Productivity Losses Associated With Diabetes in the U.S.

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OBJECTIVE — The objective of this study was to estimate the cost of productivity losses in the U.S. attributable to diabetes, with regard to specific demographic and disease-related characteristics in the U.S.

RESEARCH DESIGN AND METHODS — We used the 1989 National Health Interview Survey, a random survey of individuals in the U.S. that included a diabetes supplement. Data on individuals were obtained for labor force participation, hours of work, demographic and occupational characteristics, self-reported health status, and several variables that indicated the presence, duration, and severity (complications) of diabetes. Using multivariate regression analyses, we estimated the association of independent variables (e.g., demographics, health, and diabetes status) with labor force participation, hours of work lost, and the economic value of lost work attributable to diabetes and its complications and duration.

RESULTS — In general, the presence of diabetes and complications were found to be related to workforce participation variables. The magnitude of the lost-productivity costs depended on personal characteristics and on the presence and status of diabetes. In general, the loss of yearly earnings amounted to about a one-third reduction in earnings and ranged from $3,700 to $8,700 per annum.

CONCLUSIONS — Diabetes has a considerable net effect on earnings, and the complications and duration of diabetes have compound effects. Our findings have implications for the cost-effectiveness of diabetes control; the presence of complicating factors is the single most important predictive factor in lost productivity costs attributable to diabetes, and thus the avoidance or retardation of complications will have an impact on indirect health-related costs.

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The loss of productivity caused by illness has been a prominent topic in general health policy for several decades (1–3). Nationwide estimates have also been conducted for people with diabetes (4,5). The American Diabetes Association estimates that diabetes accounted for $27 billion in direct medical costs and $32 billion in indirect or lost-productivity costs in 1997 (4). In recent years, there has been a growing recognition that, for many reasons, the costs of diabetes should be expressed as an "excess cost" figure; this excess cost statistic has been estimated in the U.S. for people with diabetes for direct medical expenditures (6–8), and it has been estimated for both direct and lost-productivity costs in Sweden (9).

To date, in these studies, diabetes-related lost-productivity costs have been expressed for entire groups and have been categorized for only a few selected population characteristics, such as age. We know very little about the determinants of productivity losses. It is very important to gain an understanding of what factors affect them, as well as of their overall magnitude.

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Abbreviations: HRS, Health and Retirement Survey; NHIS, National Health Interview Survey.
A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

We have conducted an analysis of lost productivity attributable to the prevalence and severity of diabetes in the U.S. Using data from the National Health Interview Survey (NHIS) and its diabetes supplement, we developed estimates of how the onset and progression of diabetes influences the workplace behavior of individuals. We focused on two components: participation in the labor force and actual hours of work.

RESEARCH DESIGN AND METHODS

Data were used from the 1989 NHIS, which included a diabetes supplement, published by the U.S. Department of Health and Human Services National Center for Health Statistics. The NHIS is a personal-interview household survey of a nationwide sample of the civilian noninstitutionalized population of the U.S. It contains questions on personal and demographic characteristics, illnesses, injuries, impairment, chronic conditions, and use of health resources. The diabetes supplement includes extensive survey questions on the prevalence of diabetes and specific diabetes complications. Subjects of this study were individuals aged between 18 and 65 years, both with and without diabetes, and included those who were and were not in the labor force.

Employment status

To address the effect of diabetes on the employment status of an individual, we adopted the standard probit estimation in analyzing an individual's probability of being in the labor force, applied to the entire working-age population. The dependent variable takes the value of zero or one, with the latter meaning "in the labor force." According to the standard theory of labor supply (10–17), the decision to be in the labor force is determined by sex, age, race, marital status, educational level, regional factors, family size, and the health status of the individual. Regional factors were approximated by residence in an urban area and the region of residence. A self-reported health status measure was also included. Finally, a dummy variable indicating whether an individual has diabetes was included.

Given that diabetes is a lifelong disease and that one's health deteriorates as he/she

Table 1—*Demographic characteristics of the full sample and the sample of working individuals*

	Full sample		Sample of working individuals	
	Diabetic	Nondiabetic	Diabetic	Nondiabetic
Background information				
Male	43.30	47.31	52.87	53.43
Age <25 years	2.52	16.01	3.50	15.18
Age 25–44 years	23.32	52.20	32.31	56.62
Age 45–54 years	27.83	16.69	32.59	17.53
Age >54 years	46.34	15.09	31.61	10.67
White	68.39	81.82	73.29	83.21
Black	26.57	13.36	22.24	12.38
Married	66.69	65.88	68.95	66.35
Single	9.25	21.30	11.19	21.22
Health status				
Excellent	6.59	38.21	9.93	41.34
Very good	14.36	29.82	21.12	31.23
Good	30.57	23.15	36.64	22.14
Fair	29.46	6.59	27.13	4.57
Poor	19.02	2.22	5.17	0.71
Other information				
Type 1 diabetes	12.44	—	18.60	—
Having any diabetes complications	85.42	—	81.12	—
Number of work-loss days for the past 2 weeks	—	—	0.47 (1.89)	0.21 (1.19)
Sample size	1,351	67,283	715	52,117

Data are % or % (SD).

ages, the severity of the disease has an impact on the likelihood of one being in the labor force. To address this issue, the above probit equation was modified and reestimated for the diabetic group only. This was done by replacing the variable that indicates the presence or absence of diabetes with one that indicates whether the individual had any complications of diabetes, defined as the reporting of any of the following conditions: affected retina, high blood pressure or hypertension, angina, stroke, heart disease, cataracts, kidney disease, foot/ankle sores (peripheral vascular disease), retinopathy, glaucoma, proteinuria, gum disease, autonomic neuropathy (bladder control), amputations, and peripheral neuropathy.

The literature has generally regarded the impact of type 1 versus type 2 diabetes on indirect costs as being different. This may be true because of the clinical and demographic differences between the two conditions (e.g., earlier age of onset, longer duration of diabetes, required use of insulin, and risk of hypoglycemia). Accordingly, a dummy variable (TYPE1) indicating whether an individual has type 1 diabetes or not was included in the regression analysis to test the hypothesis that productivity losses differ between type 1 and type 2 diabetes. Type 1 diabetes was indicated by age at onset <30 years, use of insulin, and body weight (18).

Loss of productivity

The second target variable was work-loss days for diabetic and nondiabetic groups who were employed. The loss of productivity was hypothesized to be affected by sex, age, race, marital status, educational level, a self-reported health status measure and, finally, the occupation of the individual (19–23). According to the information provided by the NHIS, occupations were grouped into 13 categories. To examine the influence of the occupational effect on the productivity loss, the 13 categories were further grouped into 5 broad categories. Farming, forestry, and fishing occupations were used as the reference group. Because the work-loss days for the previous 2 weeks (the dependent variable) is left censored with a value of zero, we used a tobit regression technique (24–26).

To test for the severity of diabetes disease affecting one's productivity in the workplace, "the presence of diabetes" in the above-specified tobit equation was replaced by "the presence of diabetes with complications." Similar to the employment status issue, the differentiation between types 1 and 2 diabetes was taken into account by having the dummy variable TYPE1 included in the regression.

To derive the productivity loss associated with diabetes, we first derive the daily earnings for full-time full-year workers, disaggregated by race, sex, and age-group. Based on the *Statistical Abstract of the U.S.* (27), average yearly earnings for white males, white females, black males, and black females by three age-groups (age <25, 25–54, and ≥55 years) can be used to calculate the daily earnings with the assumption that full-time full-year workers are employed 5 days per week, 52 weeks per year. The estimated number of work-loss days for the past 2 weeks (i.e., the estimated coefficient) is then multiplied by the derived daily earnings. This amount of productivity loss is then projected back to yearly estimates. All prices were expressed in 1989 dollars.

RESULTS

Sample characteristics

In total, there were 84,572 individuals in the NHIS, 71,325 of which were between the ages of 18 and 65 years. There were 2,405 people (2.8% of the total sample) with diabetes, and of these there were 1,401 (2%) in the relevant age range. For the purpose of regression analysis, the value of variables can be neither missing nor in an irrelevant range. The construction of the working-age sample therefore has to exclude subjects with missing values on key variables. With these deletions, a total sample of 68,634 individuals remained; 1,351 (2%) were people with diabetes, and within the diabetes group, 715 (53%) of these were in the labor force. We used Student's *t* test on the sample statistics for the selected 1,351 subjects and those statistics from the original sample with subjects containing missing values for key explanatory variables. Student's *t* test showed that we could not reject the null hypothesis that there was statistically no difference between samples. Therefore, the exclusion of subjects with missing information on certain variables would not introduce a major bias in the results.

In Table 1 we present the relevant characteristics for the full sample (working and nonworking) and the working sample. For the full sample, people with diabetes were older, more likely to be black, and less likely to be single. As expected, only 53% of people with diabetes were in the labor force, compared with 77% of those people without diabetes. With respect to self-reported quality-of-life by group, ~20% of the individuals with diabetes were in poor health, whereas ~2% of the nondiabetic group ranked themselves as being in poor health. For the working sample, except for sex, age, and health status, the demographic characteristics by group was very similar to those of the full sample. We found that <19% of people with diabetes were type 1, whereas >80% of them had diabetes complications.

Table 2—*Probit regression results indicating the likelihood of being in the labor force for the full sample and the diabetes sample*

Variables	Full sample	Diabetes sample
Constant	0.2995* (0.0066)	0.0637 (0.0729)
Male	0.2110* (0.0033)	0.2279* (0.0306)
Age <25 years	−0.1116* (0.0051)	−0.1321 (0.1082)
Age 45–54 years	−0.0281* (0.0047)	−0.0462 (0.0446)
Age >54 years	−0.2581* (0.0046)	−0.3077* (0.0426)
High school education	0.0289* (0.0036)	0.1414* (0.0325)
Post–high school education	0.0451* (0.0044)	0.1998* (0.0454)
Black	−0.0240* (0.0047)	−0.0671 (0.0351)
Other ethnic groups	−0.0566* (0.0071)	−0.0913 (0.0695)
Single	−0.0377* (0.0049)	0.0532 (0.0555)
Separated, divorced, or widowed	0.0286* (0.0050)	−0.0105 (0.0373)
Very good health	−0.0117* (0.0040)	—
Good health	−0.0578* (0.0042)	—
Fair health	−0.2024* (0.0061)	—
Poor health	−0.4452* (0.0103)	—
Having diabetes	−0.0356* (0.0115)	—
Having diabetes complications	—	−0.1237* (0.0429)
Type 1 diabetes	0.1061* (0.0354)	0.1545* (0.0560)
Family size	−0.0232* (0.0011)	0.0077 (0.0107)
Urban residence	0.0094* (0.0039)	0.0470 (0.0340)
Regional factor	Only one variable is significant	All are insignificant
Log-likelihood	−30,836.16	−796.34
Sample size	68,634	1,351

SEM is provided in parentheses. *Significance at 5% level.

Employment status

In Table 2 we provide the estimates of the probability of working. In column 1 we show the results of the regression equation for the full sample when using the dummy variable that indicated the presence or absence of diabetes. Employment was associated with sex (male subjects had 21% higher employment rates [95% CI 21–22%]), education (better-educated subjects had 3–4% higher rates [2–5%]), and race (nonwhites had 2–6% lower rates [2–7%]). Age, marital status (single), and family size were associated with lower employment rates. Individuals with poor health were 45% (43–46%) less likely to be in the labor force and individuals with fair health were 20% (19–21%) less likely, compared with individuals with excellent health. Individuals with diabetes were 4% (2–4%) less likely to be in the workforce, whereas the employment probability differs between types 1 and 2 diabetes.

In column 2 of Table 2, we present the estimates for the inclusion of the dichotomous variable indicating whether people with diabetes had any complications, using only the sample for people with diabetes. Unlike in the full sample, only sex, age, and educational effects are found to be important factors determining the workforce decision. People with diabetes who had complications were ~12% (5–19%) less likely to be in the workforce than those who did not have complications. Again, the dependency on insulin did not enhance the working probability of people with diabetes.

Lost work days

In Table 3 we present the results of regression equations indicating the effect on work-loss days of variables including having diabetes during the prior 2 weeks and the severity of diabetes (results are in columns 1 and 2, respectively). In column 1, we present estimates for the sample of working individuals. We found that being male and older reduced the number of work-loss days. For the self-reported health status measure, there was a progressive increase in work-loss days as health status fell. No statistically significant effect was found for self-reported diabetes. In column 2 we address the loss of productivity for people in the diabetes group. Using this regression equation, the effect of having diabetes complications (compared with not having them) increased the number of work-loss days by 3.2 days (1–6) within a 2-week period. In either specification, the effect of having type 1 diabetes is found to be significant.

Because the presence of diabetes was not statistically significant in the full sample for the tobit regression (Table 3), in Table 4 we present lost-productivity cost estimates in relation to the diabetes group with complications. Our reference value for yearly earnings are shown in column 1. For example, a fully employed white male subject aged <25 years earned $14,339 annually in 1989. For white men with diabetes with complications who were aged between 25 and 54 years, the yearly earnings loss was be $8,616 (column 2). For each demographic group (by race and sex), such losses increase with age and peak at the prime age-group (age 25–54 years). Among the groups, nonwhite female subjects generally suffered the least compared with either their white female or male (white and nonwhite) counterparts.

CONCLUSIONS — Diabetes has a considerable impact on economic behavior in the labor force. Controlling for variables such as age, sex, and health status, the presence of diabetes itself reduced employment by 3.5%, and the presence of complications reduced employment by 12% compared with the absence of complications. For those individuals who were employed, having diabetes did not have a significant overall effect on hours worked; however, those who had complicated diabetes worked 3.2 days less every 2 weeks than those whose diabetes were without complications. The type of diabetes had no impact.

Kahn (17) used both 1989 NHIS and the 1992 Health and Retirement Survey (HRS) to study labor market outcomes for

Table 3—*Tobit regression results indicating the number of work-lost days in a 2-week period for the sample of working individuals and the diabetes sample*

Variables	Sample of working individuals	Diabetes sample
Constant	−14.6513* (0.5897)	−14.2713* (4.8590)
Male	−1.1999* (0.1565)	−1.1188 (1.2319)
Age <25 years	0.2474 (0.2237)	−7.2729 (4.5078)
Age 45–54 years	−0.8519* (0.1944)	0.6974 (1.4819)
Age >54 years	−1.6382* (0.2482)	−0.7523 (1.5306)
Educational level	NS	NS
Black	−0.3898 (0.2092)	1.2806 (1.3049)
Other ethnic groups	−1.1014* (0.3563)	2.2973 (2.4417)
Single	−0.1374 (0.1995)	2.4293 (1.6845)
Separated, divorced, or widowed	0.7456* (0.2044)	−0.3585 (1.4601)
Very good health	1.4129* (0.1775)	—
Good health	2.9959* (0.1900)	—
Fair health	5.8547* (0.2868)	—
Poor health	11.6462* (0.5135)	—
Having diabetes	0.8706 (0.5640)	—
Having diabetes complications	—	3.2456* (1.6523)
Type 1 diabetes	−0.1273 (1.2740)	0.5404 (1.6649)
Managerial, technician and related professional occupations	1.1956* (0.5109)	−1.1484 (4.4140)
Sales and services occupations	1.1352* (0.5086)	2.5458 (4.2780)
Administrative support occupations	1.7560* (0.5223)	2.4406 (4.4300)
Blue-collar occupations	1.8317* (0.5007)	3.0567 (4.2564)
Log-likelihood	−18,773.01	−426.41
Sample size	52,832	715

SEM is provided in parentheses. *Significance at 5% level.

people with diabetes. Kahn's results relating to employment indicated that people without diabetes had participation rates ~12% above those with diabetes, but he only examined the 50- to 60-year age-group. In addition, Kahn's results indicated that people with 5 years' duration of diabetes had 3% lower employment rates. In his study, Kahn focused on the issue of changes in labor markets over time, rather than on the productivity losses associated with diabetes. He did not include the complications variable, which has important implications for economic evaluations. He also did not include an analysis of days of work lost. In his analysis of the HRS sample, he found that the earnings of men with diabetes was 69% of those without diabetes; there was no difference between female groups. However, the HRS analysis was confined to people between the ages of 51 and 62 years (roughly one-half of our sample of people with diabetes).

It should be noted that the analysis could not distinguish between long- and short-term disability and productivity losses associated with diabetes. This distinction would be important in identifying lost-work time attributable to short-term complications of diabetes (e.g., hyper- or hypoglycemia)—which would likely be more prevalent in type 1 diabetes—from lost productivity attributable to longer-term complications, which could occur in both conditions. Given the limitations of the self-reported data from population surveys, we were not able to incorporate productivity losses caused by premature mortality associated with diabetes.

We should point out that the data that we have obtained were self-reported, and such data are often subject to errors related to recall. However, the variables that we examined are less likely to be subject to recall because of the short period of data collection. There could be errors related to the misreporting of diabetes because individuals might not have known they had diabetes or complications; however, given the seriousness of the condition, this should not be a significant problem. Further, given the nature of the data from this cross-sectional survey, the observed relationships must be viewed as associations and not necessarily as causal relationships. In terms of model setup, one may argue that diabetes complications may be endogenous instead of exogenous. Facing the constraint of data availability and the theme of the study, the endogeneity issue is beyond the scope of the present analysis.

Costs that can be tied to specific interventions, such as diabetes control, can yield very valuable information. Several studies, in the U.S. (28,29) and the U.K. (30) have shown that aggressive interventions for diabetes can retard the development of complications. Our results indicate that the net

Table 4—*Loss of productivity associated with diabetes complications for specific demographic groups*

	Yearly earnings for full-time full-year workers	Loss of yearly earnings for people with diabetic complications
Age <25 years		
White males	14,339	4,654
White females	12,844	4,169
Black males	11,973	3,886
Black females	11,687	3,793
Age 25–54 years		
White men	26,546	8,616
White women	18,798	6,101
Black men	19,838	6,439
Black women	19,393	6,294
Age ≥55 years		
White men	27,573	8,749
White women	17,433	5,658
Black men	19,669	6,384
Black women	15,405	5,000

Data are $U.S.

productivity costs of preventing complications once an individual has diabetes can be very significant, amounting to >$3,700–8,700 per person per year, depending on the demographic group. These costs are of the same order of magnitude as annual medical costs due to diabetes (8).

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