The Cost of Diabetes

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Abstract

Diabetics must choose how much effort to devote to health care. Technological innovation and product differentiation have lowered the price of diabetic compliance. It is now easier to frequently test blood and to adjust insulin levels. The quality of sugar free food substitutes have greatly improved. New diabetic cohorts should be healthier than previous cohorts. This paper uses the 1976 and 1989 cross-sections of the National Health Interview Surveys to study output indicators, such as income and labor force participation, and input indicators, such as diet and weight, of diabetics and non-diabetics to evaluate this "convergence" hypothesis.

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I. Introduction

Seven million people, or 2.7% of the U.S. population, have diabetes. Diabetes is a chronic disease in which the body does not produce or respond to insulin.[2] Diabetic life expectancy has dramatically increased over time. In 1900, the average ten year old with diabetes could expect to live 1.3 years. The discovery of insulin in 1921 greatly prolonged diabetic life expectancy. Table One indicates that a ten year old diabetic in 1914 had a life expectancy of 2.6 years. A ten year old's life expectancy grew to 31.7 years by 1926 and grew to 44.2 years by 1939. Since 1970, there has been a 19% decline in the underlying cause death rate from diabetes (Harris and Entmacher 1984).

The American Diabetic Association (1993) has estimated the direct and indirect cost of diabetes as $91.8 billion 1992 dollars. The private costs of diabetes stem from increased

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[2] Insulin is a hormone, produced by the pancreas, that helps the body metabolize the sugar glucose. When insulin is absent or ineffective, high levels of glucose appear in the blood. High blood glucose levels can lead to both short-term and long-term complications (American Diabetic Association 1993).

There are two major types of diabetes: insulin-dependent diabetes mellitus (IDDM also called type I) and non-insulin dependent diabetes mellitus (NIDDM, also called type II) (American Diabetic Association 1993). NIDDM is much more common than IDDM (known as juvenile diabetes). Almost 98% of people older than 20 with diabetes have NIDDM. Diabetes therapy is geared toward controlling high blood glucose levels and preventing diabetes complications. For IDDM, treatment consists of insulin injections and diet/exercise therapy. For NIDDM, treatment may include insulin injections or oral agents to lower blood glucose, diet therapy, a weight-reduction program for patients who are overweight, and a program of exercise.

morbidity and mortality risk and having to change one's lifestyle. Family consumption is not insured against such adverse health shocks (Cochrane 1991). Diabetics may not enjoy equal wage growth as non-diabetics over the lifecycle because they may be job locked and unable to contract with their best employment match[3]

Diabetics may not internalize the full cost of their condition. The social cost of diabetes may be greater than the private costs because diabetics with complications can qualify for Social Security Disability Insurance, Medicaid, and elderly nursing home assistance.[4] To quantify whether such programs create a serious moral hazard problem, one would have to estimate what diabetic health maintenance would have been in the absence of this insurance.

Diabetic behavioral change can minimize the total cost of the condition. This chronic condition can be controlled through the choice of insulin, diet, and exercise. Compliance is likely to increase as there are further innovations in sugar substitutes, improved blood sugar level monitoring technology, advances in insulin treatment and more information on the benefits of tight control. Increased product differentiation and technological advance lower "the price" of diabetic compliance. Having diabetes is becoming less costly if compliance is becoming cheaper.

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[3] Newhouse (1994) surveys the job lock literature and concludes that the results are mixed on whether pre-existing conditions leads to job-lock. Madrian (1994), using the 1987 National Medical Expenditure Survey, estimates that job-lock reduces the voluntary turnover rate of those with employer-provided health insurance by 25 percent from 16% to 12% per year.

[4] Real disability expenditures for the population aged 18-64 more than doubled between 1970 and 1977 (Berkowitz and Hill 1986). The elderly are requiring greater expenditures. In 1983, public expenditures paid for nearly 50% of the cost, mainly through Medicaid. Van Nostrand (1984) reports that in 1977 one in every seven nursing home residents was diabetic. For persons 45 years and older, the rates of diabetes in nursing home residents were twice those found in the general population.

Increased diabetic compliance reduces the likelihood that a diabetic becomes incapacitated and increases the likelihood that a diabetic is a contributing member of the labor force.

This paper uses micro data from the 1976 and 1989 National Health Interview Surveys to study whether increased diabetic compliance has translated into improved employment and earnings prospects. Has diabetic quality of life improved uniformly across education groups or have the gains been concentrated among the most educated? Output indicators such as family income, labor force participation, and occupational choice provides information about the costs of the condition. By contrasting such output measures for diabetic and non-diabetics, I study whether the two groups have "converged". I find some evidence of convergence of labor force participation rates especially for people with at least a college degree. This convergence evidence indicates improved diabetic quality of life and that the aggregate costs of the disease are falling.

This paper adds to recent research in health economics on public policies designed to minimize the aggregate cost of disease. Diabetes has a large post-diagnosis behavioral component. Conditional on being diagnosed as HIV positive or as having lung cancer, individual choices do not exacerbate the condition. People makes choices that increase their risk of becoming a diabetic and then conditional on being a diabetic they make choices that increases their chances of suffering complications. The case for government intervention in the diabetes product market hinges on whether sufficient product innovation has occurred to encourage behavioral change. Federal subsidies for developing sugar substitutes could be justified if the external benefits were large enough. To improve public health and minimize new AIDS and lung cancer cases, the government has invested in information campaigns to lobby people not to engage in risky sex and to quit smoking. The government has also passed anti-smoking laws and closed down public bath houses. The government cannot two part price sugar to make diabetic consumption more expensive. Philipson and Posner (1993) discuss policies such as subsidizing condoms to lower the transmission rate of the HIV virus. If smoking, or risky sex, or sugar eating are addictive behavior then the government should focus on discouraging new participants (Becker and Murphy 1991).

This paper is organized as follows. Section Two presents the basic model. Section Three discusses the data sources and contrasts diabetic health patterns. Section Five presents my findings.

Section Six concludes.

II. Diabetic Compliance

Diabetic personal care is a form of self-protection.[5] A diabetic derives utility from health, consumption of tasty food, and suffers utility loss from exerting health maintenance effort. One's health stock can be increased by exerting greater health monitoring effort and by reducing consumption of certain goods such as candy. Tasty food is produced through consumption of candy or a sugar free substitute. They are not perfect substitutes.[6] Effort might

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[5] Ehrlich and Becker (1972) model investments to minimize the likelihood of certain states of the world.

[6] A german study of 500 diabetics reported that over 80% were not willing to give up sweeteners (Heller pp. 38). Nutrasweet could not be a perfect substitute for sugar because it cannot be used for baking.

represent increased blood testing or decreased sugar consumption or increased exercise. Effort affects the probability of suffering complications in the future. Over time, sugar alternatives, such as Nutrasweet, are invented. This product differentiation encourages diabetics to substitute away from sugar. To maintain good health, the diabetic must test his blood and choose a level of food intake, insulin intake, and exercise to minimize the variance of his blood sugar level around the optimal level.

If a diabetic's objective was to maximize expected wealth, then there would be no externality.[7] The externality exists because diabetics value not only their wealth but also the taste of food, and they dislike costly effort.[8] Since the choice of insulin, diet, and exercise is private information, diabetics are agents whose privately optimal choices may not be socially optimal. Diabetics choose how strictly to comply with "good care". The diabetic is an agent with private information about his activities to minimize his risk of complications from diabetes. From examining the diabetic, a doctor may recognize shirking but he cannot punish the agent. The doctor can only convince the diabetic of the true health outcomes from not complying. Society does not care about the diabetic's utility level. It only cares about not having to transfer resources to the diabetic. Society is the principal because it may ultimately pay for the diabetic's

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[7] This is assuming no borrowing constraints. A poor diabetic might want to invest in monitoring equipment but might be constrained such that he could not make investments that would maximize his discounted expected income.

[8] Bergstrum (1991) makes a similar point in his analysis of the conditions such that Becker's Rotten Kid Theorem does not hold. The Rotten Kid Theorem states that selfish children will take actions to maximize the income of the family head (Becker 1981). Thus, the externality is internalized. Bergstrum (1991) shows that if the rotten kid cares about income, and about another attribute (such as utility from tasty candy), then the Rotten Kid Theorem may not hold.

complications. It wants the diabetic to consume no sugar and devote all resources to health maintenance effort.

The health externality may not be large. Its size depends on the diabetic's discount factor, the diabetic's ability to process information about the likelihood of different complications and his skill at treating himself. Sufficient state dependent utility could make a diabetic so fearful of complications that receiving monetary insurance is not full compensation. If this is true, then diabetics are not imposing an externality on society. This case requires strong information assumptions that diabetics recognize the risks and do not suffer from cognitive dissonance (Akerlof and Dickens 1982).

Several factors suggest that diabetics are imposing smaller costs on society over time. Innovation diminishes the diabetic agency problem because new products such as nutrasweet have led to sugar free soda, yogurt, ice cream that are very close substitutes to sugar. If nutrasweet is a good substitute for sugar in the Lancasterian production function (diet coke for coke), then the price of diabetic compliance has decreased. The marginal product of effort has increased over time because of technological innovations. Over time, new technologies such as blood testing have replaced imprecise urine testing. Diabetics can now more frequently test blood sugar. This provides more opportunities for fine tuning insulin and food intake to achieve optimal sugar levels. Over time, the links between increased effort such as exercise, and blood testing have become better understood. It has become cheaper, in terms of pain of needles and price, to inject insulin.

New innovations may not benefit all diabetics equally. More educated, insured diabetics would be more likely to change diet and lifestyle and be more likely to invest the time and resources to maintain compliance.[9] Scientists have found evidence of disparity of compliance rates. Watkins et. al. (1966) reported a 53% compliance rate. Nagasawa (1993) summarizes previous studies in order to find what affects the diabetic compliance rate. Patients who perceived higher benefits of compliance were more likely to comply. Compliant behavior increased with the amount of knowledge possessed by the patient. Negative social environment produced lower compliance rates. IDDM diabetics who were monitored by their parents had higher compliance rates than older adolescents. If diabetic compliance is a function of family structure then the social cost of divorce and of elderly diabetics living alone may be higher because monitoring decreases.

Some diabetics without health insurance may be constrained from investing in costly maintenance investments (Diamond 1992). The yearly financial cost of testing blood sugar levels four times a day is roughly $900. People who are insured face a zero marginal costs (ignoring the discomfort and insurance deductibles) of continued testing. Without this information, diabetics may not alter their diets and will be more likely to suffer complications in the future. The advent of expensive new treatment technologies may increase diabetic inequality. Richer diabetics would be more likely to be healthy while poorer diabetics would not enjoy the benefits of new

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[9] More educated people might be more patient and willing to make long term investments in health despite the short run costs (Becker and Mulligan 1992).

treatments. In this case, the externality diabetics impose on society would be negatively correlated with their initial pre-diagnosis permanent income.

V. Empirical Discussion and Data

Data

The 1976 and 1989 waves of the National Health Interview Survey (NHIS) are used to contrast health differences between diabetics and non-diabetics. The NHIS is a continuing nationwide sample survey on personal and demographic characteristics, illnesses, injuries, impairments, chronic conditions, utilization of health resources, and other health topics, obtained through personal household interviews. The NHIS sample is representative of the non-institutionalized U.S. civilian population. In 1976 and 1989, the NHIS included an extensive set of questions about the dietary practices, health care usage, use of medication, and other related subjects asked of each identified adult diabetic in an interviewed family. Table Two presents the summary statistics for the samples. It indicates that for people between the age of 18-70, 2.8% of the population were diabetics in 1976 and 2.5% of sample were diabetics in 1989. The NIH has also published summary statistics in the book Diabetes in America.

Ideally, we would want to have a panel data set of diabetics and non-diabetics. If diabetics have higher death rates than non-diabetics, then in any cross-section we are less likely to observe the sickest diabetics. In 1982, 34,583 deaths were attributed to diabetes as the underlying cause of death. This corresponds to a mortality rate of 14.9 deaths per 100,000 living population (Harris and Entmacher 1984). Diabetes is the seventh leading cause of death in the United States.

Who Are Diabetics?

Diabetic detection rates have increased over time. Between 1935 and 1978, the diabetic diagnosis rate has vastly increased from 7.9 per 10,000 per year up to 46.7. The "representative diabetic" is changing over time. A random draw from the diabetic population is more likely to be black man or woman in 1989 than in 1979. Table Three presents a simple probit using the 1976 and 1989 NHIS data to study how diabetics differ from the rest of the population. The NHIS does not specifically ask whether a person is a type one or type two diabetic but does report the age at diagnosis. The independent variables include age, age squared, race, and sex dummies, education, and body mass index (bmi is defined as weight in kilograms divided by height measured in meters squared)[10] Table Three indicates that diabetic probabilities increase sharply with age. Using the probits to predict diabetic probability levels, a black woman aged 50-59 with 12 years education and a bmi equal to 25 had a 4.4% probability of being diabetic in 1976 and this grew to 6.5% in 1989. A white man aged 50-59 with 16 years of education and a bmi equal to 25 had a 2.6% probability of being diabetic in 1976 and this grew to 2.9% in 1989. One's probability of being a diabetic is a decreasing function of education. Education's coefficient is

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[10] Waaler (1984) and Fogel, Costa and Kim (1993) study the relationship between bmi and health. The latter paper presents isoquants of health showing the optimal combinations of height and weight to minimize one's probability of suffering different health problems.

statistically significant in 1976 and 1989 but it is small. For example, a black man with 16 years of education has a higher probability of having diabetes in 1989 than an observationally identical white man with 7 years of schooling.

Tables Four and Five presents some demographic time trends on how the prevalence of diabetes has changed across race/sex/age cohorts between 1976 and 1989. In 1976, conditional on being between 20-44 years of age and having diabetes, there was a 16.1% probability that the person is black. In 1989, this probability is 22.8%. This indicates that the prevalence of diabetes among young whites has fallen relative to young blacks. Similarly, for people aged 45-64 and 65+, black diabetic prevalence has increased relative to whites.

Tables Six and Seven presents the education distribution of diabetes and non-diabetics across age and birth cohorts. In 1976 and in 1989, diabetics across all age groups, 20-44, 45-64, 65+, always have less education than non-diabetics. In 1976 9% of diabetics versus 17.5% of non-diabetics aged 20-44 have at least 16 years of education. In 1989, 14.5% of diabetics versus 22.5% of non-diabetics have at least 16 years of education. The education gap for diabetics aged 20-44 has closed slightly between 1976 and 1989. In 1976, 34% of diabetics aged 20-44 had less than 12 years of schooling. This fell to 21% in 1989. For non-diabetics in this age group, 20% of them had less than 12 years of schooling in 1976. This fell to 14% in 1989. For the other age groups, I find no evidence of relative educational gains for diabetics between 1976 and 1989.

Tables Eight and Nine presents the income distribution of diabetes and non-diabetics across age and birth cohorts. Diabetics are poorer than non-diabetics. In 1976, 16.8% of non-diabetics aged 45-64 had incomes of at least $25,000 while only 9.8% of diabetics in this age group had such incomes. In 1989, 27% of non-diabetics aged 45-64 had incomes of at least $50,000 versus 13% of diabetics. Why are diabetics poorer? They are less educated than the rest of the population. The condition may lower one's capacity to work and conditional on working may lower one's productivity on the job. Drury (1984) reports that diabetics are about twice as likely relative to non-diabetics to report ever having cataracts, glaucoma, arteriosclerosis, hypertension, heart attacks, strokes, and kidney trouble. Diabetics are more likely than non-diabetics to be limited in their usual activities.

Testing Convergence using Output Measures

Innovations in technology, food products, and new information about the benefits of exerting costly effort have all increase the likelihood that diabetics are taking better care of themselves now than in the past. Disease reduces the amount of time people spend working and may lower their productivity per unit of work. If people are income maximizers, then a chronic condition such as diabetes is costly because it lowers one's expected income. One goal in this section is to quantify expected income for observationally identical diabetics and non-diabetics. Controlling for age and all other socio-economic factors, have diabetic labor force participation and income been converging to non-diabetic levels? If so, this would be evidence that the private and social cost of diabetes is falling over time.

I estimate a probit model where the dependent variable equals one if the person works and equals zero if the person is unemployed or out of the labor force.[11]

$$prob(work) \; = \; X' \;\; + \;\; B_1 ed \; + \;\; B_2 \, diabetic \; + \;\; B_3 (ed * diabetic)$$

I partition the NHIS data into male and female samples in both 1976 and 1989. For each sample, I estimate four probits by age categories; 20-29, 30-39, 40-49, 50-59.[12] Equation (1) includes education, race, marital status, geographical region, and body mass index as independent regressors. I assume that conditional on these variables the diabetic indicator is an exogenous regressor. I interpret the diabetic dummy and the diabetic interaction with education variable as indicating how having the condition affects one's employment rate. It is possible that the diabetic dummy is an indicator for low unobserved health capital investments. Does diabetes make you poor or do poor people get diabetes? To study this, in results I do not present I have partioned the

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[11] Baily (1987), Stern (1986), Costa (1994) and Baldwin, Zeager, and Flacco (1994) also study the relationship between disability and labor force participation.

[12] A limitation of studying labor force participation is that I cannot fully control for the opportunity cost of working. Diabetics might be eligible for Social Security Disability Insurance (SSDI). If SSDI payments are large, then this insurance introduces a moral hazard. Diabetics might rationally choose to not change their lifestyles. If complications occur, they would simply collect SSDI. Falling real SSDI payments might increase diabetic labor force participation (Parsons 1980, Bound 1989). Changes in diabetic participation could be explained by improvements in health or reductions in real SSDI benefits. SSDI benefits are not taxable (Berkowitz and Hill 1986). Thus, the Reagan tax cut raised the opportunity cost of collecting disability insurance.

set of all diabetics into those diagnosed before age 30 (type one diabetics) and those diagnosed after age 30 (type two) and have tested whether they have equal employment and income prospects controlling for all other factors. I find that I cannot reject that the two groups of diabetics can be pooled. This is important because type one diabetes is considered to be an "exogenous" condition. In addition, for a subset of the data I have information on parents' diabetic status. In estimating simple linear probability two stage least squares models where diabetic status is first instrumented and then the predicted values are used in the second stage work probability regressions, I have found extremely low R squareds in the first stage.

Table Ten and Eleven present the men's work probability estimates. The control group are married white men, who live in the west and have a bmi less than 35. In 1976, 89.2% of diabetic men aged 40-49 who had high school degrees were predicted working while 92.2% of non-diabetic high school educated men were predicted working. For men aged 50-59 in 1976, I predict that there is a 14.3% employment gap between diabetics and non-diabetics. This gap shrinks to 12.6% in 1989. Table Ten indicates that non-diabetics are more likely to be working and that the employment gap is roughly constant across decades for high school graduates. Table Eleven presents the predicted results for college graduates. Note that for the age categories 20-29, 30-39, and 40-49, diabetics and non-diabetics have equal employment probabilities. For men aged 50-59, 76.6% of the diabetics and 89.1% of the non-diabetics are predicted to be working. This employment gap of 12.5% in 1976 shrank to 7.9% in 1989. Thus, for higher educated men I find evidence of labor force convergence but find little evidence of convergence for less educated men.

Tables Twelve and Thirteen repeat this exercise for women's employment rates. Interestingly, unlike the male sample, women diabetics have similar employment rates as non-diabetics in the 20-29 and 30-39 age range. In 1976, high school educated diabetic women aged 40-49 are predicted to have a 38.6% employment rate versus a 50.9% employment rate for their non-diabetic counterparts. Surprisingly, this 12.3% employment gap grew between 1976 and 1989 to 18.7%. For high school educated women aged 50-59, I find that the diabetic women were much less likely to be working in 1976 and that this employment gap was unchanged between 1976 and 1989. Similar to the male college sample, I find that college educated diabetic women have converged in labor force participation rates. Table Thirteen indicates that for diabetics and non-diabetics and across age cohorts employment rates have increased. For women aged 30-39, 40-49, and 50-59, the employment gap in 1976 has shrunk in 1989.

Equation (1) models diabetic status without reference to the duration that one has had the condition. If the diabetic condition leads to a yearly decrease in one's stock of health capital, then holding all other variables constant, income and employment probabilities should be a decreasing function of diabetic duration. For women high school and college graduates, I find that employment rates are a decreasing function of diabetic duration. I predict that in 1989, a fifty year old woman high school graduate has an employment rate of 56% while the same woman with ten years diabetic experience has an employment rate of 50.9%. For women, diabetic duration has a smaller impact on employment rates in 1989 than in 1976 and more educated woman are less likely to be out of the labor force because of diabetic experience. For men, I find smaller effects of diabetic experience on labor force participation rates.

This analysis has focused on diabetic labor supply. It is possible that the demand for their labor has fallen from 1976 to 1989. If employers are worried about rising health care cost and lost productivity of hiring diabetics, then I would predict that employers would only hire the high ability diabetics. In this case, employment rates should fall, income for diabetics who do work should rise, and we should observe an increase in the percentage of diabetics who work in the public sector.

I have found no evidence in 1976 or 1989 that unemployment rates differ for observationally identical diabetics and non-diabetics.

Family Income

How do diabetics and non-diabetics' incomes differ and how do the income differences evolve over time? Wages are not in the NHIS data set. Instead it has a measure of family income that is top coded at $50,000. I estimate regressions where the dependent variable is the level of family income.[13] For men, I fit family income as a function of diabetic status, geographical region, education, marital status, race, and body mass index.[14]

$$income \;=\; X' \quad + \quad {}_{1}ed \;+\; \quad {}_{2}diabetic \;+\; \quad {}_{3}(ed * diabetic)$$

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[13] Both Bartel and Taubman (1979) and Luft (1975) present evidence on the negative income impact of health problems.

[14] Costa (1994) finds evidence of a U shaped relationship between labor force participation and bmi in both 1900, using a sample of Union Army veterans, and in the 1980s, using cross-sections of the NHIS.

The control group is white men who live in large cities, who work, and are married, and have a bmi less than 35. Table Fourteen and Fifteen present the predicted income for different age groups for high school and college graduates. The key finding is that for high school graduates, diabetic status does not have a large impact on one's income in 1976 or 1989. Table Fourteen indicates that the absolute value of the within cell difference is roughly $1000. This is surprising because diabetes might make one not be able to perform certain manufacturing tasks that might be well paid for high school graduates. Table Fifteen indicates larger differences in predicted income for diabetic college graduates and non-diabetic college graduates. Non-diabetics aged 40-49 in 1976 earned roughly $4,000 more than non-diabetics. This income gap vanished in 1989. Similarly for men aged 50-59 who have college degrees, the 1976 income gap shrunk by 1989.[15] Estimates of equation (2) indicate that not participating in the work force lowers family income by roughly $10,000. Differences in family income could reflect wages or hours differences. It is possible that diabetics earn lower wages but work more hours than non-diabetics so that their total family income is comparable to non-diabetics.[16] I have also estimated equation (2) including diabetic duration as a regressor and was surprised to find that conditional on the other right hand side regressors, diabetic duration has no effect on family income.

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[15] If selecting from a less select sample of diabetics over time might observe wage fall as lfp rises from 1976 to 1989 as the less healthy enter the labor force.

[16] The NHIS data does not include information on the work status of the spouse of a diabetic. If diabetics were suffering income losses, it is likely that their spouses would work more to make up the lost income.

This small income gap between diabetics and non-diabetics suggests that diabetics are not job-locked. The NHIS data does not include turnover information. Since one's probability of having diabetes rises with age, the majority of type II diabetics are likely to have been diagnosed late in their work careers. Hall (1982) reports that 7.1% of people aged 50-55 are working in new jobs. It is likely that diabetics are not among this group. If diabetics are job locked, then I would expect to observe that they would have flatter income/experience profiles because they are less able to match with new opportunities. To study job lock, I estimate standard "Mincer" family income regressions while interacting the experience variables with diabetic status. I find no evidence that the diabetic/experience interaction terms are statistically significant. This suggests that diabetics are not suffering financial losses because their condition prohibits cross-firm migration.

A second specification for testing job lock is presented in equation (12).

$$income = X' \quad + \quad {}_1(\mathrm{exp} - duration) + \quad {}_2(duration) + V$$

$$H_0: \quad {}_1 = \quad {}_2 \qquad H_1: \quad {}_1 > \quad {}_2$$

My objective is to decompose experience into pre-diabetic and post-diabetic experience and to test whether the labor market rewards both equally. Equation (3) tests for whether a diabetic's return to experience falls after he has been diagnosed. For example, a 37 year old diabetic who has 19 years of experience and has had diabetes for 8 years had 11 years of pre-diabetic job experience and 8 years of post-diabetic experience. I estimated whether the returns differ. If diabetics were job locked once they were diagnosed as diabetic, then their incomes would grow slower with respect to experience. I find that I cannot reject the hypothesis that the returns to experience for working men is the same in the pre and post-diabetic diagnosis periods. It is important to note that the dependent variable is family income. One theory would be that a spouse of a diabetic might increase her labor supply to offset his income decline. I have estimated specifications for just set of people who are not married and found that diabetic and non-diabetic family income are roughly equal.

One explanation for the low income impact for diabetics is that they are making work related choices to minimize the dislocation caused by being diagnosed with diabetes. Diabetics can make choices to minimize the employment and wage loss. We do not have representative panel data sets to study how newly diagnosed diabetics change their lifestyles to cope with their condition. For example, if diabetics switch occupations to work in less physically strenuous occupations or in occupations that offer more flexibility, then rational choice is lowering the private costs of the health shock. To study this using retrospective data, I partioned the set of all occupations into five categories; professional, services, repair, operators, and technical. I estimate a multinomial logit models to compare occupational choice for diabetics vs. non-diabetics while controlling for bmi, race, location, education, marital status, and age. I find no evidence in 1976 or 1979 that one's occupation is a function of diabetic status. It is quite possible that these broad occupational categories mask significant occupational heterogeneity. Detailed work task information would be needed to quantify how diabetics have modified their on the job activity.

Diabetics can insure that their consumption does not fall sharply if they are not self employed or if they work for the government. Self employed workers may have to buy their own health insurance unless they can buy it through their spouse's employer. Since a diabetic's health insurance premium would be very high, I would predict that diabetics are less likely to be self employed. Estimating a simple probit that controls for all observables, I predict that in 1976 a non-diabetic 55 year old college educated white single male has a 18.2% probability of being self employed while the observationally identical diabetic has a 15% probability of being self employed. In 1989, the non-diabetic is self employed with probability 7.6% and the diabetic is self employed with probability 5.2%. These two separate predictions indicate that diabetics are taking actions to minimize the costs of their conditions. They are implicitly insuring themselves.

One further strategy that diabetics might use to minimize their income losses is to work in the public sector. Such jobs (the post office) may be less demanding than the market sector and the pay scale depends solely on experience. I estimated government employment probits and found no evidence that diabetics are more likely to be employed in the public sector.

Evidence on Inputs

Family income and labor force participation are examples of outcome indicators. If the diabetic is healthy, he is more likely to work and to earn income comparable to observationally similar non-diabetics. An alternative approach for quantifying diabetic convergence is to study inputs. Are diabetics becoming healthier over time? The 1976 and 1989 NHIS waves provide some evidence on health inputs such as diet, weight, and smoking. Unfortunately, the NHIS does not include information on alcohol consumption, and exercise or on how levels of consumption activity have changed since diabetic diagnosis.

Smoking propensities vary across education groups. I find evidence that in 1976 diabetics smoked more than observationally identical non-diabetics but that between 1976 and 1989 the percentage of diabetic smokers decreased faster than the decrease for non-diabetics. These decreases were greatest for people with at least a college degree. This is additional evidence that the more educated are altering their behavior more in the presence of the condition.

Diabetics differ in their propensity to invest in health capital depending on their education level. For all diabetics in the 1989 sample, 42% check their blood.[17] Of those diabetics with between 12 and 16 years of schooling, 47.3% check their blood, and 55.6% of college graduate diabetics check their blood. On average, a diabetic has 26 bed days a year. Controlling for family income, age, race, weight, a diabetic has 1.5 less bed days per year for each additional year of education. This is evidence that more educated people are more compliant. I find no evidence that marital status has a statistically significant effect on any of these compliance proxies.

Body mass index (weight in kilograms divided by height measured in meters squared) provides additional evidence on diabetic health. Ideally, I would like to study how the diabetic's bmi changes upon diagnosis. Such data are not available. Table Sixteen presents results where I regress individual bmi on race, sex, marital, and diabetic dummies. I use these regressions to

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[17] These predictions are from a logit regression that controls for age, race, smoking, income, weight, duration of having diabetes, and geographical indicators.

predict median bmi for diabetics and non-diabetics across age and education categories. I find that in 1976 the median white, single, woman who is aged 40-49 and has a BA degree and is not diabetic has a bmi of 22 while the same woman if she were diabetic would have a median bmi of 24.0. Table Sixteen indicates that in both 1976 and 1989, people with more education are thinner than people with less education and that diabetics and non-diabetics aged 20-29 are roughly equal in weight regardless of education. For people over age 30, diabetics are consistently heavier and the weight gap between diabetics and non-diabetics is roughly constant between 1976 and 1989. Diabetics, even highly educated ones, are not converging in bmi to non-diabetics. Given the rise in availability of diet food, this result is surprising. This absence of "weight convergence" is even more surprising given the fact that between 1976 and 1989, the percentage of diabetics following their diet has increased.[18] In both 1976 and 1989 more educated people were more likely to follow their diet plan and the impact of education is greater in 1989. One surprising finding is heavier people are more likely to follow their diet in 1989 than in 1976. In 1976, one's probability of following a diet is a decreasing convex function of one's body mass index. In 1989, one's probability of following a diet is not a function of one's weight.

It is quite possible that people who are diagnosed as diabetics as adults have trouble adhering to a diet. To separate behavior change from unobserved population heterogeneity, I restrict the sample to only include diabetics diagnosed with the disease before age 30 (juvenile diabetics and all non-diabetics). I find that people with higher education weigh less and highly

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[18] Both the 1976 and 1989 have a self reported question asking if one has ever been assigned a diet and if one is following the diet.

educated diabetics have even lower bmi levels. This education effect for early diagnosed diabetics is equal in both 1976 and 1989. An extra year of schooling lowers a non-diabetic's bmi by .7% and a juvenile diabetic's bmi by 1.7%. This is additional evidence that more educated diabetics take better care of themselves but I found no evidence for this indicator that this educational differential has grown between 1976 and 1989.

V. Conclusion

Diabetic quality of life has greatly improved since the discovery of insulin in 1921. The aggregate cost of diabetes should be calculated as the summation of willingness to pay for both diabetics and non-diabetics for the set of diabetics to not have the condition. This paper has claimed that willingness to pay to avoid the condition has been falling over time. Behavioral changes, induced by diet and health technology innovation are partially responsible for the reduced cost of the condition. Such improvements may vary across diabetics. I presented evidence that one's education plays a key role in complying with good care. Evidence was presented that the more educated are more likely to take better care of themselves and to have converged to their non-diabetic counterparts as measured by labor force participation and family income. If health inequality across education groups is growing, then this compounded with widening earnings inequality (Katz and Murphy 1992), would suggest that utility inequality is growing across education groups.

This study's findings are relevant for public policy because there will be a sharp growth of type two diabetics as the population ages. The total number of type two diabetics is growing. In 1995, there will be 32 million people over the age of 65. This age group is expected to grow to 62 million people in 2025. Whether elderly diabetics are willing to adjust their lifestyle to fight off diabetic complications will crucially affect the total cost of the disease.

The American Diabetes Association has claimed that diabetes causes over 80 billion dollars of damage a year. Assuming there are 7 million diabetics, then the per-capita annual cost is roughly $15,000. My estimates of labor force participation and income conditional on being employed indicates, that the typical diabetic man who is age 55 has a 10% lower employment rate and than those families whose head of household is not in the labor force experience a $10,000 lower family income. This suggests that a 55 year old diabetics can expect to earn $1,000 less than their non-diabetic counter-part. If we add in the additional cost of monitoring equipment, insulin, and needles and paying the deductible on medical visits, this may add an extra $1,000. Thus, in the absence of diabetic complications the average diabetic suffers an income reduction of $2,000 a year.

In this paper's empirical specification, diabetic status was included as an exogenous independent variable. It is certainly possible, that this dummy variable is picking up other factors and may be a general health proxy. If this were the case, then there is no reason we would expect to observe convergence over time relative to the general population. Future research could use the NHIS data to study how labor market outcomes for different chronic condition groups has changed over time.

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Table One

Life Expectancy

Time period	ten years old	thirty years old	fifty years old
1897-1913*	1.3	4.1	8.0
1914-1922*	2.6	6.3	9.5
1922-1925	14.3	16.8	12.3
1926-1928	31.7	22.7	13.2
1929-1938	39.8	27.6	14.4
1939-1947	44.2	29.5	16.0
* indicates pre insulin. This is a cohort age chart, source George F. Baker Clinic. Analysis by Metropolitan Life Insurance Company			

Table Two

Summary Statistics

variable				
	1976 NHIS Sample		1989 NHIS Sample	
	mean	SD	mean	s.d
age	40.2	15.2	40.4	14.4
married	.69	.46	.66	.47
education	12.1	2.7	12.6	2.91
sex	.47	.50	.47	.50
white	.89	.32	.82	.39
work	.63	.48	.71	.45
bmi	24.2	4.24	25.0	4.73
diabetic	.028	.16	.025	.15

Table Three

diabetes probit
dependent variable indicates whether person has been diagnosed with diabetes

	1976 NHIS		1989 NHIS	
independent variable	coeff	se	coefficient	standard error
age 30-39	.02	.04	-.02	.043
age 40-49	.26	.037	.28	.039
age 50-59	.54	.033	.61	.037
age 60+	.73	.032	.87	.034
body mass index (bmi)	.014	.014	.065	.011
bmi squared	.0005	.0002	-.0004	.0002
male	-.044	.021	-.043	.02
smsa	.013	.024	-.075	.02
north east	-.022	.035	.013	.037
midwest	.001	.034	.063	.035
south	.056	.033	.027	.034
married	.016	.025	-.04	.025
education	-.036	.004	-.03	.004
black	.097	.034	.30	.029
other	.10	.10	.18	.053
constant	-2.57	.21	-3.40	.19

The 1989 probit includes 71,080 observations and has a pseudo r squared of .14. The 1976 probit had 68198 observations and a pseudo r squared of .11. The estimates predict that a black woman aged 50-59 with 12 years of education and a bmi equal to 25 has a 4.4% probability of having diabetes in 1976 and a 6.5% probability of having diabetes in 1989. A white man aged 50-59 with 16 years of education and a bmi equal to 25 has a 2.6% probability of having diabetes in 1976 and a 2.9% probability in 1989.

Table Four

The Race/Sex Distribution of Diabetes Across Age and Birth Cohorts

The Race and sex distribution in 1976						
	Age 20-44		Age 45-64		Age 65+	
	Non-diabetic	diabetic	Non-diabetic	diabetic	non-diab	diabetic
white men	42.7	33.2	43.0	41.1	37.4	34.2
other men	.9	.6	.5	.5	.3	1.9
black men	4.8	4.6	4.2	6.4	3.6	4.7
white women	44.5	48.6	46.9	41.8	53.7	52.6
other women	.9	1.7	.5	.1	.3	.4
black women	6.2	11.5	4.9	10.0	4.8	7.2

Table Five

The Race and sex distribution in 1989						
	Age 20-44		Age 45-64		Age 65+	
	Non-diabetic	diabetic	Non-diabetic	diabetic	non-diab	diabetic
white men	38.9	31.2	40.3	31.7	36.2	28.6
other men	2.6	2.0	1.8	2.0	.8	1.2
black men	5.7	9.5	5.2	10.2	4.2	7.8
white women	41.9	39.3	43.4	35.2	51.6	46.7
other women	2.8	4.6	2.1	2.8	1.3	1.6
black women	8.1	13.3	7.2	18.2	5.8	14.1

Table Six

The Education Distribution of Diabetes Across Age and Birth Cohorts

The distribution of education in 1976 (source VI-27)						
	Age 20-44		Age 45-64		Age 65+	
	Non-diabetic	diabetic	Non-diabetic	diabetic	non-diab	diabetic
ed<9	7.2	15.5	21.4	33.7	45.8	55.7
9<=ed<=11	13.2	18.6	17.6	20.6	15.3	14.7
ed=12	40.6	37.7	35.6	29.5	19.8	15.6
13<=ed<=15	20.3	17.8	11.6	7.6	7.8	5.5
ed>=16	17.5	9.0	12.0	7.4	7.8	4.7

Table Seven

The distribution of education in 1989						
	Age 20-44		Age 45-64		Age 65+	
	Non-diabetic	diabetic	Non-diabetic	diabetic	non-diab	diabetic
ed<9	4.2	6.4	11.5	23.5	29.1	36.8
9<=ed<=11	9.6	14.2	13.4	22.5	16.0	19.8
ed=12	39.2	37.5	39.9	32.8	32.5	26.8
13<=ed<=15	24.5	27.3	16.0	12.4	11.7	8.5
ed>=16	22.5	14.5	19.0	9.3	10.7	8.0

Table Eight

The Income Distribution of Diabetes Across Age and Birth Cohorts

The distribution of family income in 1976						
	Age 20-44		Age 45-64		Age 65+	
	Non-diabetic	diabetic	Non-diabetic	diabetic	non-diab	diabetic
income<3000	4.8	4.9	4.8	7.9	14.6	16.0
3000<=inc<5000	5.7	9.4	6.0	11.7	20.9	22.0
5000<=inc<7000	7.6	11.1	7.4	11.6	15.6	16.2
7000<=inc<10000	11.8	11.9	10.5	11.1	12.6	11.8
10000<=inc<15000	24.0	23.4	19.7	18.5	10.7	9.1
15000<=inc<25000	27.3	26.1	24.2	18.4	7.4	6.4
25000<=inc	12.3	5.9	16.8	9.2	4.8	5.0

Table Nine

The distribution of family income in 1989						
	Age 20-44		Age 45-64		Age 65+	
	Non-diabetic	diabetic	Non-diabetic	diabetic	non-diab	diabetic
inc<10000	10.3	19.4	9.0	22.2	25.3	37.8
10000<=inc<20000	18.1	21.4	17.3	23.2	36.3	35.9
20000<=inc<50000	51.0	46.0	46.7	41.3	31.3	22.3
50000<=inc	20.6	13.2	27.0	13.0	7.0	4.1

Table Ten

Male High School Graduate Predicted Employment Rates

	Age 20-29		Age 30-39		Age 40-49		Age 50-59	
	diabetic	non-diab	diab	non-diab	diab	non-diab	diab	non-diab
Calendar year 1976	94.2	91.2	86.6	91.5	89.2	92.2	69.2	83.5
Calendar year 1989	91.1	93.6	89.2	94.2	82.6	92.7	71.1	83.7
The dependent variable is work status. I estimate a probit controlling for education, race, body mass index, region, city size, race, diabetic status and diabetic status interacted with education. I then predict the employment rate by age/birth cohort/diabetic status group for the group of men who have a high school degree, are married, white, live in the west and have a bmi<35.								

Table Eleven

Male College Graduate Predicted Employment Rates

	Age 20-29		Age 30-39		Age 40-49		Age 50-59	
	diabetic	non-diab	diab	non-diab	diab	non-diab	diab	non-diab
Calendar year 1976	99.7	93.0	97.8	94.7	96.8	95.5	76.6	89.1
Calendar year 1989	98.7	95.3	97.9	97.5	95.0	96.7	81.4	89.3
The dependent variable is work status. I estimate a probit controlling for education, race, body mass index, region, city size, race, diabetic status and diabetic status interacted with education. I then predict the employment rate by age/birth cohort/diabetic status group for the group of men who have a college degree, are married, white, live in the west and have a bmi<35.								

Table Twelve

Female High School Graduate Predicted Employment Rates

	Age 20-29		Age 30-39		Age 40-49		Age 50-59	
	diabetic	non-diab	diab	non-diab	diab	non-diab	diab	non-diab
Calendar year 1976	39.3	44.5	49.8	48.3	38.6	50.9	27.9	42.2
Calendar year 1989	54.7	64.4	55.7	65.8	52.5	71.2	44.0	57.6

The dependent variable is work status. I estimate a probit controlling for education, race, body mass index, region, city size, race, diabetic status and diabetic status interacted with education. I then predict the employment rate by age/birth cohort/diabetic status group for the group of women who have a high school degree, are married, white, live in the west and have a bmi<35.

Table Thirteen

Female College Graduate Predicted Employment Rates

	Age 20-29		Age 30-39		Age 40-49		Age 50-59	
	diabetic	non-diab	diab	non-diab	diab	non-diab	diab	non-diab
Calendar year 1976	68.7	63.7	49.6	61.7	52.5	62.7	49.8	54.7
Calendar year 1989	68.4	82.4	71.1	77.1	76.0	83.6	68.0	71.4

The dependent variable is work status. I estimate a probit controlling for education, race, body mass index, region, city size, race, diabetic status and diabetic status interacted with education. I then predict the employment rate by age/birth cohort/diabetic status group for the group of men who have a college degree, are married, white, live in the west and have a bmi<35.

Table Fourteen

Predicted Income Differences for High School Graduates

	Age 20-29		Age 30-39		Age 40-49		Age 50-59	
	diabetic	non-diab	diabetic	non-diabetic	diabetic	non-diab	diabetic	non-diab
Calendar year 1976	17676	18951	26365	26485	29132	31297	30191	30788
Calendar year 1989	25148	25392	32245	31864	35343	36284	37490	37303

The dependent variable is family income. I estimate regression controlling for education, race, body mass index, work status, region, city size and race. I report median income by age, diabetic category for white men with a bmi<35 who work and live in the west, in a small city, who are married and have 12 years of education.

Table Fifteen

Predicted Income Differences for College Graduates

	Age 20-29		Age 30-39		Age 40-49		Age 50-59	
	diabetic	non-diab	diabetic	non-diabetic	diabetic	non-diab	diabetic	non-diab
Calendar year 1976	25417	23137	34626	33971	35033	39076	36168	38603
Calendar year 1989	36614	30367	36761	39091	43022	42922	43631	44092

The dependent variable is family income. I estimate regression controlling for education, race, body mass index, work status, region, city size and race. I report median income by age, diabetic category for white men with a bmi<35 who work and live in the west, in a small city, who are married and have 16 years of education.

Table Sixteen

Predicted Body Mass Index

Dependent variable is a person's weight measured in kilograms divided by their height in meters squared

	Age 20-29		Age 30-39		Age 40-49		Age 50-59	
	diabetic	non-diab	diabetic	non-diabetic	diabetic	non-diab	diabetic	non-diab
BA - 1976	20.5	20.8	20.8	20.8	24.0	22.0	23.8	22.7
HS - 1976	21.4	21.2	24.7	22.0	26.3	23.1	26.3	24.0
BA - 1989	21.7	21.0	23.6	21.6	24.5	22.5	25.8	23.5
HS - 1989	22.0	21.9	24.6	23.3	28.1	24.2	27.7	24.5

Median regressions are estimated where the independent variables include; race, marital, sex, and a diabetic dummy. I then predict body mass index for each age/education/diabetic cell. BA - 1976 indicates that I am using the 1976 NHIS wave and only those people who have at least a BA degree. HS - 1989 indicates that the sample is the 1989 NHIS wave and that I am using only people who a high degree or less education. The omitted category is a white woman who is not married.