Human Resource Management Technology Diffusion through Global Supply Chains: Productivity and Workplace Based Health Care

by

Drusilla K. Brown¹
Thomas Downes

Department of Economics
Tufts University
Medford, MA  USA

Karen Eggleston
UCLA International Institute
Los Angeles, CA  USA

and

Ratna Kumari
Division of Work Environment
St. Johns Medical College
Bangalore, India

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Address correspondence to:

Drusilla K. Brown
Department of Economics
Tufts University
Medford, MA  02155
U.S.A.
Phone:  617-627-3096
Fax  617-627-3917

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e-mail  Drusilla.Brown@tufts.edu
Abstract

We examine the role that buyers play in helping vendors uncover productivity-enhancing labor management innovations. We report on a buyer-directed factory-based program targeting intestinal parasites and anemia in seven Bangalore apparel factories. Raw pre-post productivity comparisons were confounded by factory organizational changes that were implemented in anticipation of the termination of the MFA. Using a DDD estimator, treatment was found to increase individual productivity of anemic workers by 8 percent. The treatment program also reduced the probability that an anemic worker would leave the factory by 38 percent.
I. Introduction

Multinationals can accelerate the adoption of productivity-enhancing innovations throughout global supply chains by supporting and directing experimentation and sharing information across their vendor base. Here we particularly examine the role that retailers and distributors play helping vendors uncover labor management innovations related to employee health that enhance productivity and also improve the lives of workers.

Anti-sweatshop agitation in the early 1990s prompted several name-brand retailers and distributors [hereafter called “buyers”] to develop mechanisms for improving working conditions in the factories from which they source. Corporate codes established to regulate the conduct of the vendors in their supply base was a common early strategy. Compliance with the corporate code was typically monitored by corporate compliance officers and/or external auditors. In the early stages of code compliance enforcement, monitors simply compared observed factory conduct against a check-list of required behaviors.

Over the last five years, some corporate compliance officers have applied the corporate disciplines originally developed to promote innovations in product quality and factory efficiency to a program of continuous improvement of the management of workers in their vendor base. Sabel, O’Rourke and Fung (2000) argue that reputation-sensitive retailers and distributors have an incentive to transfer firm-specific innovations technology from their production unit to their compliance unit if more humane treatment of labor will enhance corporate reputation. According to this line of analysis, the emergence of corporate codes addresses a market imperfection that arises when inhumane working conditions generate a negative externality on consumers (Elliott and

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2 For an early history of the emergence of corporate codes of conduct in the apparel industry see Bureau of International Labor Affairs, U.S. Department of Labor (1996).
Freeman, 2001). Credibly enforced corporate codes offer consumers an opportunity to pay a premium for products they believe are produced under humane conditions.

However, correcting a failure in the market for compassion is not the only potentially efficiency-enhancing impact of workplace reorganization that could accompany effective corporate code enforcement. Harrison and Scorse (2004) argue that monitoring activity has impacted imperfections in the labor market. Analyzing Indonesian firm-level data for the period 1990-96, Harrison and Scorse find that compliance with minimum wage legislation increased more for export-oriented factories in textiles, footwear and apparel production than other sectors. Furthermore, improved minimum wage compliance was accomplished without a decline in employment in compliant textile, apparel and footwear factories. Such an outcome is consistent with the hypothesis that scrutiny by corporate compliance personnel and anti-sweatshop activists heightened the competitiveness of the labor market supplying export-orientated Indonesian textile, footwear and apparel factories.

Further, factory managers may have difficulty in the short run determining which workplace initiatives have a significant positive impact on productivity. For example, Ichniowski, Shaw and Prennushi (1997) present evidence of considerable cross-factory variance in human resource management practices (HRM) in the U.S. steel industry. Steel factories adopting innovations in recruiting, screening, training, compensation, job assignments and communication significantly increase up-time and prime-yield rates.

Identification will be particularly challenging when labor market conditions, global competition and economic policy are rapidly evolving. Thus, the buyer may employ strategies to accelerate the adoption of productivity-enhancing innovations throughout their vendor base. For example, buyers have a pecuniary interest in managing the negative impact of disease on their global supply chains. They can alert vendors to the impact of worker health on factory productivity.
and demonstrate the beneficial impact of workplace-based treatment of health conditions common in their supplier factories. The existence of supply-chain wide external benefits from experimentation by individual factory managers, in particular, provides an incentive for buyers to share the cost of experimentation in a subset of factories and disseminate the conclusions across their vendor base.

A buyer may also attempt to direct human resource management experimentation along a particular line of inquiry. This will be the case if the buyer has stronger prior beliefs than the vendors in their supply chain that a more humane factory environment also improves productivity.

Further, agreement by the buyer and the vendor to coordinate decisions on the type and amount of HRM experimentation may complement the structure of performance incentives implicit in the contract between the buyer and the vendor regulating price, quantity, quality and delivery. A reputation-sensitive buyer cannot perfectly monitor the treatment of workers by its vendors. Success may be principally measured by observing the number of adverse press reports on vendors in its supply base. As a consequence, the buyer will not be able to compensate vendors perfectly for efforts to protect the reputation of the supply-chain. In such a case, the factory will not fully internalize the payoff to its HRM experimentation and will, thus, not undertake the amount of experimentation that will maximize the value of the supply chain. Buyer-vendor coordination on HRM experimentation could address this contracting imperfection.

This paper focuses on the buyers’ role in supporting and directing experimentation to identify and mitigate the negative effects of infectious disease on production efficiency and quality of life for workers in their vendor base. We report on a buyer-directed factory-based health care intervention targeting intestinal parasites and anemia undertaken in seven Bangalore apparel factories between July 2004 and March 2005. The intervention included drug treatment for
parasites, dietary supplements for anemia and an education program on the causes, consequences and dietary treatment of iron-deficiency anemia.

The “raw” pre-post comparison was confounded by global events, misleadingly suggesting little benefit of the intervention. The study period for this intervention is co-incident with factory organizational changes that were implemented in anticipation of the termination of the Multi-Fiber Arrangement (MFA) on January 1, 2005. Strategies for expanding factory capacity were accompanied by a temporary decline in factory productivity.

We exploit two aspects of the intervention that induce individual-level differences in treatment effects within the treatment factories. First, pregnant women and those women at risk of becoming pregnant were excluded from the de-worming component of the treatment program. These women received iron therapy only. Second, the medical team determined which workers were anemic prior to treatment. We then use evidence on gender, marital status, birth control practices and anemia status to identify treated workers who should exhibit a differential impact of treatment because of the progression from helminthic infestation to anemia and/or treatment with a full regimen of medically appropriate medications. Thus, our *difference-in-difference-in-difference* identification strategy includes controls for pre-treatment differences among the treatment and comparison individuals within the treatment factories.

We turn first in section II to a review of the literature on health and productivity. We then present a brief introduction to the organization of apparel factories in Bangalore in section III, analyzing some issues that arise in measuring productivity and controlling for product heterogeneity. The sequencing of the intervention and data collection is described in section IV. The analytical framework and model used for empirical analysis are presented in section V. Sections VI and VII present empirical results on productivity and manpower turnover, respectively. Conclusions follow.
II. Workplace Based Health Care

As a matter of corporate code and local law, Bangalore apparel factories are required to have a factory clinic for treating workplace injuries. Many health conditions besides injuries, however, affect worker productivity; prominent examples include infectious diseases and inadequate nutrition. Factory managers may have an incentive to initiate a broader factory-based healthcare program if there are measurable factory-wide benefits of treating individuals, both through higher productivity of treated individuals and positive externalities for healthy workers. Such externalities may arise if treated workers are less likely to infect their co-workers and/or there are productivity complementarities among factory employees.

Information on disease and the benefits of treatment may also be less costly to acquire for factory managers than for individual workers. Workers in developing countries, particularly those with low educational attainment and minimal household resources, have limited knowledge of the range of health conditions and treatments that may affect their productivity. Thus, factory-initiated health care education and treatment programs may be a component of a cost-minimizing compensation package.

A large body of literature explores the inter-relationships between health and individual and social well-being.\(^3\) However, quantifying the causal link between good health and productivity at work has proven elusive, given the difficulty of accurately measuring at-work performance and identifying the causal impact of health.\(^4\) Many researchers use administrative data on absenteeism and cross-sectional surveys of “presenteeism,” or self-reported decrements in ability to function at work because of poor health. Although instructive, limitations of such studies include questionable

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\(^3\) The literature just within economics is vast. See for example the WHO Commission on Macroeconomics and Health 2001; Strauss and Thomas 1998; and various chapters of the Handbook of Health Economics, and sources cited therein.

reliability and comparability of self-reports and inability to capture between-worker externalities from impaired productivity.

The de-worming workplace intervention analyzed herein provides a useful setting to undercover such effects. The World Health Organization (WHO) has identified soil-transmitted helminthes (roundworm, whipworm and hookworm) along with schistosomiasis as among the critical targets in the global Massive Effort against Poverty (WHO 2005a,b). Intestinal worms infect one-quarter to one-third of the global population. Adverse long-term health effects are particularly pronounced for hookworm. Chronic blood loss occurs as a consequence of the feeding action of the parasites and damage to the intestinal mucosa. Thus, iron-deficiency anemia is a common complication of geohelminth infestation.

De-worming and iron supplementation have been linked to numerous benefits: better child health, improved cognition, significant increases in school attendance, and higher adult incomes (Nokes et al. 1992, 1999; Schultz 2003; Bleakley 2003; Miguel and Kremer 2004). However, studies examining at-work productivity remain rare. The strongest evidence of the impact of de-worming and iron supplementation is provided by Miguel and Kremer (2004) and the ongoing Work and Iron Status Evaluation. Miguel and Kremer (2004) show that accounting for community-wide positive externalities from reduced disease transmission further reinforces the benefits and cost-effectiveness of de-worming treatment for school-age children.

III. Apparel Production

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5 One of the few studies to examine the impact of health on individual at-work productivity randomly assigned male Indonesian rubber tree tappers and weeders to treatment and control groups. Those in the treatment group received iron supplements to treat anemia for 60 days; those in the control group received a placebo. Afterwards, both health measures and productivity—as measured by kilograms of latex collected by tree tappers or area of trenches dug by weeders per day—improved significantly more for those in the treatment group who had been anemic than the anemic workers in the control group (see discussion in Strauss and Thomas 1998, p.803).

6 (http://chd.ucla.edu/WISE/index.html).
Measuring the productivity impact of any factory innovation is complicated by product and production process heterogeneity. In the case of apparel, we can control for product heterogeneity by using standardized individual performance assessment measures universally employed in the apparel industry.

During the design of each garment, the item is characterized as a set of standardized seams of a designated length. The garment manufacturing industry has established a standard time required to sew each seam of a designated type and length by a skilled tailor. Times are adjusted to allow for variations in degree of difficulty for a particular seam type, material and machinery. As a result, it is straightforward in principle to estimate the time needed to stitch each garment. This theoretical time is referred to as the Standard Allowable Minutes (SAM). Factories managers establish the SAM for each seam and for each garment assembled in their factory.

Apparel assembly in Bangalore is typically organized in production lines. Bundles of pre-cut fabric are organized in the cutting section and delivered to the sewing section. Each tailor opens a bundle, stitches a single seam on each item in the bundle, closes the bundle and then passes the bundle to the next operator.

It is customary to monitor individual productivity in the apparel industry using the efficiency rate (E). E is calculated by comparing the actual (A) hourly production of an individual operator to the theoretical (T) number of such seams that can be sewn in an hour according to the international standard.

An individual working to the international standard will stitch $T = 60 / SAM$ seams per hour. The efficiency rate is given by $E = 100 * A / T = 100 * A * SAM / 60$. For example, an efficiency rate of $E=75$ indicates that a worker is producing 75 percent of the output of a worker meeting the international standard.
Converting each garment into its SAM equivalent eliminates, or at least mitigates, an important source of product heterogeneity in the analysis. By analyzing factory performance in terms of how actual production compares to theoretical production, we abstract away from analytical complications that arise as the factory moves among garment styles with varying degrees of complexity.

In an efficiently engineered factory the flow of bundles will be such that each workstation will have one bundle waiting and one bundle in process. However, in a poorly balanced factory, bundles may build up at the workstation of less efficient workers while more efficient workers sit idle. Indeed, corporate compliance personnel often note that factory inefficiencies of this type are an important contributing factor to excess overtime and low wages. In this case, low productivity of a single worker or group of workers will affect the efficiency rate of all workers in the line. As a consequence, improving the performance of individual workers will have external factory-wide benefits.

IV. Intervention Sequence and Data

The geohelminth-anemia intervention was undertaken in seven treatment factories in Bangalore between July 2004 and March 2005. Two prominent buyers in Bangalore enlisted an NGO to coordinate medical screening and delivery of care in factories from which they commonly source. The buyers enlisted three factory ownership groups to participate. Two ownership groups each provided data from one additional factory within the group that did not participate in the geohelminth-anemia intervention.

In the seven treatment factories, 10,810 workers were screened by medical personnel for treatment eligibility, offered medication and provided educational materials on the causes, consequences and treatment of anemia. In addition, a random sample of 5 percent of workers was
screened for anemia before and after the treatment program. This sample of workers was also
surveyed on basic demographic characteristics and on their knowledge, attitude and practices
concerning anemia. Factory managers provided average monthly efficiency rates for each worker
in the five percent sample for four months prior to and five months during and after treatment.
Similar demographic, attitudinal and productivity data was collected for the five percent sample of
workers selected from each of the two non-treatment factories, though no medical testing was
undertaken.\textsuperscript{7}

One challenge for intervention design arises from the clinical benefit-cost trade-off for de-
worming pregnant women. Because of laboratory evidence that anthelmintic drugs may cause birth
defects, they generally have not been given to women in the first trimester of pregnancy, or more
broadly to any female who may be pregnant. As a consequence, workers were offered one of two
drug regimes based on their eligibility.

The two protocols were developed to be consistent with WHO recommendations for mass
anthelmintic campaigns. For communities in which 30 percent or more members are infected with
geohelminths, the WHO recommends administering the anthelmintic Albendazole to all community
members (six months or older) once every six months. WHO documents characterize women of
reproductive age to be at high risk for the adverse effects of intestinal parasites. This includes
pregnant and lactating women and prospective mothers. Thus, the WHO protocol for mass
anthelmintic campaigns includes all women of reproductive age. The only recommended
qualification is that efforts should be made to avoid the first trimester of pregnancy.

\textsuperscript{7} Before beginning the study, Human Subjects Review and informed consent procedures were obtained at three
levels: (1) for the receipt of medication, (2) for recruitment and participation in the anemia screening, and (3) for
responding to the survey and collection of productivity data. The medical intervention and monitoring was reviewed by
the Internal Review Board of St. Johns Medical College, Bangalore, India, and the procedures for the worker survey and
productivity data were reviewed by the IRB of the School of Arts, Sciences, and Engineering at Tufts University,
Medford, MA, U.S.A.
However, according to the WHO formulary, Albendazole should not be administered to pregnant women and married women should be advised to use a reliable form of birth control during treatment. For this reason, pregnant women were excluded from the study and married women were screened according to their birth control practices to determine the appropriate drug regimen.

Two drug regimes were employed:

_A. Protocol for Males, Single Females and Married Females using a Reliable Form of Birth Control_

- 400 mg Albendazole, single dose
- 150 mg Dried Ferrous Sulphate, 16 weekly doses
- 0.5 mg Folic Acid, 16 weekly doses
- 100 mg Ascorbic Acid, 16 weekly doses

_B. Medical Protocol for Non-Pregnant Married Women Not Using a Reliable Form of Birth Control_

- 150 mg Dried Ferrous Sulphate, 16 weekly doses
- 0.5 mg Folic Acid, 16 weekly doses
- 100 mg Ascorbic Acid, 16 weekly doses

Data collection efforts were confounded by several factors. First, the MFA was terminated on January 1, 2005. Several factories altered factory organization in order to take advantage of relaxed restrictions on India’s apparel exports. In particular, Ownership Group I introduced a significant change in factory operations in November 2004 that reportedly adversely affected individual productivity and manpower retention. Second, data from Unit 1 in Ownership Group II appeared to have some irregularities. Third, Ownership Group III did not provide data on participating workers in the months prior to treatment.

Table I provides data describing the basic demographic characteristics of the sample. The first column for each ownership group provides data on workers who remained with the participating
factory through the entire treatment period. The second column of data reports on all workers
enrolled in the study in September and October.

As can be seen from Table 1, there was significant attrition from all factories during the sample
period. Only 71 percent of workers that were enrolled in the intervention in September and October
were retained through the entire treatment period.

The incidence of anemia in the treatment factories prior to treatment reported by the medical
team was 28.7 percent. For the subjects who remained through the entire study period, 29.6 percent
were anemic prior to treatment and 16.1 percent were still anemic following treatment. Clearly,
treatment had a significant impact on the incidence of anemia in the factory. However, the fact that
many workers were still anemic following treatment suggests that either the frequency and/or
dosage of iron supplements for anemic workers was inadequate or that the treatment program was
terminated prematurely.

IRB restrictions prohibited us from receiving individual medical data from the medical team.
However, we were permitted to ask individual workers whether they were willing to share the
medical team’s diagnosis during the survey on knowledge, attitude and practices relating to anemia.
Thus, the figures reported in Table 1 are based on self-reports.

In light of the fact that workers in the treatment factories had been informed of their
hemoglobin status just prior to survey administration, the anemia self-reports for subjects from the
treatment factories are fairly accurate. Indeed, 29 percent of workers in the treatment factories
report being diagnosed anemic during the worker survey. However, workers in the non-treatment
factories were not screened for hemoglobin status prior to survey administration and, thus, are
almost certainly under-reporting the incidence of anemia.

We were also precluded from receiving the identities of the workers eligible for Albendazole.
However, we were able to identify workers likely to receive Albendazole from the questions
relating to gender, marital status and birth control practices on the worker survey. According to
these criteria, 80 percent of subjects in treatment and non-treatment factories were eligible to
receive Albendazole. In fact, the medical personnel reported giving Albendazole to 86 percent of
workers in the treatment factories. Thus, the results presented below may suffer from attenuation
bias.

Finally, anemia appears to be uniformly distributed across demographic groups. In Table 2, we
report the incidence of anemia (based on self-reports) by age, educational attainment and household
income quartile. The only group reporting little or no anemia are workers 40 years and older. We
also found no correlation between anemia status and vegetarianism.

V. Estimation Model

To determine the impact of treatment on worker productivity, we examine several levels of
differences across worker groups prior to and during treatment. We estimate the following
equation:

\[
\text{Efficiency}_{it} = \beta_0 + \beta_1 T_{Fi} + \beta_2 A_{bi} + \beta_3 T_{Fi} \times A_{ni} + \beta_4 T_{Fi} \times A_{bi} + \beta_5 T_{Fi} \times A_{ni} + \beta_6 P_{Post} + \beta_7 P_{Post} \times A_{bi} + \beta_8 P_{Post} \times A_{ni} + \beta_9 P_{Post} \times A_{ni} + \beta_{10} P_{Post} \times A_{ni}
\]

where

- \( \text{Efficiency}_{it} \) is the efficiency rate for subject \( i \) at time \( t \).
- \( T_{Fi} = 1 \) if subject \( i \) works in a treatment factory, \( = 0 \) otherwise.
- \( A_{bi} = 1 \) if subject \( i \) meets the gender, marriage and birth control criteria for receiving Albendazole, \( = 0 \) otherwise.
- \( A_{ni} = 1 \) if subject \( i \) self-reports having been diagnosed with anemia, \( = 0 \) otherwise.
- \( P_{Post} = 0 \) \( t=1-4 \) (pre-treatment period)
and $X_i$ is a vector of worker specific characteristics including age, educational attainment, experience and factory position.

The coefficients in equation (1) are organized by subject category in Figure 1. *Difference-in-differences* is used to identify a possible placebo effect, any positive externalities for non-anemic workers and benefits of iron therapy for anemic workers. A *difference-in-difference-in-differences* is used to isolate the treatment effect on non-anemic and anemic workers receiving iron therapy and Albendazole.

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<thead>
<tr>
<th>Pre-Treatment</th>
<th>Non-Treatment Factory</th>
<th>Treatment Factories</th>
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<td></td>
<td>Albendazole Eligible</td>
<td>Iron Therapy Only</td>
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<td></td>
<td>No</td>
<td>Non-Anemic</td>
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<td></td>
<td>Yes</td>
<td>Anemic</td>
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Several issues arise in the interpretation of the coefficients in Figure 1. These are as follows:

**Non-random assignment to the Albendazole-eligible group.** Workers are not assigned to the Albendazole-eligible group randomly, but rather based on their demographic characteristics. Albendazole-eligible workers are disproportionately unmarried and, therefore, younger. As a consequence, they may have less seniority in the factory. Any changes in factory organization that
involve giving low-seniority workers less desirable assignments will differentially impact Albendazole-eligible workers. As a consequence, Albendazole-eligibility may be correlated with a change in factory assignments co-incident with the beginning of anthelmintic treatment.

The impact of factory reorganization is captured by the difference-in-differences of Albendazole-eligible and non-Albendazole-eligible workers in the non-treatment factory and is given by $\beta_s$. A finding of $\beta_s < 0$ would be consistent with a negative seniority-linked job assignment effect for Albendazole-eligible workers.

**The placebo effect and treatment factory externalities.** The study was not placebo controlled. Withholding medication with an established beneficial health effect from workers determined to be anemic for the purposes of determining the productivity impact of illness was deemed to be unethical. However, we can get some indication of a placebo effect by considering the impact of iron therapy for non-anemic workers.\(^8\) Non-anemic workers who receive iron therapy only receive productivity benefits from treatment if they benefit from co-workers’ reduced disease transmission and improved productivity. The difference-in-difference estimate of the intervention on the productivity of non-anemic, non-Albendazole eligible workers in the treatment factories relative to the non-treatment factory is given by $\beta_i$. A finding of $\beta_i > 0$ is consistent with positive spillovers in the treatment factory and possibly a placebo effect.

**Iron therapy for anemic workers.** To gauge the impact of iron-only treatment for anemic workers, we can compare the pre- and post-treatment performance of anemic workers not eligible for Albendazole with their non-anemic counter-parts. The iron-only treatment difference-in-difference estimate is given by $\beta_o$. An iron-therapy treatment effect will be indicated if $\beta_o > 0$.

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\(^8\) Note that this is not a pure placebo effect because workers close to the threshold of being labeled anemic may receive genuine individual health benefits from iron supplementation.
**Albendazole for non-anemic workers.** We next consider the impact of treating workers for helminthic infections that have not advanced to anemia. In order to do so we compare pre- and post-treatment performance for Albendazole and non-Albendazole eligible workers in the treatment factories who are not anemic. This treatment effect is given by $\beta_8 + \beta_{10}$. However, $\beta_8$ is the differential effect contributed by less-desirable job assignments for Albendazole-eligible workers. Thus, we focus on $\beta_{10}$ as the difference-in-difference-in-difference estimate of Albendazole and iron therapy treatment on productivity of non-anemic workers.

**Iron and albendazole for anemic workers.** Treatment should have its most distinctive effect on anemic workers who receive a complete regime of Albendazole and iron therapy. In order to identify the effect of adding Albendazole to the treatment regime for anemic workers, we compare pre- and post-treatment efficiency for Albendazole-eligible anemic workers to Albendazole ineligible workers. This difference-in-difference estimate is given by $\beta_8 + \beta_{10} + \beta_{11}$. In order to control for the effect of differential factory assignments for Albendazole-eligible workers we can calculate a similar difference-in-difference estimate for non-anemic workers, given by $\beta_8 + \beta_{10}$. Thus, the difference-in-difference-in-difference for anemic workers receiving Albendazole is $\beta_{11}$.

**VI. Results: Production Efficiency**

The two ownership groups for which a complete dataset was collected have different human resource management and production systems. As a consequence, the underlying processes generating individual efficiency rates across ownership groups are not similar. For this reason, separate statistical analysis was undertaken for each group.

**VI.1 Validity of the Treatment Controls**
Before estimating equation (1), we first attempt to determine whether the relationship among the various groups was stable during the pre-treatment period. For the period $t=1-4$ we estimate

$$\text{Efficiency}_{it} = \alpha_0 + \alpha_1 T_f i + \alpha_2 \text{Alb}_i + \alpha_3 T_f i \times \text{Anemic}_i + \alpha_4 T_f i \times \text{Alb}_i + \alpha_5 T_f i \times \text{Anemic}_i + \alpha_6 T_f i \times \text{Time}_i + \alpha_7 \text{Alb}_i \times \text{Time}_i + \alpha_8 T_f i \times \text{Anemic}_i \times \text{Time}_i + \alpha_9 T_f i \times \text{Alb}_i \times \text{Time}_i + \alpha_{10} T_f i \times \text{Alb}_i \times \text{Anemic}_i \times \text{Time}_i + X_i \eta_i + \nu_i + \varepsilon_{it}$$

where $\text{Time}_i = t-1$ for $t=2,3,4$. In the case of Ownership Group I, we found no evidence of a time trend for any group. Estimates of $\alpha_6$ to $\alpha_{10}$ are all less than 0.5 in absolute value and none is statistically different from zero.

In Figure 2, we have plotted the raw average efficiency rate for each month of the study period for Ownership Group I. Here we report deviations from the July average in order to suppress proprietary information on factory productivity. Series are plotted for the ownership group as a whole, the treatment factories, non-anemic workers and anemic workers in the treatment factories.

In the pre-treatment period, August-October, all four groups exhibit stable productivity. No series deviated by more than 0.5 percentage points from the July level. However, in November, the first full month of treatment and coincidentally the first month of expanded capacity, the average efficiency rate for the ownership group dropped by 1.5 percentage points. Furthermore, the performance in the treatment factories fell a full 2.0 percentage points. The efficiency rate rebounds over the next two months and ultimately exceeds its July level by one percentage point by the end of the study period.

To disentangle the positive impact of treating anemia from the negative effects of expanding capacity, factory managers would have needed to know the anemia status of each worker. As can be seen from Figure 2, the efficiency rate for anemic workers holds steady during the factory reorganization in November and then begins to rise, peaking at 2.25 percentage points above the
July rate. Since the other organizational changes masked this effect in the average productivity data, it is not surprising that factory managers did not consider the intervention very successful.

We performed a similar analysis for Ownership Group II. However, the efficiency rate in the non-treatment factory exhibits a strong positive time trend throughout the study period. Thus, for Ownership Group II, it appears that the non-treatment factory was a poor control for the treatment factories.

**VI.2 Efficiency Results for Ownership Group I**

We estimate equation (1) for factory group I with a GLS random effects estimator and robust standard errors. In Table 3, we report coefficient estimates and standard errors for a
balanced sample of workers who remained employed in Ownership Group I throughout the entire nine-month study period. Table 4 reports similar results for all workers recruited to the study in late September and early October.

The placebo effect and factory-level externalities. The coefficient of $TF*Post$ indicates the spillover and placebo effect. This coefficient is positive in the balanced panel and negative in the unbalanced panel. However, in both cases the effect is less than one in absolute value and statistically insignificant.

Capacity expansion. The coefficient of $Alb*Post$ measures the impact of reorganization in the non-treatment factory as the end of the MFA approaches. In both the balanced panel and the unbalanced panel, this coefficient is negative. Factory reorganization appears to have lowered the efficiency rate for reassigned workers on the order of one percentage point (-1.18 in the balanced panel and –0.93 in the unbalanced panel). However, neither of these estimates is statistically significant.

Iron therapy for anemic workers and Albendazole for non-anemic workers. The coefficient of $TF*Anemic*Post$ measures the impact of iron therapy only for anemic workers and the coefficient of $TF*Alb*Post$ measures the impact of Albendazole in non-anemic workers. In both the balanced and unbalanced panels, these coefficient estimates are negative though, again, not significantly different from zero. In light of the fact that neither low-dose iron supplements nor Albendazole are associated with any adverse reactions, it is highly unlikely that the negative coefficient estimates for $TF*Anemic*Post$ and $TF*Alb*Post$ are attributable to the medication.9 Indeed, that none of these coefficients are statistically different from zero may reflect positive spillovers from treatment offsetting negative effects from production reorganization.

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9 The medical team reported that less than one percent of workers in the treatment factories refused the iron preparation. The few that dropped out of the study reportedly did so due to gastritis, itching, loose motions or tiredness.
Iron and Albendazole for anemic workers. To control for any factory reorganization effects that are coincident with medical treatment and might vary between treatment and non-treatment factories, we focus on the DDD estimate of the impact of treating anemic workers with the iron preparation and Albendazole. This is given by the estimated coefficient of $TF*Alb*Anemic*Post$ in Tables 3 and 4.

In the balanced sample, the DDD estimate is 6.18 and is statistically significant with 99 percent confidence. In the unbalanced panel, the DDD estimate is 4.76 and is statistically significant with 95 percent confidence.

These estimates indicate a significant improvement in productivity for anemic workers receiving comprehensive medical care for their condition. The average efficiency rate for Bangalore apparel factories that produce for export of name-brand products is around 75 percent. Thus, a four to eight percentage point improvement in the efficiency rate translates into a six to eight percent improvement in productivity for affected workers.

The second set of regression results reported in Tables 3 and 4 disaggregates the $TF*Alb*Anemic$ variable over the treatment months in order to determine the time profile of the improvement in efficiency. $TF*Alb*Anemic5 - TF*Alb*Anemic9$ indicate treatment variables for months five through nine.

For the balanced sample, the treatment effect for November is 5.73 percentage points, rises to 8.37 percentage points in January and declines to 5.36 percentage points by March. This profile is consistent with our expectations given the medical regime on three accounts. (1) The Albendazole administered at the end of October should produce some positive health benefit by November. (2) The therapeutic benefit of iron supplements will only emerge over the duration of treatment. (3) Intestinal worm loads normally recover six months following a single dose of Albendazole. Thus, it
is not surprising that efficiency gains peak in January and then begin to dissipate in February and March.

We observe a similar profile for the unbalanced sample, although the treatment effect is only about two-thirds as large as for the balanced panel. Further, only the January and February estimates are statistically significant at 99 percent confidence.

The estimation of equation (1) also allows us to identify how anemic workers were managed prior to this intervention. The coefficient, $\beta_3$, of $TF^{*}Anemia$ provides an indicator. The point estimate of $\beta_3$ is -1.81 but it is not statistically different from zero. Thus, in the pre-treatment period, anemic workers are no less productive on average than non-anemic workers. Anemic workers must have some innate ability other than age, education or experience that compensates for the negative impact of their poor health. That is, anemic workers who survive in the factory are latent high productivity workers. Anemic workers of average innate ability are culled from the workforce either voluntarily because they cannot deal well with the factory environment or involuntarily as a consequence of their comparatively low productivity. Thus, the failure to treat anemic workers left unrealized the potential of the most productive workers and likely contributed to manpower turnover.

VI.3 Efficiency Results for Ownership Group II

We also estimate equation (1) for the factories in Ownership Group II. Analysis for Ownership Group II was complicated first by the fact that data reported from unit 1 appeared to have some anomalies. Further, the human resource management systems differ across the three units in some critical aspects. Finally, the three units differ in terms of the customers supplied from each unit. As a consequence, the three units had very different average efficiency levels and time trajectories in the pre-treatment period.
We report three sets of regression results in Tables 5 and 6. The first set in columns (1)-(3) analyzes data received from unit 2 only. Unit 2 received treatment and appears to have reported a complete set of data for the entire sample period. Columns (4) and (5) report similar results for unit 2 and the non-treatment factory. Columns (6) and (7) report results for all factories in Ownership Group II.

Results for unit 2 reported in columns (1) and (2) differ importantly from those obtained analyzing data from Ownership Group I. Nevertheless, there are some similarities. As with Ownership Group I, there is a decline of about four percentage points in the point estimate of the efficiency rate for anemic workers following treatment. The point estimate for Albendazole-eligible workers who are not anemic also declines during the treatment period by one percentage point in the balanced sample and 0.15 percentage points in the unbalanced sample. The $DDD$ estimate is also positive and around three percentage points for anemic workers receiving Albendazole. Though similar in magnitude and sign to the estimates obtained from Ownership Group I, none of these results is statistically significant.

However, while the results comparing different groups of workers over time are not significant, the impact of treatment on the factory overall is quite pronounced. The coefficient estimate on $TF*Post$ is 7.92 in the balanced sample and 8.17 in the unbalanced sample. Both estimates are statistically significant at 99 percent confidence.

While not definitive, these results are consistent with the hypothesis that treatment exhibits strong external effects across all workers. Such an outcome will occur if lines are unbalanced so that bundles of material are piling up at some workstations, leaving other workers idle. It remains a possibility, though, that this factory introduced some other efficiency-enhancing innovation during October or November 2004.
VII. Results: Manpower Turnover

We turn now to the evaluation of manpower turnover. Workers in the treatment factories were recruited to the study during September and October 2004. The drug regime was then begun in the last week of October. As a result, we have little evidence on the determinants of duration of employment prior to treatment. We are limited to looking for a differential impact of treatment on the duration of employment of anemic workers following treatment.

Duration of employment in Bangalore apparel factories is driven by both demand and supply factors. To identify the contribution of treatment, we estimate a Cox proportional hazard function:

\[
\lambda(t_i) = \exp\{-\beta_1 T_F i * Post_i - \beta_2 T_F i * Anemia_i * Post_i - Y_i \phi\}.
\]

Equation (3) is fitted for each ownership group using maximum likelihood estimation with robust standard errors and clustering by factory. Estimation results are reported in Table 7.

Treatment did not have a statistically significant effect on manpower turnover for Ownership Group I, as can be seen from the estimation results reported in columns (1)-(4). The factory reorganization that took place in Ownership Group I during November appears to have swamped any role that the opportunity for treatment may have had on the decision of workers to remain with the factory.

Nevertheless, worker health may still be affecting retention in Ownership Group I. First, in the course of the survey, workers were asked to rate their health as excellent, very good, good, not good or poor. We do find that workers who rate their health as excellent or very good are significantly less likely to leave their factory’s employment during the study period than other workers. Thus, improving worker health may improve retention during periods in which the production process is more stable.
Second, the efficiency rate during the first month of observation has a strongly significant positive impact on retention. Thus treatment may improve retention indirectly by raising the efficiency of anemic workers.

The impact of treatment on retention is more evident from the analysis of Ownership Group II. Regression results are reported in columns (5) to (8). The estimated coefficient of $TF*Post$ is less than one but statistically insignificant. Thus, the general availability of treatment did not significantly reduce the chance of separation in the treatment factories. However, for anemic workers, treatment greatly reduces the risk of separation. The point estimate for $TF*Anemic*Post$ in ownership Group II is 0.62 and is statistically less than one at 99 percent confidence. Thus, anemic workers receiving treatment were 38 percent less likely to leave the factory during the treatment period than their non-anemic co-workers. Similar though slightly weaker results were obtained by focusing on anemic workers receiving Albendazole, as can be seen from columns (7) and (8) of Table 7.

The fact that the treatment effect on the retention rate for anemic workers receiving Albendazole was no higher than that for anemic workers receiving iron only provides us with some indication as to why treatment improves retention. Adding Albendazole to the iron regime should enhance the therapeutic effect of iron supplements. As a consequence, anemic workers receiving iron and Albendazole should have greater improvement in their health status than workers receiving iron only.

If the link between worker health and productivity was driving the improved retention in Ownership Group II, then workers receiving iron and Albendazole should have a higher retention rate than workers receiving iron only. On the other hand, if anemic workers remain in the treatment factories in order to gain access to the entire duration of the iron supplementation program, then
there would be no difference in retention between the Albendazole-eligible group of anemic workers relative to all anemic workers.

In fact, the latter is the case. Thus it appears that access to treatment is regarded as an important benefit for workers employed in Ownership Group II above and beyond the impact that treatment has on worker productivity. These results indicate that factory-based health care specifically, and workplace conditions generally, may be a component of a cost-minimizing compensation package.

**VIII. Conclusions**

The results presented above suggest that treating anemic workers with Albendazole and dietary supplements significantly improved apparel worker productivity. In the results presented above, we find that treatment could raise productivity of anemic workers by six to eight percent in a well-managed Bangalore apparel factory. In light of the fact that about 30 percent of workers in the study were anemic, treatment can be expected to raise factory productivity by two to three percent. Benefits are even larger in those factories with cross-worker productivity externalities such as those in which assembly lines are poorly balanced. For one such factory, we observed a factory-wide productivity impact closer to 10 percent. These results contribute to the literature linking health improvements to enhanced at-work productivity.

We did not collect data for a complete cost-benefit analysis. Yet, the benefits of treatment would seem clearly to outweigh the costs, given that workers can be de-wormed with Albendazole for $0.04 per year per worker for medication plus modest healthcare personnel and distribution costs.

In spite of the fact that treatment is relatively inexpensive, workers for whom their anemic condition has reduced productivity typically leave factory employment. A simple program of
treatment could help factories realize the latent abilities of the anemic workers who have managed to endure factory employment in spite of their poor health as well as increase the retention rate for anemic workers of average ability.

A key question, however, is whether in the normal course of experimentation in human resource management practices, the individual factory ownership groups could have expeditiously uncovered the benefits of treatment for factory performance. Factory managers may have difficulty uncovering such workplace innovations in a rapidly changing economic and policy environment. To the extent that factories have difficulty identifying such worker management innovations, buyer-NGO coordinated health interventions can be used to reveal the benefits of treatment to the buyer and the vendors in their factory base.

In the case of Ownership Group I, the buyers played a critical role in enlisting and funding the medical team’s data collection on the pre-treatment incidence of anemia. The external effect generated throughout the supply chain from information acquired through experimentation by a subset of factories provided an incentive to the buyers to share the cost and provide technical assistance.

Ownership Group II had a better chance, in principle, of uncovering the beneficial impacts of treatment on productivity without collecting medical evidence. There are a sufficiently large number of factories in the ownership group to conduct a randomized assignment of factories to treatment and control groups. Furthermore, the apparent presence of cross-worker productivity externalities of treating anemic workers characteristic of factories in Ownership Group II diminishes the importance of identifying anemic workers in the pre-treatment period.

Nevertheless, Ownership Group II may still have required prompting by its customers to undertake this experimentation. The buyers perceived a greater expected pay-off *ex ante* of
providing treatment to workers because of their *a priori* beliefs concerning the complementarity between benefits for workers and increased productivity.

Concern for reputation of the supply-chain may have also induced collaboration between the buyers and the vendors. We might normally expect the buyers to provide a simple pecuniary reward for factory compliance with the corporate code. However, if the buyers’ compliance officers believe that they have limited ability to observe genuine code compliance, the buyers cannot fully reward vendors for efforts to protect the supply chain’s reputation. Organizing and subsidizing interventions that demonstrate the benefits of humane HR practices, such as providing treatment for infectious and chronic disease, may provide an alternative mechanism for protecting the buyers’ reputation.

We conclude that the level of health care within these factories prior to the intervention was not profit-maximizing for the factory or the supply chain for at least six inter-related reasons: (1) the payoff from the productivity gains associated with treatment considerably exceeded the cost; (2) positive productivity externalities were generated from treated anemic workers to non-anemic workers due to other inefficiencies in production line organization; (3) the abilities of the factories’ inherently most productive workers was not realized due to poor health; (4) high turnover related to poor health impaired the ability of the factory to retain investments in worker skills; (5) workers value access to health care as a component of the compensation package; and (6) attention to worker health may generate positive reputation effects for the entire supply chain.

The buyers had an interest in directing the intervention and subsidizing its cost, thereby identifying a profit-increasing labor management innovation for all vendors in their supply chains, for at least four reasons: (1) the buyers had a stronger prior belief concerning the impact of worker health on productivity than the factory managers; (2) the buyers cannot perfectly monitor and, therefore financially reward, vendor efforts to protect the supply chain’s reputation; (3) most vendor
ownership groups are too small to experiment with more than one production innovation at a time; and (4) changes in market conditions confounded experiments in labor management practices. These last two considerations, in particular, created substantial cross-supply chain externalities of experimentation by a sub-set of vendors.

Indeed, despite the fact that factories in Bangalore are not required by law or corporate code to offer general health care to their workers, many factories in Bangalore and Chennai now offer workers and family members extensive healthcare benefits. These include (1) education programs on topics such as HIV/AIDS and reproductive health, (2) annual health camps in which workers and their families have an opportunity to consult medical professionals for non-work-related health concerns, (3) free factory-affiliated clinics accessible to workers and their families open after regular work hours, (4) factory clinics regularly staffed with doctors and nurses providing treatment to workers and their children in factory daycare centers and even (5) a fully-appointed infirmary and pharmacy.
References


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<td>October 2004</td>
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**Sample**

- Treatment Factory: 147, 201, 126, 171
- Control Factory: 32, 42, 53, 89

**Gender**

- Female: 159, 212, 158, 175
- Male: 20, 31, 58, 85

**Anemic (self-report)**

- Yes: 38, 52, 40, 56
- No: 141, 191, 139, 204

**Albendazole Eligible**

- Yes: 129, 183, 149, 222
- No: 50, 60, 30, 38

**Age (years)**

- 18-20: 30, 44, 35, 48
- 21-25: 63, 91, 71, 116
- 26-30: 52, 61, 37, 53
- 31-35: 21, 30, 26, 33
- 36+: 13, 17, 10, 10

**Education Level**

- Illiterate: 12, 15, 9, 13
- Primary: 23, 27, 20, 24
- Middle: 28, 41, 34, 48
- Secondary: 96, 135, 92, 138
- Senior Secondary+: 20, 25, 24, 28

**Monthly Income (rupees)**

- Average: 4560.7, 4622.0, 4303.7, 4213.2
- Standard Deviation: 1756.1, 1812.1, 1700.3, 1614.0

**Experience in Apparel**

- 0-6 months: 8, 10, 4, 6
- 6-12 months: 14, 21, 18, 28
- 1-3 years: 52, 73, 64, 94
- >3 years: 103, 137, 91, 128

**Marital Status**

- Never Married: 56, 90, 76, 126
- Currently Married: 116, 144, 95, 124
- Divorced/Widowed: 7, 9, 8, 9
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*Statistically significant at the 95% level of confidence.
**Statistically significant at the 99% level of confidence.
### Table 4
Efficiency Rates and the Treatment of Anemia with Iron and Albendazole
Factory Ownership Group I
Unbalanced Panel

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R-squared: 0.28

# of observations: 1980
# of subjects: 238
Average obs./group: 8.3
Wald chi2: 251.86

*Statistically significant at the 95% level of confidence.
**Statistically significant at the 99% level of confidence.
### Table 5
Efficiency Rates and the Treatment of Anemia with Iron and Albendazole
Factory Ownership Group II
Balanced Panel

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<tr>
<td>sigma-e</td>
<td>8.86</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Wald chi2</td>
<td>100.56</td>
<td></td>
<td></td>
<td>6249.23</td>
<td></td>
<td></td>
<td>724.88</td>
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</tr>
<tr>
<td>Prob&gt;chi2</td>
<td>0.00</td>
<td></td>
<td></td>
<td>0.00</td>
<td></td>
<td></td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

*Statistically significant at the 95% level of confidence.

**Statistically significant at the 99% level of confidence.
## Table 6

### Efficiency Rates and the Treatment of Anemia with Iron and Albendazole

#### Factory Ownership Group II

#### Unbalanced Panel

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Unit 2</th>
<th>Unit 2 + Control Unit</th>
<th>All Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Factory Albendazole</td>
<td>42.8**</td>
<td>2.19</td>
<td>32.85</td>
</tr>
<tr>
<td>TF*Anemic</td>
<td>2.48</td>
<td>3.80</td>
<td>3.67</td>
</tr>
<tr>
<td>TF*Albendazole</td>
<td>0.07</td>
<td>2.06</td>
<td>2.67</td>
</tr>
<tr>
<td>TF<em>Alb</em>Anemic Post</td>
<td>-0.25</td>
<td>4.23</td>
<td>4.02</td>
</tr>
<tr>
<td>TF*Post</td>
<td>8.79**</td>
<td>2.47</td>
<td>8.46</td>
</tr>
<tr>
<td>Alb*Post</td>
<td>2.25</td>
<td>2.94</td>
<td>2.99</td>
</tr>
<tr>
<td>TF<em>Anemic</em>Post</td>
<td>-4.14</td>
<td>3.00</td>
<td>3.58</td>
</tr>
<tr>
<td>TF<em>Alb</em>Post</td>
<td>-0.15</td>
<td>1.48</td>
<td>2.60</td>
</tr>
<tr>
<td>TF<em>Alb</em>Anemic*Post</td>
<td>3.60</td>
<td>3.62</td>
<td>3.94</td>
</tr>
</tbody>
</table>

### Summary Statistics

- **R-squared**: 0.16
- **# of observations**: 769
- **# of subjects**: 109
- **Average obs./subject**: 7.1
- **sigma-u**: 4.38
- **sigma-e**: 9.10
- **Wald chi2**: 143.18
- **Prob>chi2**: 0.00

*Statistically significant at the 95% level of confidence.

**Statistically significant at the 99% level of confidence.
Table 7
Manpower Turnover and the Treatment of Anemia with Iron and Albendazole
Estimates of a Cox Proportional Hazard Function

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Ownership Group I/TFOnly</th>
<th>Ownership Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Iron or Iron+Albendazole</td>
<td>Iron+Albendazole</td>
</tr>
<tr>
<td></td>
<td>Coefficient Estimate</td>
<td>Robust Standard</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>Error (2)</td>
</tr>
<tr>
<td>Health Status</td>
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</tr>
<tr>
<td>VeryGood/Excellent</td>
<td>0.67*</td>
<td>0.20</td>
</tr>
<tr>
<td>Poor/Not Good</td>
<td>1.06</td>
<td>0.22</td>
</tr>
<tr>
<td>Efficiency First Month</td>
<td>0.96***</td>
<td>0.01</td>
</tr>
<tr>
<td>TF*Post</td>
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<td>0.44</td>
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<tr>
<td>TF<em>Anemia</em>Post</td>
<td>1.36</td>
<td>0.77</td>
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<tr>
<td>TF<em>Alb</em>Post</td>
<td></td>
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</tr>
<tr>
<td>TF<em>Alb</em>Anemic*Post</td>
<td>1.39</td>
<td>0.75</td>
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<tr>
<td># of observations</td>
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<td>1673</td>
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<tr>
<td># of subjects</td>
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<td>196</td>
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<tr>
<td># of failures</td>
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<td>51</td>
</tr>
<tr>
<td>Log pseudo-likelihood</td>
<td>-250.22</td>
<td>-250.23</td>
</tr>
</tbody>
</table>

*Statistically significant at the 80% level of confidence.
**Statistically significant at the 90% level of confidence.
***Statistically significant at the 99% level of confidence.