ON THE ECONOMIC IMPACTS OF MEDICAL TREATMENTS: WORK PRODUCTIVITY AND FUNCTIONING*

Ernst R. Berndt

Abstract

In this essay I provide a wide-ranging overview of recent research linking medical treatments to productivity and ability to function. The studies that examine how do illness and medical treatments affect absenteeism, at-work productivity ("presenteeism") and ability to function vary in the type of data employed, and in particular, on whether ability to function is measured subjectively (by "asking") or objectively (by "counting").

Resumen

El objetivo de este documento es brindar un enfoque global de tres recientes estudios que examinan el impacto económico de las enfermedades y los tratamientos médicos en la productividad y rendimiento laboral. Los estudios analizados difieren en el tipo de información que emplean y, en particular, en la manera en la cual miden la productividad laboral del trabajador: subjetivamente ("preguntando") u objetivamente ("contando").

JEL Classification: *I10, J24*

Keywords: *Medical treatments, work productivity.*

☐   Louis B. Seley Professor of Applied Economics MIT Sloan School of Management, and Director, National Bureau of Economic Research Program on Productivity and Technological Change Cambridge, MA 02142 USA

I. INTRODUCTION

In the early to mid-20th century, in many countries public health investments such as those involving sewage treatment, water sanitation and widespread vaccinations undoubtedly had enormous impacts on reducing the spread of diseases, decreasing mortality and increasing life expectancy. Related advances in medical knowledge and greater access to medical care have helped lead even to the eradication of some diseases. Clearly, the combination of education, public health investments, and advances in medical knowledge have significantly reduced the costs and burdens of many illnesses.

It is useful to distinguish various components of the costs of illnesses. Among these distinct costs are direct medical care costs, caregiver costs (including the opportunity costs of caregivers' time), premature death, and disability or functional impairment ("morbidity").

In recent years health economists have increasingly focused on the disability and impairment costs of illnesses, rather than just on mortality. For example, several years ago the World Health Organization (Murray and Lopez [1996]) released a study attempting to measure the current and likely future worldwide burdens of various illnesses and conditions, where one measure of burden was based on a concept known as disability-adjusted life years (DALY's). One of the surprising findings of the study was that among the ten leading causes of DALYs, a seemingly disproportionate number (four) involved central nervous system mental disorders – unipolar major depression (#1), alcohol use (#4), bipolar disorder (#6) and schizophrenia (#9). The reason that these mental disorders have so large a cost burden is that among other impacts, they adversely affect cognitive functioning, ability to concentrate and energy levels, i.e. they affect morbidity, not just mortality.

Energy levels and the ability to function are critical components of daily living, both at home and in the workplace. Although there is quite a large body of literature dealing with the effects of work environment and work stress on health status, there has been relatively little analysis of the reverse causation – how do illness and medical treatments affect absenteeism, at-work productivity ("presenteeism") and ability to function? These economic impacts of medical treatments are very important – for employees, employers, those working at home, as well as for health officials seeking to assess the benefits of health services.

In this essay I review three types of studies that examine economic impacts of medical treatments. The studies vary in the type of data employed, and in particular, on whether ability to function is measured subjectively (by "asking") or objectively (by "counting"). First, I will look at the relationship between traditional symptom measures used by clinicians and subjective measures of at-work productivity generated by patients and their therapists, in the context of a clinical trial in which patients were monitored as they were treated for chronic depression.

In the second study, using traditional measures of educational attainment as well as federal government census data and a conventional model of human capital accumulation relating wage rates to educational attainment, I will examine the impact of early onset chronic depression (initial onset before age 22) on subsequent human capital accumulation. This study therefore employs some-

what more objective data than the first, and also integrates clinical trial data with government census figures.

The third type of study I will report on here examines the impacts of illnesses, and their treatments, on objective productivity measures, where the employee-specific productivity measures are observed daily by the employer. The three disease categories for which such objective productivity data are gathered involve allergies and antihistamines, asthma (pediatric and adult), and anxiety and several related mental disorders.

By looking at these rather diverse sets of studies, all focusing on the impacts of illnesses and their treatment on ability to function, but differing greatly in terms of the underlying data employed, I hope to provide a wide-ranging overview of recent research linking medical treatments to productivity and ability to function.

I begin with chronic depression, and examine how clinical response to treatment also manifests itself in improved subjective productivity performance.

II. CHRONIC DEPRESSION: SUBJECTIVE PRODUCTIVE DATA, CLINICAL TRIAL

As discussed in greater detail in Berndt *et al*. (1998), depression is an illness having a lifetime prevalence of around 10-15%, with females being about twice as likely as males to suffer from its symptoms. For females, initial onset is not uncommon between ages 15 and 25, although the incidence is highest during the prime working ages of 25 to 54. For both males and females, relapse and recurrence is quite common. Indeed, for a substantial portion of patients, depression is chronic rather than episodic. Depression is thought to be significantly undertreated, with patients either not seeking treatment or often instead presenting themselves to physicians with various ill-defined somatic symptoms. Depression is a treatable condition, with modern treatment success rates approaching 80% (although success rates from first-line treatments may be only 50-60%).

While the medical costs of treating depression are substantial (typically involving pharmacotherapy, psychotherapy, or some combination of the two), the non-medical costs are even larger. For the U.S. in 1990, Greenberg *et al*. (1993) estimated that direct medical costs accounted for about 28% of the total burden of depression, mortality costs from suicide were 17%, while excess absenteeism and reduced productivity at work accounted for about 55% of the $ 44 billion total cost burden.

Ware *et al*. (1989) have documented that in terms of functional impairment, the burden of depression is larger than that of many other somatic episodic and chronic medical illnesses. An implication of these facts is that if depression were diagnosed and properly treated, the benefits from treatment could be considerable, and could manifest themselves in large part in terms of increased ability to function and greater at-work productivity.

In Berndt *et al*. (1998), economists collaborated with physician clinical investigators in a clinical trial involving 635 chronically depressed patients, where the current depressive episode was one that had lasted at least 24 months. In the 12-week acute phase of this trial, patients were randomized to treatment with a modern selective serotonin reuptake inhibitor (chemical name sertraline) or an

older generation tricyclic antidepressant (imipramine). The hypothesis examined in this study was that treatment of depression leading to improved mental health status (assessed using conventional symptomatic measures) would also lead to improved work performance. The subjective measures of work performance were constructed from six behavioral instruments that were administered at baseline, week 4 and week 12 of the trial. In this study, absent objective measures of work performance, it was assumed that subjective measures, constructed from clinician-rated or patient self-assessed instruments, were closely related to true work performance. Since our hypothesis simply related symptomatic improvement (however achieved) to changes in subjective work performance, we did not distinguish between the two medications.

The econometric/psychometric model was a rather simple one. Let Y_0, Y_1 and Y_2 be the baseline, week 4 and week 12 index of the subject's work performance, where higher values of Y indicate greater performance. Let X_0, X_1 and X_2 be the baseline, week 4 and week 12 index of the subject's depression status, where a higher score for X indicates greater severity, and thus lower values of X indicate less severe symptoms. Since the relationship between *levels* of Y and X may be idiosyncratic across patients, one could incorporate fixed effects and specify bivariate relationships between *changes* in Y and *changes* in X, one between baseline and week 4, and the other between week 4 and week 12 of the trial.

Suppose further, as is commonly observed in medicine, that Y and X display spontaneous regression to the mean. Let Y and X follow a first-order autoregressive process, $Y_1 = \rho_y \cdot Y_0 + \varepsilon_y$, $X_1 = \rho_x \cdot X_0 + \varepsilon_x$, with $0 < \rho_x$, $\rho_y < 1$ and the ε's being random disturbance terms. Let the medical intervention cause a change in X ($\Delta X = X_1 - X_0$), which in turn results in a change in Y ($\Delta Y = Y_1 - Y_0$), where the changes are related to each other as follows:

$$\Delta Y = \beta \cdot \Delta X.$$

Our hypothesis is that β is negative. After some rearranging, we can derive an equation relating changes in work performance to changes in symptom severity and levels of X and Y, as follows, between, say, week 4 and baseline:

$$\begin{aligned}Y_1 - Y_0 &= (\rho_y - 1) \cdot Y_0 + \beta \cdot (X_1 - X_0) + \beta \cdot (1 - \rho_x) \cdot X_0 + \varepsilon \\ &= \beta_0 \cdot Y_0 + \beta_1 \cdot (X_1 - X_0) + \beta_2 \cdot X_0 + \varepsilon,\end{aligned}$$

(1)

where $\beta_0 \equiv \rho_y - 1$, $\beta_1 \equiv \beta$, $\beta_2 \equiv \beta \cdot (1 - \rho_x)$, and ε is assumed to be an i.i.d. normal disturbance term. Given the stationary AR(1) assumptions and the hypothesized negative sign for β, we expected β_0, β_1 and β_2 to be negative. An analogous equation can be derived for changes between time periods 1 and 2 (between week 4 and week 12 of the acute phase of the trial).

As measures of Y (work performance), we took patients' responses to three self-assessed work performance index questions, as well as their responses to three clinician-rated work performance index questions from widely used investigation scales. We averaged these over the six questions for each patient, and then transformed these Y and ΔY variables into standardized normal variates (mean zero, variance one).

To measure X (depression symptom severity), we used patients' responses to the widely employed Hamilton Depression Rating Scale ("HAMD"). Measures of X and Y were collected at baseline just prior to initial antidepressant treatment, at week 4, and at week 12 of the trial.

Considering the chronicity of their illness, trial subjects displayed remarkably rapid response to antidepressant treatment. By week 12, mean HAMD scores had fallen to about one-half their baseline values, indicating substantial improvement, with about two-thirds of the reduction occurring already by week 4. For subsequent use in the econometric modeling effort, similar to that for the Y's, we transformed the X's and ΔX's into standardized normal variates.

Since the transformed work performance and depressive status measures are standardized variates, there is no intercept term in Eqn. (1), and each β coefficient indicates by how many standard deviations the dependent variable changes, given a one standard deviation increase in that explanatory variable, other things equal. The regression coefficients in this standardized model can also be interpreted directly as partial correlation coefficients.

Berndt *et al*. (1998) report regression estimates for a number of different measures of work performance, based on data from 493 patients involved in the multisite clinical trial. A typical regression is the following:

$$\Delta Y = -0.730 \cdot \Delta X - 0.512 \cdot Y_0 - 0.320 \cdot X_0,$$
$$(24.55) \qquad (18.04) \qquad (10.37)$$

where absolute values of t-ratios are in parentheses. The R^2 from this regression was 0.638. The implicit estimates (t-ratios) of ρ_y and ρ_x were 0.488 (17.20) and 0.562 (14.53), respectively. As expected, the estimate of each of the β's was negative and statistically significant. Not only does subjective productivity performance improve as the severity of depressive symptoms decline, but individuals having lower initial work performance levels, ceteris paribus, experience greater work improvement. Moreover, patients having lower baseline depressive indices, other things equal, report greater work improvement.

Moreover, this rather simple model captures much more than just regression to the mean. One way to see this is to examine how much of the variability in predicted work performance would have occurred had there only been regression to the mean, and no medical intervention. For the 493 trial participants, based on the above estimated equation, about 41% of the predicted variation in work performance is due to regression to the mean, while 59% reflects the impact of antidepressant medical interventions.

In summary, evidence from the clinical trial strongly supports the research hypothesis that for chronically depressed individuals a reduction in depressive severity improves the patient's perceived work performance. Improvement in work performance is rapid, with about two-thirds of the change occurring already by week 4. An implication of these findings is that even in the short run when wages are fixed, employers have a stake in ensuring that their employees who may suffer from depression are properly diagnosed and treated, for when such interventions are medically efficacious, they also positively impact workplace productivity.

III. Early Onset Depression and Lost Human Capital:
Mixed Data Sources

Because labor markets are sticky, one would not expect that over the course of only a twelve-week clinical trial, as chronically depressed patients' depressive symptoms were mitigated, a significant portion of patients would change their employment status and experience wage rate increases. If such labor market changes were to result from improvement in mental health status, it is instead likely that they would take much more time to manifest themselves.

There is relatively little systematic research on how illnesses at an early point in one's life affect subsequent educational attainment, occupational choice and economic well-being. After the data from the clinical trial discussed above had been collected and assembled, in analyzing the data several of the economists noticed that while the average age of trial participants was 42, more than half of the patients in the trial had first experienced depressive states before age 15. This pattern of early onset was corroborated to us informally by the clinicians conducting the trial, who noted that early onset depression was a very common characteristic of patients they saw in their medical practices.

This set of observations, discovered by us rather accidentally but well-known to the clinicians, led us to propose another hypothesis: Early onset depression impairs a person's ability to accumulate human capital and to avoid secondary health and social behavior problems such as substance abuse, thereby adversely affecting subsequent wage rates and earnings.

More specifically, the ability of young adults to successfully accumulate human capital depends in part on their health status during the years in which most post-high school education typically occurs, i.e., ages 18-30. Illnesses with an early age of onset that substantially reduce physical, social or cognitive functioning are particularly burdensome. The costs of such disorders include not only direct and indirect medical costs, but also costs associated with reduced functioning and impaired ability to accumulate human capital. Detection and effective treatment of such early onset disorders could reduce these costs.

As discussed in Berndt, Koran, Finkelstein *et al*. (2000), about 15.7% of the U.S. population is estimated to have experienced an episode of major depressive disorder between the ages of 15 and 24, with a higher incidence seen in young women than in young men (20.8% vs. 11.0%). Using data from the same multisite randomized chronic depression clinical trial discussed in Section II of this essay, in Berndt, Koran, Finkelstein *et al*. (2000) four issues were addressed involving the "lost human capital" associated with early-onset depression: (i) does early-onset major depressive disorder reduce educational attainment more than late-onset major depressive disorder? (ii) do human capital impairments associated with early-onset major depressive disorder vary by gender? (iii) do the efficacy and sustainability of antidepressant treatments for chronic depression vary by initial age at onset? and (iv) among individuals in the U.S. in 1995 who were 21 years of age, what are the differences in future lifetime expected mean earnings, by gender, attributable to lost human capital for those who experienced early-onset major depressive disorder vs. those in whom it occurred later or never at all?

To examine these issues, the authors first disaggregated the sample of 635 clinical trial subjects into two groups: those age 30 and over at baseline (n = 531),

and those under age 30 at baseline (n = 104). The reason for this partiacular age split is that the researchers wanted to identify differential human capital accumulation paths. In the U.S., by age 30, most individuals tend to have completed any post-high school education. It is these older individuals that became the focus of analysis in the assessment of lost human capital. Based on a structured clinical interview administered by certified raters at baseline, it was found that among the 531 patients age 30 and over at baseline, 226 (42.6%) experienced their initial onset of major depressive disorder before age 22 ("early onsetters"), while 305 (57.4%) experienced their initial onset of major depressive disorder at age 22 or later ("late onsetters"). The cutoff age of 22 was chosen because most students attending college in the U.S. graduate around age 22.

A number of logistic multivariate regressions were run (controls included age and age squared, as well as age of onset dummies, gender, and their interactions), using data from the 531 individuals age 30 and older. The impact of early-onset major depressive disorder on whether the patient had never married varied by gender. The likelihood of women with early-onset depression never having married was not significantly different from that of women whose onset was later (p-value 0.69). However, men with early-onset depression were more than twice as likely (p-value 0.03) to have never married than were men whose depressive onset occurred later. While men and women with late-onset major depressive disorder did not differ from each other (p-value 0.62), men with early-onset depression were more than twice as likely to have never married than were women with early-onset depression (p-value 0.02). For men, the impact of early-onset major depressive disorder was most apparent on this simple index of intimate relationships.

The impacts of early-onset major depressive disorder on substance abuse also varied by gender. Women with early-onset depression were much more likely than those with late-onset depression to have had a history of alcohol or drug abuse (p-values < 0.01). By contrast, for men age at onset did not significantly affect the risk of having a history of alcohol or drug abuse (p-value 0.27). However, the propensity for men to have a history of alcohol or drug abuse was generally larger than that for women, regardless of age of onset. While men with late-onset depression had an almost fourfold greater risk of alcohol abuse history than women with late-onset depression (p-value for equality < 0.001), the male-female relative risk dropped by about half (odds ratio of 1.89, p-value 0.04) when both genders had early-onset depression.

In terms of the more typical human capital measures used by economists, my collaborators and I found that although the likelihood of having attended college was unaffected by age at onset of depression (p-value for early equal late 0.41 for women, 0.77 for men), early-onset depression negatively affected the probability of graduating, particularly for women. Specifically, women with early-onset depression were about half as likely to obtain a college degree as their older-onset counterparts (odds ratio 0.57, p-value 0.04). Across genders, within the early-onset group, men were almost twice as likely as women to graduate (odds ratio 1.89, p-value 0.05). When combined with the earlier findings on whether an individual had never married and whether he/she had a history of substance abuse, these results provide a somewhat striking profile: Early onset males are more likely never to marry, instead engage in substance

or alcohol abuse, yet somehow graduate from college, while early onset fe-
males are more likely to marry but not graduate from college.

Moreover, the large negative impact of early-onset depression appeared to
continue beyond college into graduate studies, as women with early-onset
depression were half as likely as those with late-onset depression to seek
postgraduate training (odds ratio 0.50, p-value 0.09). For men, however, the
likelihood of attempting a postgraduate degree was unaffected by age at onset
(p-value 0.91).

Related medical findings from this trial are discussed in detail in Berndt,
Koran, Finkelstein *et al*. (2000). In brief, responsiveness to treatment was inde-
pendent of age at onset, both in terms of subject attrition during various phases
of the trial, and treatment responsiveness for those who completed a trial phase.
During the final 52-week maintenance phase of the trial, the likelihood of a
patient randomly assigned to receive placebo maintaining a therapeutic response
during this trial phase was only one-quarter that of a patient randomly assigned
the sertraline medication, but this differential did not depend on age of onset.

From an economic viewpoint, a very striking implication emerging from
this analysis is that early onset depression adversely affects the subsequent edu-
cational attainment (human capital accumulation) of young women, and thereby
is likely to reduce their future wage rates and earnings. To obtain quantitative
measures of these adverse subsequent earnings impacts of early-onset depres-
sion, we used U.S. Current Population Survey data from the U.S. Census Bu-
reau for 1995, covering 83,007 individuals between ages 19 and 70. Defining
the dichotomous 0-1 labor force participation variable as being one for an indi-
vidual when total annual earnings from employment or self-employment were
greater than $ 260 ($ 5 per week), we estimated a traditional logistic labor force
participation equation, with various demographic and educational attainment
explanatory variables. Conditional on the individual being in the labor force,
we then regressed annual log-earnings on the same set of demographic and
educational attainment variables. These estimated equations provided the basis
for a quantitative evaluation of changes in expected annual earnings (the prod-
uct of the predicted proability of labor force participation times the predicted
earnings conditional on labor force participation) associated with reductions in
educational attainment, controlling for other socioeconomic characteristics.
Though results are not shown here, we found that annual earnings are greater
and peak at older ages with successive increases in educational attainment, con-
sistent with findings from the existing labor economics literature.

When the age at onset and educational attainment data from the clinical trial
were then merged with U.S. census data relating labor force participation and
earnings to educational attainment and other socioeconomic variables, they re-
vealed significant declines in expected future annual earnings for women expe-
riencing early-onset vs. late-onset/never occurring depression.

Specifically, the expected annual earnings at age 35 for two women 21 years
of age in 1995 would be $ 22,461 for the woman with late-onset/never-occur-
ring depression, but only $ 19,795 ($ 2,666, or 11.9% less) for the woman with
early-onset depression. At age 45, the expected annual earnings gap widened to
$ 26,071 vs. $ 22,341 ($ 3,730, or 14.3% less), and at age 55, expected annual
earnings are $ 19,415 vs. $ 15,937 ($ 3,478, or 17.9% less). These differences
are annual decrements, and were they to be summed over a lifetime potentially

in the labor force, the differences would be even larger. Thus, early-onset major depressive disorder has considerable consequences for the expected earnings of women.

Interestingly, for those women participating in the clinical trial, employment rates were similar for early vs. late onset individuals. However, the reduced educational attainment of women with early-onset major depressive disorder resulted in their having lower current and expected future earnings.

IV. STUDIES USING OBJECTIVE PRODUCTIVITY MEASURES:
RETROSPECTIVE CLAIMS DATA

In both sets of productivity studies reviewed above, data from prospective randomized clinical trials were employed. In the first study, productivity was measured subjectively based on patients' and clinicians' assessments. In the second study, a somewhat different and slightly more objective measure of productivity or performance – educational attainment – was utilized base on information drawn from the clinical trial case report forms. Additional publicly available data on educational attainment, incomes and sociodemographic characteristics were imported from the U.S. Current Population Survey and then integrated with the clinical trial data.

While both sets of studies are informative, they suffer somewhat in their subjective productivity measure (the first study) or somewhat coarse measure of performance (educational attainment, the second study). Is it not possible to utilize more objective measures of productivity, and relate these objective measures to medical treatments and health states of individuals? That is the goal of a third set of studies.

In Cockburn *et al*. (1999), we analyzed data provided by a large U.S. insurance company on the objectively measured productivity and retrospective health claims data of 5,888 individuals employed as claims processors during the period January 1993 to July 1995. To protect individuals' confidentiality, records were made anonymous by deleting personal information and assigning a specially generated ID number that allowed us to match information across different files without identifying individuals.

The job task of insurance claims processors consists largely of checking, entering and authorizing payment of medical claims, and involves viewing a computer monitor and entering appropriate keyboard strokes. Output is therefore easily and accurately measured by computer tracking of the number of claims processed each day.

Workers at this firm are paid based on a fixed contractual number of hours per week; therefore, we do not directly observe actual hours worked per day. Although some claims were more "manual" and others more "automatic", to aggregate we used the same weights used by the employer in tracking performance and computing compensation. The mean daily output was about 185 claims, or about 25 per hour at work. About 95% of the claims processors were women, with the mean age being about 42.

The first hypothesis we examined with this data was that illness, possibly in conjunction with available treatment, has a measurable impact on an individual's

ability to function at work. Thus, if objective productivity is measurable, we expect to observe a well-defined pattern of work impairment when health status changes.

A. Sedating vs. Nonsedating Antihistamines for Treatment of Allergies

More specifically, in our initial analysis we examined 682 individuals who filled prescriptions for antihistamine medications. We obtained information on employees' prescription drug use from a file of prescription claims, from which we extracted 1890 prescriptions for antihistamines. We indexed each observation by the employee's ID number and the date the prescription was filled.

These prescribed antihistamines are used primarily for the treatment of allergic rhinitis ("allergies"). About 55% of the prescriptions taken by these individuals were for one of the three recent generation H_1-antagonist medications commonly described as "non-sedating" antihistamines. The remaining 45% of prescriptions were for a portfolio of older generation medications, those with well-documented "sedating" effects. Although we observed a substantial number of prescriptions for the older, more strongly sedating antihistamines, because such older drugs are also sold over-the-counter in the U.S., these data surely understate the actual use of these drugs.

The integrated productivity and prescription drug claims data allowed us to distinguish among various health status days at work – days in which no antihistamines were likely to be taken and the individual was apparently symptom-free, days just before an employee filled a prescription for an antihistamine drug, and days just after an employee filled a prescription for an antihistamine drug. In the latter two cases, we were also able to distinguish whether the prescribed antihistamine was sedating or non-sedating.

Using 36,497 workdays for these 682 individuals, we estimated multivariate regression models where the dependent variable was the logarithm of total weighted claims that day, and explanatory variables included a variety of economic factors and worker characteristics, in addition to various drug-use dummy variables. Estimation was by ordinary least squares, and standard errors were adjusted for heteroskedasticity using the White procedure.

To capture drug use effects, we classified observations (daily productivity measures) as falling into brief "before" and "after" time periods bracketing the date on which the employee filled a prescription for an antihistamine drug. We defined alternative lengths of the window surrounding the prescription date – three, five, seven, ten and fourteen days. Not surprisingly, only a very small fraction (just over 1% for three-day periods) of days fell into the time periods we identified as just preceding and just following the filling of a prescription for antihistamine drugs.

Detailed results of this research are found in Cockburn *et al*. (1999). In the three days just prior to filling a prescription for an antihistamine, productivity was not significantly different from apparently "healthy" days (hereafter, we call this "average"); hence, the "before" effect was insignificant. Untreated, the condition for which the drugs were being prescribed seemed to have little impact on productivity. However, during the three days after filling a prescription for a sedating antihistamine (the "after" effect), employees were 7.8% less productive than average, whereas those who filled a non-sedating antihistamine

prescription were 5.2% more productive. The contrast between these two latter effects was highly significant (p-value 0.005), and the magnitude of the contrast (13%) was very substantial and meaningful. Hence, the choice of medical treatment had very substantial consequences with respect to at-work productivity. These results were qualitatively unchanged when larger windows of five, seven, ten and fourteen days were used to define the "before" and "after" periods, although the negative effect on output of using sedating drugs fell as the time period increased.

Interestingly, when sedating and non-sedating antihistamines were further stratified according to whether the drug was combined with a stimulating decongestant, the productivity advantage of non-sedating, non-stimulating drugs over sedating, non-stimulating antihistamines increased to almost 25%. Although this difference was statistically significant (p-value < 0.01), the number of observations in the various drug categories was small.

Since these antihistamines are used primarily to treat allergic rhinitis, which is often attributable to exposure to airborne allergens, we repeated the analysis for a subset of employees identified as living in well-defined regions (based on zip codes of their addresses) for which we obtained weekly data on counts of pollen from trees, grass, and shrubs, as well as airborne moulds. This reduced our sample by about 35%, so results are not directly comparable. However, our principal findings were unaffected after controlling for pollen counts in this manner.

B. Effects of Own and Dependent's Asthma on Objectively Measured Productivity

In our next study, Finkelstein *et al*. (2000), we utilized the same integrated productivity and medical claims data base involving 5888 claims processors, but instead we focussed on absenteeism and objectively measured productivity on those days just before and after an individual visited a physician to seek treatment for asthma. We were particularly interested in two very different sets of individuals: (i) adult employees who were diagnosed as asthmatics; and (ii) adult employees who had dependents diagnosed with asthmatic conditions. What we wanted to investigate was the extent to which exacerbations of asthmatic symptoms (prompting visits to a physician) were associated with excess absenteeism and/or reduced at-work productivity, and whether these work-related adverse impacts differed when the employee was dealing with his/her own asthma, or when the employee was the parent of a dependent asthmatic.

To quantify the impact of dependent and employee asthma on workplace performance and absenteeism, we again employed multivariate regression methods and retrospective analyses of data relating medical claims to employee records on daily absenteeism, objectively measured productivity, and other characteristics.

About 38% (2222) of the 5888 individuals employed as claims processors at this large U.S. insurance company received medical and drug benefits in the company's self-insured, indemnity or preferred provider organization plans, continuously while employed. Among these, 1845 employees processed clients' indemnity health claims as their principal job, while 367 processed a variety of health maintenance organization claims. Since the complexity of the lat-

ter claims differed from the indemnity claims and from each other, we focussed our attention on the 1845 employees processing indemnity claims, and their dependents.

We defined an absentee day as a regularly scheduled workday in which an employee processed no claims. Thus our measure of absentee days includes all scheduled absences due to vacation and other company-authorized absentee days, as well as unscheduled absences due to one's own or one's dependent illness.

To identify dependent and employee asthmatics, we examined medical claims and extracted the medical claims of all individuals diagnosed with a number of asthmatic-related specific disorders; details are given in Finkelstein *et al*. (2000). Each claim was indexed by the employee's ID number, the date that the medical service was provided, and whether the claim was for the employee, a spouse or a dependent. From the prescription drug data file, we also identified all prescription claims filed on behalf of the employee, spouse and dependents.

To be identified as an asthmatic, we required that an individual have at least one medical claim with the appropriate asthma diagnostic codes, and at least one asthma pharmaceutical claim attributed to their family ID number. This yielded a sample consisting of 35 non-asthmatic employees having dependent asthmatics, and 61 asthmatic employees (none, coincidentally, having dependent asthmatics). The number of potential workdays observed (at-work plus absentee days) for which objective daily productivity could be analyzed was 11,123 for the 35 employees with asthmatic dependents, and 21,056 for the 61 asthmatic employees. These potential work-day observations constituted our two data samples – asthmatic employees, and employees with asthmatic dependents.

As in the analysis involving antihistamines, we again defined episodes of varying length surrounding a medically related event. Specifically, we created window time periods directly before and just after the medical system interaction (a physician visit involving an asthma treatment diagnosis) of varying time lengths – three, seven, or ten days. The "before" period was defined to be all days in between the first and last visit within an episode in addition to a window of days before the first visit in the episode corresponding to the selected window size. Thus the "before" period included days during the treatment episode. The "after" period is simply the number of days corresponding to the selected window size after the last medical visit in the episode. As in the case of antihistamines, with alternative window sizes of three, seven and ten days, only a small proportion (about 1-2%) of potential workdays fell within these medical interaction windows.

To allow for the possibility that preschool asthmatics have a differential impact on parental at-work productivity and absenteeism from older asthmatic dependents (e.g., adolescents), we defined separate "before" and "after" windows depending on whether the age of the dependent asthmatic was greater than, or less than or equal to five years at the time of the episode. No age window distinctions were made for adult asthmatic employees.

In the absentee multivariate logistic regressions, the 0-1 dependent variable was whether the employee was absent that day, the observations incorporated in the regression included all at-work productivity days and all absentee days,

and the regressors included the "before" and "after" window variables, age, age squared, the inverse of current job tenure (one over time in days since initially employed as claims processor at this company, designed to capture learning curve effects), marital status, gender, highest educational attainment, day of week and monthly dummy variables, and several other job-related characteristic variables; details are provided in Finkelstein *et al*. (2000). This logistic equation was estimated separately for asthmatic employees, and employees with asthmatic dependents.

In the at-work productivity ("presenteeism") equation, the dependent variable was the logarithm of number of claims processed that day, the observations were limited to days in which at-work productivity was non-zero (i.e., absentee days were excluded), and the same set of regressors were employed as in the absenteeism logistic regression. This equation was estimated by ordinary least squares separately for asthmatic employees, and employees with asthmatic dependents, with estimated standard errors being adjusted for heteroskedasticity using the White correction.

Our findings on the workplace burden of asthma can be summarized as follows; further details are given in Finkelstein *et al*. (2000). Asthmatic employees were more likely to be absent during windows of time just prior to and particularly immediately following medical treatment for their own asthmatic conditions. If they chose to show up at work, their daily objectively measured productivity was essentially unaffected. In brief, asthmatic employees apparently had learned how to deal with their asthma – when at work, their productivity was unaffected, but when their asthmatic symptoms were exacerbated, they took time off from work to seek medical attention.

Employees with asthmatic dependents, however, had just the opposite type of behavior. Note that about 95% of the employees with asthmatic dependents in our sample were women. The probability of a parent employee being absent was insignificantly affected by concurrent asthma-related medical treatments involving its dependents. However, if these (largely female) employees showed up at work, their daily at-work objectively measured productivity declined by about 11-12%. Thus, the "worried at-work parent" manifested a significant cost burden of asthma in the form of reduced productivity while at work. Incidentally, the decline at-work productivity of the worried parent was no different when the dependent was a pre-school vs. older dependent child.

Thus our main findings paint a striking picture of some of asthma's less visible costs. Employees who are parents of children with asthma are relatively unlikely to be absent from work during episodes of the child's illness. Yet these exacerbations of their children's asthma are associated with declines in parental work productivity averaging about 11-12% per day during the dependent's episode window. In contrast, employees who themselves experience symptomatic episodes of asthma requiring medical visits are somewhat more likely to miss work just prior to, or following the physician visit. However, when these asthma sufferers are at work, their productivity is unaffected.

It is worth noting, incidentally, that one other possibly very significant cost burden of asthma – the effects of asthma episodes on children's absenteeism from school and thus their own capital accumulation – is not captured by this type of analysis.

C. Chronic Illnesses: Average Productivity Over Longer Time Periods

The workplace impacts of illnesses and their treatments that we examined in the previous two examples – sedating vs. non-sedating antihistamines for the treatment of allergies, and employees dealing with their own or their dependent's asthmatic episodes, each involved looking at objectively measured productivity and absenteeism over rather short time intervals, such as three, seven, ten or fourteen days before and after a medical treatment event. Such window lengths are likely to be quite appropriate when the illness or disorder has a clearly defined acute episode, and this acute phase is of limited duration.

There are many illnesses and disorders, however, whose symptoms are present over an extended time period, and for whom treatment is ongoing. In the case of chronic diseases, or illnesses that require long-term use of medications, it is unclear how one can best define an illness episode, or an episode of care. For such extended illnesses or treatments, it is therefore not as informative to examine absenteeism and at-work productivity trends over short time periods. Rather, what might be more appropriate in such cases is to examine the average productivity of the employee over a longer time period, such as a year or longer. For many employers, particularly in cases where performance of the job is not time-sensitive, what is of prime interest is not transitory variations in productivity, but rather average productivity over a longer time period, such as a year or more. Thus it is of some interest to compare the average productivity of employees that differ in the illnesses from which they suffer, where the productivity comparison is over a long time period such as a year, rather than over, say, a two-week window. But as I shall soon argue, even this long-term comparison is fraught with ambiguity.

Consider a central nervous system disorder such as anxiety, or depression. These disorders are frequently chronic in nature, and also often require maintenance medication rather than just medication surrounding an acute episode. It is also well-known in the medical literature that there is extensive comorbidity among the various mental disorders, i.e., quite frequently an individual deals with more than one mental disorder over a time window of a single year.

In Berndt, Bailit, Keller *et al.* (2000), I examined the objective productivity of employees with and without anxiety, and with other mental disorders, at the same national claims processing firm discussed in the above subsections A and B. The objective measure of productivity employed in the analysis was the daily productivity of the employee averaged over all days the employee was at work during the 30-month time period between January 1, 1993 and June 30, 1995. Absenteeism days were defined as was discussed in the earlier analysis involving asthma (subsection B above), but here absenteeism measures were converted into annualized equivalents for each employee.

The first striking finding from this study was the relatively high rate of diagnosed prevalence of mental disorders – 14.9% of the company's claims processors had a primary diagnosis of, and received treatment for, a mental disorder. This is striking, for mental disorders are widely thought to be underdiagnosed and undertreated. Furthermore, slightly more than half of the employees diagnosed with a mental disorder during the study period had multiple distinct primary mental disorder diagnoses: 24.2% had two, 11.8% had three, 4.5% had four, 2.7% had five, 2.7% had six, 11.5% had seven, and 2.1% had eight (the

largest was sixteen). Hence it was not uncommon at this firm for employees to show up at work and attempt to function even as they coped with and were being treated for one or more mental disorders.

Based on a preliminary analysis, we stratified the employees into those with one mental disorder, more than one mental disorder, those having post-traumatic stress disorder (PTSD), and employees with no mental disorders. For comparison, we also constructed a 10% random sample of all employees. Using multivariate regression procedures (with age and gender controls) and the mental disorder indicator variables, we then assessed the impacts of mental disorders on various measures of work performance. When job tenure was the dependent variable (time since first employed at the company to the last date observed at work, in elapsed days), we found that as a group, there was no statistically significant difference in job tenure among those with one or more mental disorders relative to those without any diagnosed and treated mental disorder. However, using two-way comparisons between various sub-groups, we found that those employees having depression only had a slightly shorter job tenure (about 20%), while the anxious only employees had a slightly longer (about 30%) job tenure, relative to those without any mental disorder, other things equal.

When the logarithm of annualized absenteeism days was the dependent variable, we again found that as a group, there were no statistically significant differences in annualized absenteeism between employees with one or more diagnosed/treated mental disorders and those with none. The only statistically significant two-way comparisons involved those employees with depression plus another mental disorder, and those employees with PTSD, who had respectively approximately 37% and 200% more annualized absentee days than those with no mental disorders, other things equal.

We then excluded absentee days and instead addressed the question: Does the average daily at-work productivity of employees with various diagnosed and treated mental disorders differ from that of others? Using multivariate regression procedures with the log of average daily productivity as the dependent variable, we found no evidence supporting the notion that employees diagnosed with and being treated for one or more mental disorders are any different as a group in their average at-work productivity than those not diagnosed/treated for a mental disorder. None of the various two-way comparisons was statistically significant as well.

In summary, our analyses suggests that while several of the mental disorders are associated with differential lengths of job tenure and with differential absentee rates relative to those with no mental disorders, there is no differential effect on average at-work objectively measured productivity.

These findings may at first glance appear to be surprising. That average absenteeism rates over extended time periods are not different between those with and without diagnosed/treated mental disorders could reflect the fact that those without mental disorders used up their allotted sick days by "calling in sick" when in fact they were well, whereas those dealing with mental disorders actually use them when ill. In such cases, because of intertemporal substitution the observed total number of days away from work over an extended period would be similar for those with and without mental disorders.

In terms of average at-work productivity, the lack of differences between those with and without mental disorder diagnoses/treatments may reflect measurement problems. We are of course unable to identify those employees who suffer from but are not being treated for mental disorders. If treatments were effective, then the observed average productivity levels of treated employees would reflect any improvements resulting from treatments. In contrast, since the average productivity of the persons who go untreated (and are therefore unobserved) is likely lower, this reduces the measured average productivity of the no mental disorder groups. Thus, to the extent that treatments are effective for those diagnosed, while functional impairments of the untreated employees rise, the observed average productivity difference between these two groups is biased downward.

Finally, and perhaps most importantly, the similarity in average productivity between those with and without mental disorders may reflect selection and sorting behavior. Specifically, those individuals having chronic mental disorders are likely to have sorted themselves into occupations and jobs where they can perform at a level equal to that expected of the average employee. Thus, it may not be surprising to observe no difference in average productivity at work for mature employees with and without diagnosed/treated mental disorders. If the chronic illness were fully and permanently remitted, however, after some time one might expect that some employees would permanently improve their work performance, perhaps work more hours, or eventually change to an upgraded job. Moreover, as I discussed in Section IV of this essay, if the mental disorder were diagnosed and treated effectively early, educational attainment and occupational choice could be affected.

Nonetheless, that persons with more than one diagnosed and treated mental disorder are able to function satisfactorily at work (where productivity is objectively measured) is an important finding, with encouraging implications for employers, employees and providers.

V.   CONCLUDING REMARKS

My purpose in this essay has been to overview a wide-ranging body of research with which I have had the opportunity to participate that focuses on the impacts of illnesses and their treatments on ability to function at work. I have emphasized the differences in the sources of underlying data for this diverse set of studies.

It is useful briefly to conclude with some other remarks regarding data and future research paths. First, on *a priori* grounds, as economists we likely prefer objective to subjective measures of productivity. There is a problem, however, in generalizing from one specific type of work – processing of medical claims, for example – to other jobs and occupations. In future research it might be useful to focus on certain activities that are common in a number of jobs, e.g., word processing, entering data, conducting transactions over the telephone, loading and transporting freight in a warehouse using fork lift equipment.

Second, the objective productivity data used in the studies I have discussed in this essay all involve use of retrospective medical claims data. This retrospective data does not yield much useful information on, for example, the se-

verity of an illness, and on the outcome of the treatment. Typically such information is gathered in prospective clinical trials, where in addition patients are randomized to treatments so that there is a reasonable probability that unobserved variables are unlikely to bias the results. Perhaps it will be possible in the near future to conduct prospective trials in the workplace, but to do that in a way that does not disrupt the work environment will be challenging. Developments in the technology of virtual reality may soon make it possible to simulate various work environments and work tasks, and thus to analyze impacts of medical interventions on reliably measured ability to function. Such developments could have a very significant impact on research, eventually yielding more reliable quantification of medical treatments and their impacts on ability to function.

   Third and finally, in assessing the workplace performance impacts of illness and its treatments, one must be very careful in choosing the appropriate time period – be it a week, a month, a year, or even several years. This is particularly important in jobs and occupations where an employee can substitute his/her own efforts and productivity intertemporally (make up for a bad day next week), or where the employee is a member of a team in which team members can cover for each other both concurrently and intertemporally. How one selects an appropriate time duration to analyze the work impacts of medical treatments is an important topic for future research.

REFERENCES

E.R. Berndt, S.N. Finkelstein, P.E. Greenberg, R.H. Howland, A. Keith, A.J. Rush, J.M. Russell and M.B. Keller (1998). "Workplace Performance Effects from Chronic Depression and Its Treatments," *Journal of Health Economics*, Vol. 17, pp. 511-535.

E.R. Berndt, H.L. Bailit, M.B. Keller, J.C. Verner and S.N. Finkelstein (2000). "Health Care Use and At-Work Productivity Among Employees with Mental Disorders," *Health Affairs*, Vol. 19, N° 4, July/August, pp. 244-256.

E.R. Berndt, L.M. Koran, S.N. Finkelstein, A.J. Gelenberg, S.G. Kornstgein, I.M. Miller, M.E. Thase, G.A. Trapp and M.B. Keller (2000). "Lost Human Capital from Early-Onset Chronic Depression," *American Journal of Psychiatry*, Vol. 157, N° 6, June, pp. 940-947.

I.M. Cockburn, H.L. Bailit, E.R. Berndt and S.N. Finkelstein (1999). "Loss of Word Productivity due to Illness and Medical Treatment," *Journal of Occupational and Environmental Medicine*, Vol. 41, N° 11, November, pp. 948-953.

S.N. Finkelstein, I.M. Cockburn, H.L. Bailit, J.C. Verner, K. Haver and E.R. Berndt (2000). "Lost Work Productivity and Absenteeism Among Parents of Children with Asthma," Cambridge, MA: Massachusetts Institute of Technology, Program on the Pharmaceutical Industry, *Working Paper* 57-00, November.

P.E. Greenberg, L.E. Stiglin, S.N. Finkelstein and E.R. Berndt (1993). "The Economic Burden of Depression in 1990," *Journal of Clinical Psychiatry*, Vol. 54, November, pp. 405-418.

C.J. Murray and A.D. Lopez, eds. (1996). *Global Burden of Disease: A Comprehensive Assessment of Mortality and Disability from Disease, Injuries, and Risk Factors in 1990 and Projected to 2020*, 2 Volumes, Cambridge, MA: Harvard University Press.

K.B. Wells, A. Stewart, R.D. Hays, M.A. Burnam, W. Rogers, M. Daniels, S. Berry, S. Greenfield and J. Ware (1989). "The Functioning and Well-being of Depressed Patients: Results from the Medical Outcomes Study," *Journal of the American Medical Association*, Vol. 262, Nº 7, pp. 914-919.