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Can Chronic Disease Management Programs for Patients with Type 2 Diabetes Reduce Productivity-Related Indirect Costs of the Disease? Evidence from a Randomized Controlled Trial

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Abstract

The objective was to assess the impacts of diabetes self-management programs on productivity-related indirect costs of the disease. Using an employer's perspective, this study estimated the productivity losses associated with: (1) employee absence on the job, (2) diabetes-related disability, (3) employee presence on the job, and (4) early mortality. Data were obtained from electronic medical records and survey responses of 376 adults aged ≥18 years who were enrolled in a randomized controlled trial of type 2 diabetes self-management programs. All study participants had uncontrolled diabetes and were randomized into one of 4 study arms: personal digital assistant (PDA), chronic disease self-management program (CDSMP), combined PDA and CDSMP, and usual care (UC). The human-capital approach was used to estimate lost productivity resulting from 1, 2, 3, and 4 above, which are summed to obtain total productivity loss. Using robust regression, total productivity loss was modeled as a function of the diabetes self-management programs and other identified demographic and clinical characteristics. Compared to subjects in the UC arm, there were no statistically significant differences in productivity losses among persons undergoing any of the 3 diabetes management interventions. Males were associated with higher productivity losses (+$708/year; $P<0.001$) and persons with greater than high school education were associated with additional productivity losses (+$758/year; $P<0.001$). Persons with more than 1 comorbid condition were marginally associated with lower productivity losses (-$326/year; $P=0.055$). No evidence was found that the chronic disease management programs examined in this trial affect indirect productivity losses. (*Population Health Management* 2014;17:112–120)

Background

The relationship between an individual's health status and his or her ability to participate in the labor force are significant health policy concerns nationally and globally. In the United States, labor force participation is so closely intertwined with access to health insurance that the government closely regulates and monitors health insurance status, providing sufficient incentives for employees to remain employed and making health insurance affordable. Access to health care occupies substantial political debate as illustrated by the Patient Protection and Affordable Care Act (PPACA). With the passage of PPACA, the government will now monitor both employer and employee enrollment in health insurance programs with the goals of decreasing the number of uninsured Americans and reducing the overall costs of health care. Consequently, the impacts of the health care reform law on chronic diseases are very important as these diseases represent a major source of unsustainable growth in health care costs,[1,2] representing up to 75% of total health care costs in 2009.[1]

The productivity-related burden posed by chronic illnesses, and diabetes in particular, is increasingly an issue at both the state and national policy level. A number of studies

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have discussed the impact of diabetes on health and labor market performance,[3] employment,[4–6] workforce participation, and productivity,[4,7–11] as well as education and labor force attachment.[12,13] Largely, these studies have shown that health-related problems associated with diabetes have a significant negative effect on labor market activity—in particular, on labor force participation, causing large earnings losses.[14,15]

Productivity-related costs typically represent indirect health care costs and manifest in the form of employee absence on the job and/or reduced productivity while on the job. Although difficult to estimate, these costs have been measured for different health conditions, including physical and mental illnesses,[16–18] by translating productivity losses into dollar terms for specific health and disease categories or across multiple health conditions.[19]

This study estimated (1) the productivity-related costs associated with employee absence on the job, by using a conservative approach of time away from work because of a diabetes-related hospitalization, (2) the productivity losses associated with diabetes-related disability, (3) the productivity losses associated with employee presence on the job (reduced productivity while on the job and/or reduced time at work because of diabetes-related ambulatory care visits), and (4) productivity losses related to early mortality. Total productivity loss (the sum of 1, 2, 3, and 4 above) also was modeled as a function of intervention groups and relevant demographic and clinical characteristics.

Although other studies have focused on the impact of diabetes at the national level, this study focuses on the effects of diabetes in a randomized controlled trial (RCT) conducted in Texas. This study is important and timely in the face of increasing diabetes prevalence and incidence rates, and the skyrocketing costs associated with the disease. In their 2010 article in *Health Affairs*, Dall and colleagues noted, "[t]his diabetes burden represents a hidden 'tax' in the form of higher health insurance premiums and reduced disposable income."[20] In light of the recent PPACA law, several employers will become responsible for the health insurance status of their employees. Studies of this nature add to the literature on how diabetes and its associated complications may affect labor productivity; help employers determine where overall cost problems are most pronounced; facilitate discussions on how to ensure optimum employee health and how health and disease management intervention programs should be prioritized.

Methods

Data

A retrospective cohort analysis was conducted using secondary data from a recently concluded National Institutes of Health-funded RCT on type 2 diabetes (T2DM) self-management interventions in Central Texas. Individuals enrolled in the RCT were recruited from 7 participating clinics of a large university-affiliated health care system and multispecialty group practice associated with an 186,000-member health maintenance organization. These 7 clinics were selected based on their relatively higher numbers and overall percentage of African American and Hispanic patients diagnosed with T2DM (S. Forjuoh, J.N. Bolin, C. Huber, et al, unpublished data, 2013). Potential participants were identified in the health care system through the electronic medical records (EMRs) if they had a diagnosis of T2DM, were 18 years of age or older, had a lab-assessed HbA1c value of at least 7.5 within the last 6 months, and were able to read, write, and speak English. Subjects were excluded if they had reports of alcoholism or drug abuse, were pregnant or planning to become pregnant within 12 months, or were unwilling to sign an informed consent to be randomized to any of the 4 treatment/control groups. A total of 1897 potential subjects were contacted by project staff, 922 of whom voiced their interest in the study. Of these, only 376 individuals met the study criteria and agreed to participate in the study. A fixed, equal-allocation, stratified randomization procedure (stratifying by clinic setting and race/ethnicity) was used to randomize the 376 participants into one of 4 study arms: the diabetes pilot software on a personal digital assistant handheld device (PDA) (n = 81), Stanford University's chronic disease self-management program (CDSMP) (n = 101), combined PDA and CDSMP (COM) (n = 99), and usual care (UC) (n = 95) (S. Forjuoh, J.N. Bolin, C. Huber, et al, unpublished data, 2013). Subjects randomized to the CDSMP arm received a 6-week, 2½-hour, once a week classroom-based training on diabetes self-management. Each subject in the PDA arm was given a PDA and trained to monitor his/her blood glucose, blood pressure, medication usage, physical activity, and dietary intake by tracking these measures in the PDA diabetes pilot software. Subjects were enrolled in the study for a maximum of 2 years. Details of subject recruitment and retention are described elsewhere (S. Forjuoh, J.N. Bolin, C. Huber, et al, unpublished data, 2013).

Clinical data for participants enrolled in the RCT were obtained from EMR records downloaded on a quarterly basis. The EMR records include HbA1c levels; ambulatory care visits, acute hospital events relating to diabetes (ie, emergency room [ER] visits, observation, inpatient hospitalization); length of stay (LOS) for each acute event; health care financing and reimbursement; past and current comorbidities; and pharmaceutical data. Patient surveys were administered periodically during the study and included information on sociodemographics (eg, age, sex, race/ethnicity, education, yearly income); technological experiences (eg, any experience using computers, the Internet, a PDA); self-reported health-related quality of life (HRQoL) measures (eg, number of days impairments kept participant from usual activities such as work); diabetes self-care activities (number of days, 0–7, any specific self-care activity was performed in the past week); pain and fatigue measures (on a scale of 1–10, 1 indicating none and 10 severe); and physical activity measures (eg, number of physically active days in the past week).

Measurement

The dependent variable for this study was total productivity-related losses associated with absenteeism (defined as employee absence on the job for acute hospital events relating to diabetes and diabetes-related disability), presenteeism (defined as reduced productivity while on the job and reduced time at work because of diabetes-related ambulatory care visits), and premature mortality. Diabetes-related acute events were identified based on the diagnoses listed on inpatient claims, obtained from the EMR. Ambulatory care visits, including visits to primary care physicians, medical specialists (cardiology, ophthalmology, and neurology) and outpatient dialysis centers also were also identified from *International Classification of Diseases, Ninth Revision* codes on EMR claims.

To assess absenteeism, EMR data were used to estimate employee absence on the job because of a diabetes-related hospitalization using LOS over a 1-year period. The sum of LOS over a 1-year period (for acute hospital events relating to diabetes) was calculated and costed out using income ranges reported in the survey. Survey responses to health limitations that kept the subject from doing usual activities, such as self-care, work, or recreation were used to estimate employee absence on the job because of diabetes-related disability. Specifically relating to diabetes, the survey question asked "During the past 30 days, for about how many days did your health/health limitation keep you from doing usual activities, such as self-care, work, or recreation?" This question was modified from the HRQoL-4 measurement. Developed by the Centers for Disease Control and Prevention, all HRQoL questions have shown validity and reliability in persons with and without disability.

For presenteeism, survey responses from the literature and EMR were used to estimate reduced productivity and time on the job. In particular, reduced productivity was calculated based on a multiplication factor obtained from prior literature.[10] Tunceli and colleagues estimated that males and females with diabetes were 5.4 and 6 percentage points (absolute increase), respectively, more likely to have work limitations that affected productivity.[10] Reduced time at work was calculated based on the number of diabetes-related ambulatory care visits, including physician office, ER, and outpatient visits. In the base model, visits to physician offices were assigned a half day, dialysis treatments were assigned a full day, and ER visits were initially assigned zero days. These estimates were varied in the higher estimate sensitivity analysis.

Other ambulatory care cost components were imputed using estimates from the National Ambulatory Medical Care Survey. Based on the 2007 Survey, persons with diabetes had 28.1 million ambulatory care visits, earning diabetes the rank of 7th position among the leading primary diagnoses for ambulatory care. Of these, approximately 17.8 million visits were to primary care offices, 4.4 million visits were for surgical specialty, and another 1.7 million visits were to medical specialty offices. Hospital outpatient departments had 3.7 million diabetes-related visits while ERs had 462,000 visits.[21]

The resulting total time away from work (for each person) related to ambulatory visits was summed up and costed using annual income ranges reported in the survey. Based on EMR records of ambulatory care visits for each subject, the resulting time away from work because of an ambulatory care visit varied from person to person.

Mortality costs were calculated as a product of life years lost and income. Age- and sex-adjusted life expectancy values in 2008 were used to estimate the life years lost. The National Center for Health Statistics 2008 life tables were used to compare life expectancy at any age from birth onward. On the basis of mortality experienced in 2008, a person aged 65 years could expect to live an average of 18.8 more years for a total of 83.8 years; a person aged 85 years could expect to live an additional 6.4 years for a total of 91.4 years, on average.[22] After obtaining life years lost and assuming the same income over these years, the value of lost productivity from premature mortality was estimated using net present value (PV) calculations. Net PV was calculated using:

$$PV = \frac{F_1}{(1+r)^1} + \frac{F_2}{(1+r)^2} + \frac{F_3}{(1+r)^3} + \ldots + \frac{F_T}{(1+r)^T}$$

Where Ft (t = 1, 2, 3…T) equals the payment, or net benefit, received annually for T years, and r is the discount rate. A 3% social discount rate was used in the calculations.

From an employer's perspective, the human-capital approach to estimate value was used to cost components 1, 2, and 3, which are summed to obtain total productivity loss. Widely used in previous studies,[23–25] the human-capital approach estimates the value of an individual's productivity loss (labor earnings) because of an illness or early mortality. Subjects who reported no income (6% of the total sample) were assigned the median income for the zip code in which they lived, adjusted to 2008 dollars (the year when the data were collected) using PV calculations. To test whether this proxy affected the results, data were excluded for persons who reported no income and the model was rerun. The productivity costs reduced slightly but there were no significant differences in any of the intervention groups. This cost estimation for those who report no income has been used previously in the literature.[11]

Independent predictor variables include intervention groups; demographic information such as patient's age, sex, race, education, and body mass index (BMI); clinical data such as HbA1c levels and identified medical conditions/comorbidities; and risk factors such as time (in years) since initial diagnosis of diabetes; and the Summary of Diabetes Self-Care Activities (SDSCA) measures. The SDSCA measure is a brief self-report questionnaire of diabetes self-management that includes items that assesses the following aspects of the diabetes regimen: diet, exercise, blood glucose testing, foot care, and smoking. This measure has been tested for validity and reliability.[26]

Analysis

Descriptive statistics including means and standard deviations were employed to describe productivity losses by patient demographic characteristics. To control for influential observations, a robust regression model was used to model total productivity loss as a function of the different diabetes self-management programs, as well as other identified demographic and clinical characteristics. Gender effects were observed for following well-documented differences between the sexes in labor force participation and wage earnings.[27–30] Other independent variables in the model included age, education, BMI, race/ethnicity, comorbidities, HbA1c levels, and diabetes duration. All analyses were conducted in STATA 12.0 (StataCorp LP, College Station, TX).

A simple sensitivity analysis was performed by varying inputs of the productivity components. A higher series estimate was obtained by making additional assumptions for some of the productivity components, based on past study reports. For persons hospitalized, 2 additional absence days were included for recuperation before returning to work. For persons who reported more than 14 days of health limitations that kept the person from doing usual activities (eg, self-care, work, recreation), 8 hours of home health were included every month. Because only cardiology, ophthalmology, and neurology were included in the base model, an additional ambulatory care visit to a medical specialist or for other health services such as physical therapy was included in the higher series model. Lastly, the number of days assigned to ER visits were varied from zero days (in the base model) to a quarter of a day. A logistic regression model was employed to show the nature of clinical end points that capture health care utilization for diabetes-related hospitalization and ER visits.

Results

Over a 1-year period, the total diabetes-related productivity losses for subjects in this study, regardless of intervention arm, is estimated at close to $2 million, representing more than 20,000 lost work days and 3 diabetes-related deaths (Table 1). The highest productivity loss was from premature mortality, representing almost $1 million dollars. Reduced productivity while on the job accounted for more than 40% of productivity losses.

Table 2 shows the average diabetes-related productivity loss (less mortality) by select baseline characteristics. Overall, productivity losses for subjects in the 4 study arms were generally comparable across baseline demographic and clinical characteristics. On average, a living subject in this trial is expected to lose $2683 in productivity annually. Males in this study had a higher annual productivity loss than females. Likewise, persons with greater than high school education had higher productivity losses than those with a high school education or less. Productivity loss by race (excluding those who died) was also different across the 3 race categories of non-Hispanic whites, Hispanics, and non-Hispanic blacks. Non-Hispanic whites had the highest productivity losses of all races, followed by Hispanics and non-Hispanic blacks.

Productivity losses were generally comparable by BMI and comorbidity count. Obese and overweight persons lost slightly over $2500 on average, per person, while persons with normal BMI ranges lost an average of $125 less. The productivity loss for persons with 1 comorbidity was greater than the productivity loss for persons with more than 1 comorbidity. Although productivity losses by age did not attain significance at the 0.05 level, diabetes patients age 65 or older had the lowest productivity losses annually.

Table 3 shows the total productivity losses for subjects in the 4 study arms by the number of days lost and the associated costs. Although they had the lowest absenteeism following inpatient hospitalization, persons in the CDSMP only group experienced the highest number of lost productive days while on the job, and the highest number of disability days.

Results of the multivariate robust regression model with total productivity loss as a dependent variable are shown in Table 4. Compared to subjects in the UC arm, there were no statistically significant differences in productivity losses among persons undergoing any of the 3 diabetes management interventions—CDSMP, PDA and COM. Males were associated with higher productivity losses and persons with greater than high school education also were associated with additional productivity losses. Persons with more than 1 comorbid condition were marginally associated with lesser productivity losses. Compared to non-Hispanic whites, there were no statistically significant differences among persons of Hispanic or African American descent. Persons aged ≥ 65 were associated with smaller losses although this was not significantly different when compared to individuals aged 40–64. Neither higher baseline HbA1c values nor longer diabetes duration were significantly associated with productivity losses.

The higher series calculations from the sensitivity analysis are shown in Table 5. This higher estimate factors in absenteeism costs following recuperation from a hospitalization (additional $12,685 compared to base model) and receipt of home health services (additional $111,478 compared to base model). Presenteeism components in the higher estimate include additional ambulatory care visit for physical therapy or other specialty services not previously included in the base model, and productivity losses following ER visits, when each visit is assigned a quarter day (additional $26,120 compared to base model).

Clinical end points that capture health care utilization for diabetes-related ER visits and hospitalization are shown in Table 6. Compared to subjects in the UC arm, persons in the CDSMP only arm had significantly lower odds of health care utilization.

Table 1. Total Productivity Losses Attributed to Diabetes

	Productivity Loss # of days	*Total Cost US $*	*Proportion of TPL %*
Presenteeism losses			
Reduced time at work because of ambulatory care visit* (n = 376)	280	31,665	2
Reduced productivity on the job$^{\Omega}$ (n = 371)	7864	866,744	44
Absenteeism Losses			
Disability^{+} (n = 371)	11,664	85,314	4
Inpatient hospitalization (n = 80)	256	25,219	1
Mortality	3 deaths	953,373	49
Total Productivity Loss	20,064 days	1,962,314	

*Includes physician office visits, emergency department visits, and outpatient visits (eg, for dialysis treatment).

$^{\Omega}$Determined by asking subjects if they had any impairments or health problems that limited the kind or amount of paid work they could do.

$^{+}$Based on number of days that health limitation kept subject from doing usual activities, such as self-care, work, or recreation.

TPL, total productivity loss.

Discussion

The main contribution of this study is to assess the impacts of chronic disease management programs for patients with T2DM on productivity-related indirect costs of the disease. To the best of the research team's knowledge, no study has investigated diabetes indirect productivity losses stratified by subject randomization into diabetes self-management

Table 2. Average Diabetes-Related Productivity Loss (Less Mortality) by Select Demographics

	CDSMP only group		PDA only group		Combined group		Control group		All	
	N=101		N=81		N=99		N=95		N=376	
Participant Characteristics	*US $*	*SD*	*US $*	*SD*	*US $*	*SD*	*US $*	*SD*	*US $*	*SD*
Sex										
Female	2185	1383	2390	1577	2425	1647	2291	1649	2320	1558
Male	2990	1600	2715	1962	3312	1506	3416	1876	3128	1730
Education										
High school or less	2036	1174	1902	1247	1947	988	1863	1370	1938	2976
Greater than high sch	2741	1608	2838	1880	3188	1712	3119	1870	2976	1762
Race										
Non-Hispanic black	1711	1057	2787	1432	2541	1380	2454	1352	2275	1317
Hispanic	2283	1292	2539	1526	2662	1563	2928	1643	2584	1490
Non-Hispanic white	2948	1624	2465	1898	2951	1712	2846	1992	2819	1808
Body mass index (kg/m2)										
Normal	2398	1531	2164	1178	3454	2954	2188	2009	2375	1652
Overweight	2584	1614	2910	1557	3009	1550	3188	1614	2888	1576
Obese	2571	1525	2476	1823	2782	1646	2746	1870	2654	1715
Comorbidity count										
1 comorbid cond.	2647	1525	2461	1445	2893	1698	2996	1690	2748	1592
>1 comorbid cond.	2361	1560	2627	2145	2784	1591	2478	2008	2588	1811
Age categories										
<45	2865	1676	2935	2075	2465	1384	2773	1805	2756	1671
45–64	2568	1537	2544	1630	3025	1619	2919	1736	2770	1630
65+	2448	1499	2359	1983	2577	1748	2511	2083	2476	1830
Average loss per person	2559	1534	2526	1745	2837	1637	2789	1832	2683	1684

CDSMP, chronic diabetes self-management program; PDA, personal digital assistant; SD, standard deviation.

programs. Although previous research does show direct cost components of diabetes and its complications, as well as indirect costs on a national level, the present study is unique in that it compares the indirect productivity costs of diabetes by different interventions designed to reduce the burden of the disease. This state-based study also provides leverage to validate national findings.

The research team is unable to find evidence that the chronic disease management programs examined in this trial control indirect productivity losses. Compared to the control group who received no self-management training, the CDSMP, PDA, or COM intervention had no significant effect on productivity losses despite significant improvements in health care utilization rates for persons in the CDSMP group. Plausible reasons why there was no translation of potential health gains into productivity gains following diabetes self-management programs include: (1) The intervention might require a longer time period to impact productivity. In other words, the productivity gains expected from chronic disease management programs might accrue in the future, considering previous findings on the effectiveness of chronic disease self-management programs.[31] (2) Subjects in the study might have passed stages where they can be helped. For example, all but 1 person in the study had 1 or more comorbidities in addition to diabetes; 40% of study subjects had 2 or more comorbidities. A previous study based on the parent RCT[31] concluded that persons with fewer comorbidities are more likely to experience longer time to hospitalization or longer time to absenteeism following enrollment in a diabetes self-management program. (3) The diabetes self-management programs employed might be effective in theory, but not implemented efficiently. For example, persons in the PDA arm discontinued using their PDAs primarily because they were frustrated with the device and/or the diabetes pilot software on it.[32] (4) In the short term, there might be a trade-off between absenteeism and presenteeism. Persons in the CDSMP arm had the least absenteeism rates but the highest presenteeism losses.

Although non-Hispanic whites typically are associated with higher incomes and higher productivity losses,[33] productivity loss by race/ethnicity in this study was insignificant. This is driven largely by the deaths in the study, which were all non-Hispanic white deaths, driving up the productivity losses for this group. Persons with lesser productivity losses were females and those with lesser education attainment, supporting previous findings that report differences between the sexes with regard to pay.[34–36] It is also well established that persons with higher educational attainment have a greater likelihood of earning higher incomes, and being more productive members of society.

The findings of this study corroborate other findings that suggest that persons with chronic conditions such as diabetes may continue to work despite their illnesses, until they are unable to work. In this study, reduced productivity while on the job constituted 44% of the total productivity loss. A national study by the American Diabetes Association estimated reduced performance at work to constitute 35% of the total indirect productivity costs attributed to diabetes.[4] Despite the significant productivity burden posed by continuing to work while ill, presenteeism goes largely unnoticed because of the huge focus on the direct costs

Table 3. Total Productivity Losses Attributed to Diabetes by Intervention in a 1-Year Period

	CDSMP only group		*PDA only group*		*Combined group*		*Control group*		*All*	
	N=101		N=81		N=99		N=95		N=376	
	Productivity Loss # of days; deaths	*Total US $*	*Productivity Loss # of days; deaths*	*Total US $*	*Productivity Loss # of days; deaths*	*Total US $*	*Productivity Loss # of days; deaths*	*Total US $*	*Productivity Loss # of days; deaths*	*Total US $*
Presenteeism losses										
Reduced time at work because of ambulatory care visit*	65	7542	78	7662	59	7504	78	8956	280	31,665
Reduced productivity on the job[Ω]	2109	222,781	1699	167,023	2067	245,487	1989	231,453	7864	866,744
Absenteeism Losses										
Disability[+]	4332	27,369	2412	21,562	2868	20,329	2052	16,055	11,664	85,314
Inpatient hospitalization	7	805	110.5	8383	71.5	7558	67	8473	256	25,219
Mortality[α]	0.5	188,169	1	250,879	0.5	243,711	1	270,614	3	953,373
Total Productivity Loss	6513	446,666	4299.5	455,509	5065.5	524,589	4186	535,551	20,064	1,962,315

*Includes physician office visits, emergency department visits, and outpatient visits (eg, for dialysis treatment).
ΩDetermined by asking subjects if they had any impairments or health problems that limited the kind or amount of paid work they could do.
+Based on number of days that health limitation kept subject from doing usual activities, such as self-care, work, or recreation.
αDiabetes-related deaths only (ie, diabetes as first listed or any listed cause of death). Costs adjusted to present value.
CDSMP, chronic diabetes self-management program; PDA, personal digital assistant.

Table 4. Multivariate Model for Total Productivity Losses (TPL)

TPL	*Coefficient*	P>*t*	*95% Confidence Interval: Lower Limit*	*95% Confidence Interval: Upper Limit*
Sex				
Males	707.93	0.00	385.98	1029.88
Females			*Ref*	
Intervention				
CDSMP	−196.78	0.36	−622.83	229.28
PDA	−237.76	0.30	−691.15	215.63
Combined	113.09	0.60	−314.39	540.56
Control			*Ref*	
Education				
>High School	757.58	0.00	393.12	1122.02
≤High School			*Ref*	
Body mass index				
Normal	−288.62	0.43	−1008.62	431.39
Overweight	−149.63	0.47	−554.88	255.61
Obese			*Ref*	
Comorbidity				
1 comorbid condition			*Ref*	
>1 comorbid condition	−325.80	0.06	−659.18	7.57
Race/Ethnicity				
Non-Hispanic black	−349.66	0.12	−790.81	91.48
Hispanic	37.03	0.86	−386.98	461.03
Non-Hispanic white			*Ref*	
Age groups				
30–44	−90.37	0.73	−602.76	422.0
45–64			*Ref*	
≥65	−329.46	0.10	−722.64	63.71
Glycated hemoglobin (HbA1c)	−11.38	0.83	−116.04	93.28
Diabetes duration	15.72	0.65	−52.583	84.03

CDSMP, chronic diabetes self-management program; PDA, personal digital assistant.

associated with the disease. This relationship between illness and work has been explained by the contextuality of work—it depends on the labor market, compensation level, and type of condition.[37,38] People are less likely to be absent from work because of sickness when they are faced with a potential threat of unemployment.[39,40] A previous study found that persons with diabetes did not work fewer hours per week on average but had more work loss days and work limitations than those without diabetes, suggesting that diabetes affects work productivity.[10] A more recent study[38] noted that presenteeism is a public health hazard that delays recovery from illness. Although the research team does not suggest that persons with diabetes ultimately stop working, they encourage the design of workplace policies that address chronic illnesses, such as those promoted by the PPACA.

These findings also confirm previous studies that suggest that diabetes results in productivity losses for employers and employees. Employees may experience lost wages if their work loss days extend beyond an allotment of paid sick leave. Previous research indicates that the risk of diabetes

Table 5. Results of Sensitivity Analysis Varying Productivity Components

	Productivity Loss Base series # of days	*Total Cost Base series US $*	*Proportion of TPL %*	*Productivity Loss High series # of days*	*Total Cost High series US $*	*Proportion of TPL %*
Presenteeism losses						
Reduced time at work because of ambulatory care visit* (n=376)	280	31,665	2	500.25	57,785	3
Reduced productivity on the job$^{\Omega}$ (n=371)	7864	866,744	44	7864	866,744	41
Absenteeism Losses						
Disability^{+}(n=371)	11,664	85,314	4	13,016	196,792	9
Inpatient hospitalization (n=80)	256	25,219	1	380	37,904	2
Mortality	3 deaths	953,373	49	3 deaths	953,373	45
Total Productivity Loss	20,064 days	1,962,314		21,760	2,112,598	

*Includes physician office visits, emergency department visits, and outpatient visits (eg, for dialysis treatment).
$^{\Omega}$Determined by asking subjects if they had any impairments or health problems that limited the kind or amount of paid work they could do.
$^{+}$Based on number of days that health limitation kept subject from doing usual activities, such as self-care, work, or recreation.
TPL, total productivity loss.

might be reduced through workplace wellness programs that target diabetes prevention as well as other health improvement strategies.[10] Cancelliere and colleagues[41] provide preliminary evidence that some workplace health promotion programs are effective at improving presenteeism. Some also have alluded that although containing health care-related costs and absenteeism have been important strategies for companies,[41] greater gains may be realized by improving on-the-job productivity and investing in preventive and early intervention services.[42–44] Other researchers have suggested the need for policies addressing unrestricted paid sick leave, systematic processes for screening ill employees, and mandatory exclusion rules.[38] It is paramount that employers begin to view measures such as unrestricted sick leave and evidence-based work health promotion programs as not solelly employee benefits,[38] but as real investment opportunities that boost workforce productivity.

It is important to note that the costs reported in this study do not include medical claims costs, health insurance premiums, or other direct costs, which can significantly increase diabetes costs to the employer. McMaughan et al estimated the average direct costs attributable to diabetes to be $9928 for persons in the CDSMP group, $10,741 for persons in the PDA group, and $11,459 for persons in the COM group. Direct costs for the control arm were estimated at $9814, on average (D.K. McMaughan, O.E. Adepoju, J.N. Bolin, et al, unpublished data, 2013). Clearly, diabetes deals significant financial blows in the form of direct and indirect losses.

This study is not without limitations. First, a very conservative approach was taken in estimating the productivity component. Omitted from this analysis because of data limitations are the productivity contributions of family members in caring for the patients. For example, the productivity loss associated with adults who took time off from work to care for a subject in this study were not included in the cost estimates. The research team also was unable to accurately assess what home health services were received by subjects in this time frame, which of these services were strictly diabetes-related, and how much time was associated with these services. Hence the value of formal and informal caregiving is excluded from the productivity loss estimate. These areas can be improved on in future studies.

Second, self-reports from patient surveys were used to estimate reduced productivity while on the job. This subjectivity has potential construct validity issues. Patients may exaggerate symptoms in order to make their situation seem worse, or they may underreport the severity or frequency of symptoms in order to minimize their problems. Patients also might simply mistake or misremember the material covered by the survey. Regardless of these limitations, the estimates presented in this study show a consistent picture that diabetes places an enormous burden on society—in both economic terms and reduced quality of life. The advantage of this conservative approach is that the actual productivity cost is, at the barest minimum, what is reported in this study. This study's findings warrant the need for additional research in the long term.

Table 6. Logistic Regression for Diabetes-Related Hospitalization and ER Visits by Randomization Groups

	Hospitalization				*ER visits*			
Parameter	*Odds Ratio*	*95% Hazard Ratio Confidence Limits*		P *value*	*Odds Ratio*	*95% Hazard Ratio Confidence Limits*		P *value*
CDSMP	0.12	0.03	0.43	0.001	0.05	0.01	0.21	<.001
PDA	3.20	1.64	6.23	0.001	2.71	1.46	5.03	0.002
COM	1.14	0.60	2.28	0.705	1.19	0.65	2.20	0.563
Control	Ref				Ref			

*$P<0.05$.
CDSMP, chronic diabetes self-management program; COM, combined CDSMP and PDA; ER, emergency room; PDA, personal digital assistant.

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