Immediate and longer-term effects of health on socio-economic success

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There is abundant evidence that health status and socio-economic success are positively correlated. Isolating the component of the correlation that can be attributed to a causal effect of health on socio-economic success has proved to be very difficult in studies that use non-experimental data. Causality almost surely runs in both directions and, in most empirical studies, there are likely to be unobserved factors that affect both health and socio-economic success. Analyses using non-experimental data rely on statistical assumptions that are difficult or, in some cases, impossible to verify.

This paper describes a random-assignment treatment-control experiment which was specifically designed to rigorously test whether an important dimension of health, micronutrient status, has a causal impact on social and economic prosperity. The Work and Iron Status Evaluation (WISE) is an on-going study following over 18,000 people living in 5,000 households in Central Java, Indonesia. Half the study subjects were assigned to a treatment of 100 mg of iron every week for a year; the controls were given an identical placebo. This study focuses on 10,000 older adults (age 30 through 70 years).

The experiment focuses on iron status for four reasons. First, iron deficiency is widespread throughout the developing world with estimates indicating that over 5 billion people are iron deficient in the world today. Moreover, among older adults in Indonesia (including the study site) over 30 per cent of males and 50 per cent of females are iron deficient. Second, the impact of iron on metabolic functioning is extremely well understood right down to the cell level. Iron plays an essential role in oxidative energy production. Low hemoglobin, an indicator current iron levels, reduces the maximum amount of oxygen the body can use. In addition, low iron stores result in reduced endurance through forcing the heart to work harder for the same activity. Random assignment laboratory experiments have demonstrated with both animal and human subjects that iron deficiency results in reduced work capacity and energy efficiency which provides a potential causal mechanism for health to affect economic and social prosperity. Third, implementing social experiments is extremely difficult because subjects may adjust their behavior because of their perception of the benefits of the experiment. This may be manifest by failure to comply with the study protocol. By carefully measuring levels of iron in the blood during the study, it is possible to monitor the impact of the iron supplements on the treatments, relative to the controls and, thereby, measure the extent to which the protocols have been successfully implemented. Finally, it is relatively inexpensive and technically straightforward to eradicate iron deficiency through food fortification which means that the study results have the potential to be of practical value.

The first goal of the paper is to describe the design and implementation of the experiment, highlighting some of the ways in which we sought to assure the quality of the study, evaluate the effectiveness of the protocols and maintain the highest ethical standards. The second goal is to present analytic results from the experiment regarding the causal impact of health on social and economic prosperity.

We begin with a careful description of the protocols that were developed to provide iron tablets to the study subjects, the trade-offs that were encountered in designing the field protocols and the results of a series of pilot tests that were conducted to evaluate different protocols. In a study of this nature, it is critically important that study participants comply with the intervention regimen. Procedures for assuring the highest possible compliance was maintained are discussed in detail, including a description of the pilot studies that were conducted to test different protocols, methods that were adopted to maintain subject co-operation through the course of the entire study and strategies used to of subjects. Subjects were given a blister pack of four tablets every four weeks and were visited twice a week at the beginning of the study and less frequently as the study progressed. The number of pills that are removed from the blister packs is recorded at each visit and provides an upper bound estimate of the number of pills consumed by the subject. An advantage of focusing on iron is that we are able to measure the level of iron in the blood throughout the study and, thereby, have a direct indicator of compliance and protocol efficacy. Hemoglobin (Hb) levels were measured for every subject in the home using a Hemocue photometer. Hb was measured three times before the intervention, at four month intervals during the intervention and at four month intervals for a year after the intervention. Transferrin Receptor concentrations, an indicator of iron stores, were also measured using dry blood spots.

The iron supplement was designed to balance the goal of raising iron levels in the blood against possible side effects. Drawing on the nutritional biochemistry literature, we estimated that the average adult male who was iron deplete prior to the intervention and received the treatment would be iron replete after about six months of supplementation. The average female would take longer. In addition, supplementation should have no effect on the iron levels of subjects who were iron replete at baseline. Our results are consistent with these predictions.

After 6 months of supplementation, there is no difference in the iron levels of treatment and control subjects who were not iron deplete at baseline. However, among iron deplete subjects, iron levels of treatments were significantly higher than that of controls. These differences were large and significant after 12 months of supplementation. Subjects were followed for 24 months after the iron supplements ended in order to measure the longevity of these effects. We find that the benefits of supplementation dissipated for females who were iron deplete at baseline: 12 months after the intervention ended, the gap in iron levels between treated and control females had been reduced by around 25 per cent. The gap was no longer significant after 24 months. For males who were iron deplete at baseline, the benefits of the supplementation are considerably more long-lived: the gap between treatments and subjects declined marginally after supplementation ended but continue to be both large and significant one year and two years after supplementation ended.

In order to measure the impact of the intervention on economic and social prosperity, study subjects have been interviewed every four months during the four years of the study. Subjects were interviewed three times prior to the initiation of the iron intervention, three times during the intervention and six times after subjects stopped taking the pills.

The evidence suggests that iron supplements given to iron deplete subjects have resulted in greater economic productivity as well as improvements in health and social well-being. For example, after six months of supplementation, average hourly earnings among iron deficient

males who received the treatment was about 15 per cent higher than the hourly earnings of comparable controls. Almost all of these gains are concentrated among males who were working in the self-employed sector at baseline. Most of the self-employed men work in farming, construction or provide services (such as bicycle rickshaw riders), all of which are physically demanding occupations. For self-employed people, hourly earnings are likely to be good indicators of productivity and so we interpret this as evidence that iron deficiency is causally related to economic productivity. The 15 per cent difference is consistent with the evidence on the effect of iron depletion on work capacity from clinical trials conducted on treadmills and stationery bicycles. We also replicated that result for a small sub-sample of respondents in WISE.

Among men who were working in the wage sector at the baseline, there was no difference in the hourly earnings of the treatments relative to the controls. This is to be expected since hourly wages are not tied to productivity among workers in this sector. There was no difference between treatments and controls in the hours of work or type of work after 6 months of supplementation.

After 12 months of supplementation, the difference in hourly earnings between treatments and controls who were iron-deplete and in the self-employed sector at baseline was smaller although the difference continued to be significant. There was some evidence of movement away from wage work towards self-employment among treatments who were iron-deplete at baseline.

A year later, the differences in earnings between treatments and controls who were iron deficient at baseline was further reduced and no longer significant. The gap was essentially zero two years after the intervention ended.

Time allocation also responded to the intervention. Whereas hours of work were no different for treatments or controls, wage-sector iron-deficient males who received the treatment tended to sleep fewer hours than the controls six months into the intervention. This difference was slightly smaller at the end of the intervention and had disappeared a year after the intervention. The reduced time sleeping was accounted for by an increase in the time spent on leisure activities. There was no change in time allocation among self-employed iron-deficient males who received the treatment.

This evidence suggests that the shock of an improvement in health due to the iron intervention was accompanied by elevated productivity at work among those who were self-employed. They worked harder, earned more and slept the same number of hours as usual. Among wage-workers, the greater level of energy was channeled towards more leisure time as these people slept less. Although the intervention resulted in elevated levels of iron in the blood beyond the end of the intervention, the impact on earnings and time allocation was short-lived suggesting that there is a behavioral response to the health improvement and people adjust their lives to take into account.

Among self-employed iron-deficient males, there is also evidence of asset accumulation during the intervention. Whereas accumulation ended with the intervention, these people remained at a higher level of assets after the intervention than they had prior to the intervention.

Turning to physical and psycho-social health status, the results are broadly similar. After 6 months of intervention, iron-deplete treatments were able to physically arduous tasks, suffered less from fatigue and reported themselves to be in better psychological health. These differences persisted through the end of the intervention and then dissipated over time.

There is evidence that health, as indicated by iron deficient anemia, has a causal effect on an array of dimensions of socio-economic prosperity. However, there is also evidence that as this dimension of health improves, people adjust behaviors to take that into account so that the immediate benefits in terms of greater productivity, improved physical health and psycho-social are dissipated over time. The evidence suggests that there are also important dynamic feedbacks so that as health improves, social and economic behaviors adjust which likely, in turn, affect health. A key advantage of the randomized treatment-control design of WISE is that it has been possible to isolate one element of this complex causal chain.