, which is a standard hurdle for information-based interventions given that they tend to work best among the relatively well-off.

Although it is difficult to be certain, this particular subpopulation also may be one for which supplements have a disproportionately large potential effect on school performance. In particular, they are vulnerable to anemia but do not face other significant barriers to schooling attainment. The fact that they update aspirations so readily in response to treatment suggests that these are students who have been struggling against an achievement barrier that has now been relaxed. The fact that the messages work best on students that are high performers also suggests that the videos are filling an information gap and not motivating take-up through some other channel such as imitation, which also explains why the information conveyed by the doctor had just as large an effect on take-up as the same information conveyed by the soccer star.

III. Conclusion

A key question in development economics is the degree to which nutrition-based poverty traps, which arise when economic outcomes are predetermined by the amount of nutrients an individual consumes, constrain households or regions from escaping poverty. Our results indicate that iron deficiency, which is thought to be the most prevalent micronutrient deficiency in the world, is a significant deterrent to human capital accumulation among adolescents in developing countries, and hence a potentially important barrier to economic growth.

Furthermore, our results indicate that brief media messages are a highly effective means of encouraging adolescents to take advantage of supplements made available through public clinics. In 1993, the WHO recommended actions for the development of assessment, advocacy, prevention, and control initiatives in most countries to reduce anemia among adolescent girls. Yet, while effective, national WIFS programs are extremely costly to implement and thus out of the question in many resource-poor settings.

Furthermore, even when programs like WIFS are put into place, it may be difficult to reach adolescents who are not in school. Our results demonstrate that the passive distribution of iron supplements through health clinics can achieve very high rates of compliance among anemic adolescents with the addition of simple, low-cost media messages delivered on a regular basis. Similar programs could be implemented at scale in much of the world at a much lower cost than current WIFS recommendations.

Appendix

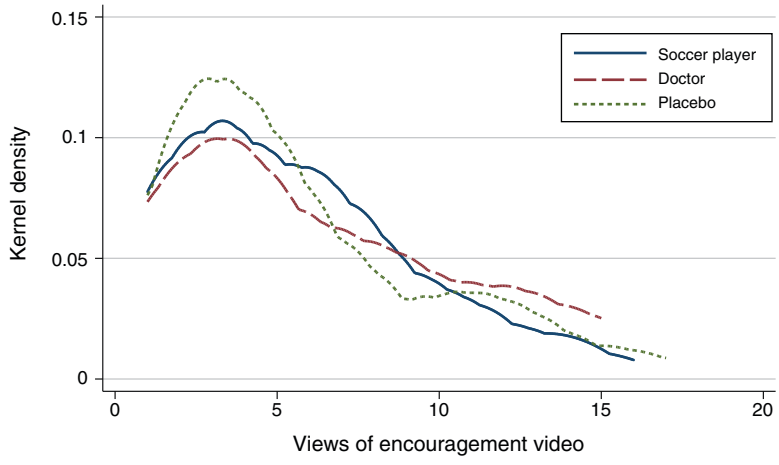

Figure A1. Distribution of Video Sessions by Treatment Assignment

Table A1—Comparison of Sample in the Study and Secondary Students in Rural Peru

	Study sample	Rural Peru
Mother's years of schooling[a]	3.40	4.05
	(2.94)	(3.30)
Electricity[a]	0.73	0.72
	(0.45)	(0.45)
Household income[a]	7.89	9.32
	(8.65)	(9.96)
Male[a]	0.52	0.54
	(0.50)	(0.50)
Age[a]	15.06	14.72
	(1.78)	(2.01)
Hemoglobin levels[b]	12.31	12.94
	(1.85)	(1.23)
Height (cm)[b]	148.71	151.28
	(3.56)	(5.40)
Weight (kg)[b]	51.30	51.14
	(5.11)	(6.64)
Number of students in school[c]	204	102.00
		(69.85)
Number of teachers[c]	13	8.51
		(3.23)
Students per teacher[c]	15.69	11.61
		(5.21)

Note: Standard errors are in parentheses.

[a]Data for mother's years of education, electricity, household income, gender, and age come from our survey and the 2012 Peruvian National Household Survey (ENAHO). The data for ENAHO has been restricted to students enrolled in public high schools in rural areas.

[b]Data for hemoglobin levels, height, and weight come from our survey and the 2012 Peruvian Demographic Household Survey (ENDES). For comparability with the ENDES, we have restricted our sample to girls that are 15 years or older.

[c]Data for enrollment and number of teachers come from the 2013 National School Survey.

TABLE A2—SUMMARY STATISTICS FOR OUTCOMES

Variable	Anemic subsample			Non-anemic subsample		
	Treatment mean (1)	Control mean (2)	Observations (T/C) (3)	Treatment mean (4)	Control mean (5)	Observations (T/C) (6)
Number of pills taken	8.783	7.862	60/29	12.198	4.651	81/43
Anemia	0.383	0.586	60/29	0.444	0.419	81/43
Cognitive functions	486.39	405.786	59/28	478.61	496.952	77/42
Grades[a]	0.051	−0.348	60/29	0.047	0.09	81/43
Promoted	0.965	0.862	57/29	0.949	0.902	78/41
Index of Perceived Upward Mobility[b]	0.830	0.660	56/25	0.791	0.775	79/40
Leave hometown	0.750	0.462	56/26	0.688	0.667	80/42
Continue school	0.911	0.846	56/26	0.899	0.854	79/41

[a] Average grades of five subjects (math, foreign language, social science, science, and communications) in the third and fourth quarters of 2009. Averages have been standardized to the control group: $(Y_i - \mu_Y)/\sigma_Y$.
[b] Perceived Upward Mobility is an index of whether the student plans to leave their hometown after graduation and whether they plan to continue their education after graduation.

TABLE A3—HEALTH OUTCOMES

	Days missed				Minutes run			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment	0.993	0.230	1.175	0.314	−0.333	−6.542	−1.260	−6.077
	(1.140)	(0.765)	(1.189)	(0.788)	(5.059)	(4.130)	(5.175)	(4.173)
Male student	0.376	0.384	0.201	0.393	3.731	0.459	4.582	1.078
	(1.205)	(0.747)	(1.251)	(0.758)	(5.078)	(4.022)	(5.311)	(4.084)
Monthly income (100 S/.)			0.010	0.051			−0.339	0.247
			(0.090)	(0.071)			(0.205)	(0.398)
Electricity in home			−0.591	0.053			1.693	0.306
			(1.548)	(0.785)			(6.412)	(4.434)
Mother's years of schooling			−0.305	0.210			−0.006	−1.021
			(0.163)	(0.140)			(0.758)	(0.760)
Wald test (Prob > χ^2)	0.5517		0.5166		0.2996		0.4108	
Sample	Anem	Non-anem	Anem	Non-anem	Anem	Non-anem	Anem	Non-anem
Observations	61	91	61	91	83	124	83	124
Control mean	2.900	2.485	2.900	2.485	21.370	27.651	21.370	27.651

Notes: Wald test for equality across columns. Standard errors are in parentheses.

Table A4—Cognitive Function—Identify and Memorize Outcomes

	Identify				Memorize			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment	27.536	−3.544	25.877	−3.520	7.018	−9.723	6.199	−11.683
	(12.473)	(8.820)	(12.286)	(8.834)	(13.619)	(11.378)	(13.614)	(11.212)
Male student	37.198	13.096	34.030	14.101	27.962	17.472	26.243	16.876
	(12.471)	(8.673)	(12.468)	(8.738)	(13.618)	(11.188)	(13.816)	(11.090)
Monthly income (100 S/.)			−0.082	0.665			−0.398	−0.787
			(0.495)	(0.834)			(0.549)	(1.058)
Electricity in home			21.797	18.884			9.891	17.282
			(14.873)	(9.233)			(16.481)	(11.718)
Mother's years of schooling			3.024	0.592			4.352	3.783
			(1.783)	(1.635)			(1.976)	(2.076)
Wald test (Prob $> \chi^2$)	0.045		0.048		0.3504		0.2951	
Sample	Anem	Non-anem	Anem	Non-anem	Anem	Non-anem	Anem	Non-anem
Observations	87	121	87	121	87	121	87	121
Control mean	100.214	126.095	100.214	126.095	88.429	105.833	88.429	105.833

Notes: Wald test for equality across columns. Standard errors are in parentheses.

Table A5—Cognitive Function—Analyze and Compute Outcomes

	Analyze				Compute			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment	27.593	−2.199	27.774	−3.038	11.425	8.230	9.877	8.135
	(9.201)	(6.995)	(9.299)	(7.016)	(10.686)	(8.514)	(10.401)	(8.438)
Male student	26.531	14.129	25.010	15.356	3.900	2.861	2.784	3.556
	(9.200)	(6.878)	(9.437)	(6.939)	(10.685)	(8.372)	(10.555)	(8.346)
Monthly income (100 S/.)			−0.086	−0.065			0.317	0.598
			(0.375)	(0.662)			(0.419)	(0.796)
Electricity in home			1.876	11.495			11.132	19.348
			(11.258)	(7.332)			(12.591)	(8.819)
Mother's years of schooling			2.940	1.907			3.644	1.373
			(1.350)	(1.299)			(1.509)	(1.562)
Wald test (Prob $> \chi^2$)	0.0139		0.0092		0.8115		0.8906	
Sample	Anem	Non-anem	Anem	Non-anem	Anem	Non-anem	Anem	Non-anem
Observations	87	121	87	121	87	121	87	121
Control mean	85.214	107.190	85.214	107.190	98.179	113.214	98.179	113.214

Notes: Wald test for equality across columns. Standard errors are in parentheses.

TABLE A6—COGNITIVE FUNCTION—VISUALIZE OUTCOMES

	(1)	(2)	(3)	(4)
Treatment	13.067	−4.381	11.038	−3.714
	(8.930)	(5.593)	(8.448)	(5.660)
Male student	15.198	5.812	14.672	6.827
	(8.928)	(5.499)	(8.573)	(5.599)
Monthly income (100 S/.)			−0.403	0.751
			(0.340)	(0.534)
Electricity in home			14.315	6.426
			(10.227)	(5.916)
Mother's years of schooling			3.580	0.113
			(1.226)	(1.048)
Wald test (Prob > χ^2)	0.0794		0.1267	
Sample	Anem	Non-anem	Anem	Non-anem
Observations	87	121	87	121
Control mean	33.750	44.619	33.750	44.619

Notes: Wald test for equality across columns. Standard errors are in parentheses.

TABLE A7—COMMUNICATION AND ENGLISH GRADES[a]

	Communication				English			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment	0.065	0.175	0.083	0.172	0.397	−0.206	0.378	−0.209
	(0.216)	(0.177)	(0.213)	(0.179)	(0.222)	(0.186)	(0.228)	(0.188)
Male student	−0.335	−0.516	−0.461	−0.503	−0.371	−0.428	−0.412	−0.385
	(0.215)	(0.173)	(0.216)	(0.176)	(0.222)	(0.181)	(0.231)	(0.184)
Monthly income (100 S/.)			0.002	0.003			−0.011	0.010
			(0.009)	(0.017)			(0.009)	(0.018)
Electricity in home			0.237	−0.240			0.269	−0.037
			(0.262)	(0.188)			(0.279)	(0.197)
Mother's years of schooling			0.069	0.052			0.028	0.059
			(0.031)	(0.033)			(0.033)	(0.034)
Wald test[b] (Prob > χ^2)	0.686		0.733		0.020		0.023	
Sample	Anem	Non-anem	Anem	Non-anem	Anem	Non-anem	Anem	Non-anem
Observations	89	126	89	126	89	126	89	126
Control mean[c]	12.034	12.012	12.034	12.012	11.741	12.698	11.741	12.698
Control SD[c]	1.369	2.272	1.369	2.272	1.360	2.027	1.360	2.027

Note: Standard errors are in parentheses.

[a] Average grades in the third and fourth quarters of 2009. Averages have been standardized to the control group: $(Y_i - \mu_Y)/\sigma_Y$.

[b] Wald test for equality across columns.

[c] Control mean and standard deviation of the original (nonstandardized) grades.

TABLE A8—MATH AND SCIENCE GRADES[a]

	Math				Science			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment	0.190	−0.181	0.128	−0.178	0.377	−0.055	0.380	−0.062
	(0.231)	(0.183)	(0.226)	(0.186)	(0.227)	(0.180)	(0.228)	(0.185)
Male student	−0.134	−0.138	−0.091	−0.137	−0.086	−0.314	−0.081	−0.342
	(0.230)	(0.179)	(0.230)	(0.182)	(0.226)	(0.176)	(0.231)	(0.181)
Monthly income (100 S/.)			−0.013	0.001			−0.001	−0.008
			(0.009)	(0.018)			(0.009)	(0.018)
Electricity in home			0.105	−0.303			−0.264	−0.011
			(0.278)	(0.195)			(0.280)	(0.194)
Mother's years of schooling			0.055	0.024			0.071	−0.002
			(0.032)	(0.034)			(0.033)	(0.034)
Wald test[b] (Prob > χ^2)	0.1713		0.2447		0.1059		0.0857	
Sample	Anem	Non-anem	Anem	Non-anem	Anem	Non-anem	Anem	Non-anem
Observations	89	126	89	126	89	126	89	126
Control mean[c]	10.621	11.140	10.621	11.140	10.983	11.686	10.983	11.686
Control SD[c]	1.265	1.737	1.265	1.737	1.526	1.626	1.526	1.626

Note: Standard errors are in parentheses.
[a]Average grades in the third and fourth quarters of 2009. Averages have been standardized to the control group: $(Y_i - \mu_Y)/\sigma_Y$.
[b]Wald test for equality across columns.
[c]Control mean and standard deviation of the original (nonstandardized) grades.

TABLE A9—SOCIAL SCIENCE GRADES[a]

	(1)	(2)	(3)	(4)
Treatment	0.549	−0.158	0.535	−0.165
	(0.198)	(0.176)	(0.194)	(0.177)
Male student	0.018	−0.615	−0.052	−0.586
	(0.197)	(0.172)	(0.197)	(0.173)
Monthly income (100 S/.)			−0.014	−0.001
			(0.008)	(0.017)
Electricity in home			0.243	0.387
			(0.238)	(0.185)
Mother's years of schooling			0.067	−0.046
			(0.028)	(0.032)
Wald test[b] (Prob > χ^2)	0.0116		0.0094	
Observations	89	126	89	126
Sample	Anem	Non-anem	Anem	Non-anem
Control mean[c]	10.517	11.128	10.517	11.128
Control SD[c]	1.448	1.287	1.448	1.287

Note: Standard errors are in parentheses.
[a]Average grades in the third and fourth quarters of 2009. Averages have been standardized to the control group: $(Y_i - \mu_Y)/\sigma_Y$.
[b]Wald test for equality across columns.
[c]Control mean and standard deviation of the original (nonstandardized) grades.

TABLE A10—GRADES BY SUBJECT (*pooled data*[a])

	Anemic		Non-anemic	
	(1)	(2)	(3)	(4)
Treatment	−0.047	−0.065	0.138	0.137
	(0.317)	(0.304)	(0.347)	(0.349)
Treatment × English	0.804	0.799	−0.541	−0.546
	(0.366)	(0.368)	(0.362)	(0.363)
Treatment × math	0.311	0.306	−0.497	−0.503
	(0.328)	(0.331)	(0.355)	(0.357)
Treatment × science	0.618	0.613	−0.265	−0.271
	(0.365)	(0.367)	(0.287)	(0.288)
Treatment × social science	0.715	0.711	−0.388	−0.393
	(0.377)	(0.379)	(0.344)	(0.345)
Male student	−0.273	−0.324	−0.701	−0.687
	(0.235)	(0.232)	(0.251)	(0.249)
Observations	445	445	630	630
Control mean	11.179	11.179	11.733	11.733
Controls[b]	No	Yes	No	Yes
$\beta_{English}$[c]	0.757	0.733	−0.404	−0.409
	(0.355)	(0.351)	(0.378)	(0.378)
β_{Math}[c]	0.264	0.240	−0.360	−0.366
	(0.297)	(0.279)	(0.323)	(0.325)
$\beta_{Science}$[c]	0.572	0.547	−0.128	−0.134
	(0.336)	(0.323)	(0.321)	(0.323)
$\beta_{SocScience}$[c]	0.668	0.646	−0.250	−0.256
	(0.273)	(0.264)	(0.222)	(0.230)

Note: Standard errors (clustered at the student level) are in parentheses.

[a]Pooled data of grades in five courses (communications, English, math, science, and social science). Specification: $Grade_{ic} = \beta Treatment_i + \theta_c Course_c + \gamma_c Treatment_i Course_c + \gamma_c Teacher_c + \theta \mathbf{X}_i \ \varepsilon_{ic}$. Base category of the estimation is communications.

[b]Additional controls: monthly income, electricity at home, and mother's years of schooling.

[c]Sum of coefficients: $\beta + \gamma_c$.

TABLE A11—DROPPED OUT OUTCOMES

	(1)	(2)	(3)	(4)
Treatment	0.070	0.002	0.060	0.001
	(0.051)	(0.047)	(0.052)	(0.045)
Male student	0.069	0.004	0.050	−0.009
	(0.051)	(0.045)	(0.054)	(0.044)
Monthly income (100 S/.)			−0.001	−0.006
			(0.002)	(0.004)
Electricity in home			0.096	−0.138
			(0.062)	(0.048)
Mother's years of schooling			−0.007	−0.002
			(0.007)	(0.008)
Wald test (Prob > χ^2)	0.2183		0.2423	
Observations	72	113	72	113
Control mean	0.000	0.051	0.000	0.051

Notes: Wald test for equality across columns. Standard errors are in parentheses.

TABLE A12—SUMMARY OF STATISTICS FOR SIBLINGS[a]

Variable	Treatment	Control	Difference T–C All	Difference T–C Anemic	Observations (T/C)
Male	0.500	0.476	0.024	0.048	72/21
	(0.504)	(0.512)	(0.125)	(0.228)	
Age (months)	183.077	180.495	2.583	5.535	72/21
	(24.011)	(20.946)	(5.796)	(12.484)	
Distance to school (hours)	0.670	0.770	−0.101	−0.681	70/21
	(0.823)	(0.963)	(0.213)	(0.324)	
Baseline hemoglobin level	12.529	13.492	−0.963	−0.226	70/21
	(1.974)	(2.250)	(0.507)	(0.447)	
Baseline anemia status	0.431	0.286	0.145	N/A	72/21
	(0.499)	(0.463)	(0.122)		
Height (cm)	149.625	148.343	1.282	4.432	69/21
	(8.706)	(8.867)	(2.179)	(3.907)	
Weight (kg)	47.544	45.519	2.025	6.169	70/21
	(7.447)	(8.459)	(1.912)	(3.248)	
No. members in household	6.431	6.190	0.240	−0.419	72/21
	(1.743)	(1.806)	(0.436)	(0.796)	
2009 first quarter grades	12.147	11.695	0.452	0.459	72/21
	(1.129)	(0.689)	(0.260)	(0.424)	
Grade at baseline	2.972	2.667	0.306	0.328	72/21
	(1.424)	(1.278)	(0.346)	(0.794)	
Monthly income (100 S/.)	7.557	8.376	−0.819	−4.474	72/21
	(6.547)	(8.475)	(1.740)	(3.516)	
Mother's years of educ.	3.889	2.810	1.079	1.796	72/21
	(3.033)	(1.99)	(0.704)	(1.329)	
Owns land	0.778	0.905	−0.127	−0.258	72/21
	(0.419)	(0.301)	(0.098)	(0.184)	
Father present in HH	0.861	0.952	−0.0910	−0.161	72/21
	(0.348)	(0.218)	(0.080)	(0.154)	
Size of house (m^2)	115.458	93.952	21.506	27.720	72/21
	(163.986)	(42.743)	(36.266)	(71.988)	
Index of Perceived Upward Mobility[b]	1.618	1.571	0.046	0.056	68/21
	(0.574)	(0.598)	(0.145)	(0.305)	
Total Computer Time (hours)[c]	7.153	7.524	−0.371	−0.694	72/21
	(5.608)	(6.055)	(1.416)	(2.418)	
Household electricity	0.812	0.762	0.050	−0.006	69/21
	(0.394)	(0.436)	(0.101)	(0.174)	
Joint *F*-test (Wald test)			16.34	23.13	

Notes: Standard errors are in parentheses.

[a] Sample restricted to students who have siblings in the school.

[b] Index of Perceived Upward Mobility is an index of whether the student plans to leave their hometown after graduation, and whether they plan to continue their education after graduation.

[c] Total Computer Time refers to the number of hours the student spent on a computer through the program.

TABLE A13—MEAN EFFECT SIZES

	Mean effect size			
	Non-anemic		Anemic	
Estimate	−0.0650	−0.0631	0.2857	0.2645
SE	0.0931	0.0946	0.1053	0.0936
p-value	0.4848	0.5049	0.0067	0.0047
Controls	No	Yes	No	Yes
Observations	126	126	89	89

Notes: We estimate a system of seemingly unrelated regressions for grades (communication, English, math, science, and social science), cognitive function (identify, memorize, analyze, compute, and visualize), grade promotion, non-anemic status at endline, and aspirations (i.e., want to leave town and want to continue school upon graduation): $Y_{ki} = \beta Treat_i + \theta \mathbf{X}_i + \varepsilon_i$, where Y_k represents each of the k variables in each family and X_i is a basic set of controls (gender and class in 2009). The mean effect is given by $\tau = \frac{1}{K}\sum_{k=1}^{K} \beta_k$.

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Online Appendix: "Iron Deficiency and Schooling Attainment in Peru"

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Table O.A.1: Summary Statistics by Treatment Group

Variable	(1) Treat 1 - Soccer (Mean)	(2) Treat 2 - Physician (Mean)	(3) Control (Mean)	(4) Treat 1 vs Control (P-Value)	(5) Treat 2 vs Control (P-Value)	(6) N (Treat 1 / Treat 2 / Control)
Male	0.514	0.452	0.597	0.323	0.081*	70/73/72
Age (months)	181.462	178.919	181.871	0.913	0.408	70/73/72
Distance to school (hours)	0.756	0.654	0.746	0.935	0.426	67/70/71
Baseline Hemoglobin Level	12.744	12.689	13.042	0.452	0.301	69/72/72
Baseline Anemia Status	0.391	0.458	0.403	0.890	0.504	69/72/72
Height (cm)	147.584	148.515	150.536	0.062*	0.166	68/72/72
Weight (kg)	46.675	46.136	47.879	0.440	0.188	69/72/72
No. Members in Household	6.114	5.507	5.764	0.308	0.414	70/73/72
2009 First Quarter Grades	12.031	12.266	11.917	0.527	0.073*	70/73/72
Grade at Baseline	2.700	2.685	2.764	0.778	0.724	70/73/72
Monthly Income (100 S/.)	8.228	7.126	8.340	0.945	0.284	70/73/72
Mother's Years of Education	3.429	3.500	3.319	0.809	0.721	70/72/72
Owns Land	.886	0.781	0.847	0.504	0.308	70/73/72
Father Present in HH	0.700	0.795	0.833	0.061*	0.552	70/73/72
Size of House (m2)	100.343	119.685	103.653	0.753	0.437	70/73/72
Perceived Upward Mobility[1]	1.672	1.648	1.629	0.649	0.832	67/71/70
Has Sibling	7.300	8.397	7.625	0.728	0.442	70/73/72
Total Computer Time (hours)[2]	0.400	0.452	.444	0.595	0.927	70/73/72
Household Electricity	0.676	0.819	0.690	0.864	0.073*	68/72/71
Joint F-Test (Wald Test)	17.383	16.663		0.5639	0.6127	

1 Perceived Upward Mobility is an index of whether the student plans to leave their hometown after graduation and whether they plan to continue their education after graduation.

2 Total Computer Time refers to the number of hours spent on a computer through the program.

Table O.A.2: Family-Wise Error Rate Adjusted[1] p-values

	Anemic					
	Coefficient	Unadjusted p-value	Adjusted p-value	Coefficient	Unadjusted p-value	Adjusted p-value
Average Grades	0.455	0.040	0.262	0.434	0.047	0.256
Cognitive Function	86.64	0.038	0.141	80.77	0.045	0.099
Promotion	0.114	0.050	0.262	0.105	0.075	0.256
Perceived Upward Mobility	0.175	0.006	0.047	0.170	0.010	0.074
Controls[2]		No			Yes	

	Non-Anemic					
	Coefficient	Unadjusted p-value	Adjusted p-value	Coefficient	Unadjusted p-value	Adjusted p-value
Average Grades	-0.098	0.591	0.956	-0.102	0.586	0.970
Cognitive Function	-11.62	0.698	0.967	-13.82	0.639	0.970
Promotion	0.044	0.356	0.494	0.042	0.397	0.481
Perceived Upward Mobility	0.008	0.889	0.967	0.025	0.662	0.970
Controls[2]		No			Yes	

1 Adjusted p-values are estimated using Westfall and Young's free stepdown resampling algorithm (Kling, Liebman and Katz 2007; Liebman and Luttmer 2015).

2 All regressions include controls for sex and class. Some specifications include additional controls for household income, electricity at home, and mother's years of schooling.

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