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Estimating the Impact of Diabetes Mellitus on Worker Productivity using Self-Report, Electronic Health Record and Human Resource Data

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Abstract

Objective—We assessed the relationship between diabetes mellitus (DM) and measures of worker productivity, direct health care costs, and costs associated with lost productivity among health care industry workers across two integrated healthcare systems.

Methods—We used data from the Value Based Benefit Design Health and Wellness Study Phase II (VBD), a prospective study of employees surveyed across health systems. Survey and healthcare utilization data were linked to estimate lost productivity (LP) and healthcare utilization costs.

Results—Mean marginal lost productive time per week was 0.56 hours higher for respondents with DM. Mean adjusted monthly total healthcare utilization costs were \$467 higher for respondents with DM.

Conclusion—The impact of DM is reflected in higher rates of LP and higher indirect costs for employers related to LP and higher healthcare resource use.

Keywords

diabetes mellitus; productivity; healthcare utilization; healthcare costs; absenteeism; presenteeism; lost productivity; economic burden

Background

The economic impact of diabetes mellitus from both increased health care use and lower workforce participation and productivity is estimated to be US \$245 billion per year¹.

Although more attention has been paid to increased health care costs attributed to diabetes,

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Conflicts of Interest
None Declared.

one third or US\$69 billion of the annual cost of diabetes is due to lower workplace productivity¹ attributable to complications related to diabetes^{2-5,6}.

Several previous studies using patient-reported outcomes including functional status and productivity, both from national and site-specific survey data sources, have compared productivity among respondents with and without diabetes. Among respondents with diabetes experiencing hypoglycemic events⁷⁻¹², diabetes, including complications from diabetes and diabetes treatment, is associated with lost productivity and increased medical costs. Little is known about how these patient-reported outcomes relate to variation in healthcare utilization and costs.

Estimating rates of absenteeism (not coming to work) and presenteeism (coming to work while ill) among workers with and without diabetes can further quantify the impact of diabetes on productivity loss in the U.S. workforce. Health care workers are particularly susceptible to absenteeism; the Bureau of Labor Statistics reports health care and social assistance occupations had the highest absence rates among all private sector occupations in 2015¹³. Presenteeism can be a predictor of future absenteeism events and may also predict more intensive use of health care services^{14,15}. Prior research has shown higher rates of presenteeism among workers in the health care industry compared to other occupations¹⁶, and higher rates of presenteeism than absenteeism among workers in the health care industry^{16,17}.

The purpose of this paper is to assess the relationship between diabetes and measures of worker productivity, direct health care costs, and costs associated with lost productivity among health care industry workers. We linked survey data on self-reported productivity loss (absenteeism and presenteeism), patient demographics, self-reported health behavior, with detailed data on health care utilization, to further investigate costs associated with diabetes.

Methods

Our study population was employees of the Kaiser Permanente Regions of Colorado (KPCO) and Washington (KPWA) (formerly Group Health Cooperative) who enrolled in the Value Based Benefit Design Health and Wellness Study Phase II (VBD). Each health care delivery and finance system employs between 7,000 and 9,000 individuals in both clinical and administrative roles. KPCO and KPWA are integrated health systems serving managed care patient populations of approximately 650,000 patients annually.

Our study was part of a larger research project examining the impact of value-based insurance and incentives for health promotion programs among Group Health and KPCO employees, which has been described in detail elsewhere.¹⁸ In support of this larger research, a random sample of administrative and non-physician clinical employees received a survey in the winter and spring of each year between 2010 and 2013. Physicians received a different benefit package than other employees and were therefore excluded from the study.

We report analyses based on responses to the 2010 administration of the survey, during which cross-sectional productivity outcomes and healthcare utilization costs are calculated. Study participants were asked to provide consent for the research team to access their

medical records and for those individuals that agreed we linked survey data with information on diagnoses made at all health care encounters and pharmacy dispenses for prescription drugs as well blood pressure measurements taken at outpatient visits and recorded in the electronic medical record in use at all Group Health outpatient facilities was captured. The Institutional Review Boards in both regions approved the study design and all project materials.

Annual survey

The survey was administered in the following way: randomly selected employees received an email at their workplace address inviting them to participate in the study. Those that did not decline to participate received a second email with a link to web based survey that collected socio-demographic information including age, gender, race, education, household income, marital status, height and weight.

We measured workplace productivity using the Work Health Questionnaire (WHQ), a self-administered version of the Work and Health Interview (WHI)¹⁹. As described elsewhere,^{18,20} the WHQ measures employees' ratings of their employment status, usual work time, missed full or partial workdays due to illness, and health-related lost productive time (LPT) on work days over a two-week recall period. Absenteeism is measured as any health-related total or partial days an employee missed work.²⁰ Presenteeism is measured as an employee's reduction in performance while at work attributable to personal health, and is assessed using the average amount of lost work time attributed to working more slowly, lack of concentration, doing a job over, not working at all, and the time it takes to start working after first arriving to work. The WHQ translates presenteeism into hours of lost productivity that – when aggregated with hours missed from work (absenteeism) – provides a measure of total LPT due to personal illness per employee.

Human Resource (HR) and Electronic Health Record (EHR) data

For survey respondents who provided consent, survey data were linked to the individual's human resource (HR) and electronic health record (EHR) data. HR data included information on employment history, compensation, and health plan benefits enrollment and coverage. Health record data included detailed health care utilization (all diagnoses and procedures coded in the EHR and from external claims), pharmacy dispenses and over-the-counter fills for prescription drugs.

EHR data from each site were formatted in the Virtual Data Warehouse (VDW)²¹, which is the common data model for participating sites in the Health Care Systems Research Network (HCSRN)¹⁹. Respondents' healthcare utilization data were gathered from the VDW from January 1, 2006- December 31, 2013. For the purposes of these analyses, we limited our EHR data to January 1, 2010-December 31, 2013, and established a baseline period for respondents in 2010.

Diabetes Mellitus

To compare the difference in workplace productivity among respondents with and without diabetes, we created a binary exposure variable using the Surveillance, Prevention, and

Management of Diabetes Mellitus (SUPREME-DM) consortium²² definition, described in detail elsewhere²³. Briefly, respondents were classified as having Diabetes Mellitus (DM) in the 2010-baseline period if they had one inpatient International Classification of Disease, 9th Revision Clinical Modification (ICD9) diagnoses code (250.XX, 357.2, 366.41, and 362.01–362.07); or any combination of two or more of the following events January 1, 2009 through December 31, 2009 – 1) HbA1c concentration $\geq 6.5\%$ (≥ 48 mmol/mol); 2) fasting plasma glucose concentration ≥ 126 mg/dL (≥ 7.0 mmol/L); 3) random plasma glucose concentration ≥ 200 mg/dL (≥ 11.1 mmol/L); 4) an outpatient diagnosis code for diabetes (from same ICD9 diagnosis codes in inpatient setting); and 5) a prescription fill for antihyperglycemic medication. Individuals could have two of the same criteria count as a diagnosis for DM (i.e. two HbA1c concentrations $\geq 6.5\%$), provided they occurred on different dates.

Workplace productivity and healthcare cost outcomes

Workplace productivity was based on self-reported data from the 2010 VBD survey. We defined the following productivity outcomes: 1) absenteeism, defined as the number of work hours missed in the past two-week recall period due to illness; 2) presenteeism, defined as the number of work hours in the past two-week recall period with reduced efficiency attributable to illness, including lost work time due to a lack of concentration, doing a job over, working more slowly, not working at all, and the time it takes to start working after arriving at one's workplace;¹⁸ and 3) total lost productive time, defined as the sum of absenteeism and presenteeism). Each of these outcomes was analyzed both as continuous measures (number of hours), and as binary measures ("any" lost productivity, defined as >0 hours per week lost).

We used the Standardized Relative Resource Cost Algorithm (SRRCA)²⁴ to assign costs to health service use contained in the VDW. The SRRCA uses standardized codes (e.g. Current Procedural Terminology (CPT) Diagnosis-Related Group (DRG) and National Drug Codes (NDCs)) from VDW utilization data to link patient healthcare utilization with published Center for Medicare and Medicaid Services (CMS) 2013 fee schedules to assign costs. The SRRCA calculates monthly total utilization costs paid for each respondent. Total utilization costs for the current analysis were defined based on health care utilization data extracted from the EHR for all care encounters occurring over a four-year period, from the baseline period of January 1, 2010 through study follow-up of December 31, 2013. Follow-up for health care utilization was censored at disenrollment from the health plan, or withdrawal from the study.

Statistical analysis

We used chi-squared tests for categorical variables and t-tests for continuous variables reported as means to compare clinical, demographic, self-reported survey responses and employment information between respondents with and without DM. We computed adjusted marginal means and mean differences from generalized linear regression models (GLM) with an identity link and normal errors to compare the mean number of hours reported for each lost productivity outcome measure between respondent exposure groups. We used logistic regression models to estimate crude and adjusted odds ratios for each binary productivity outcome variable, comparing respondents with and without DM.

The following covariates were included in the final adjusted linear and logistic models: age, gender, race, ethnicity, annual household income, marital status, number of children <18 years of age, union membership, work environment (clinical or administrative), work schedule (including days worked per week and hours worked per day), coinsurance, smoking status, self-reported physical activity, and total number of years enrolled in health plan. These measures were selected a priori for inclusion in adjusted models, as they were hypothesized to be important potential confounders, related both to diabetes status and to measures of lost productivity and/or health care utilization and costs.

GLM repeated measures with a gamma distribution and log link were used to estimate differences in monthly total costs between respondents with DM and respondents without DM over the 2010–2013 study period.^{25,26} We used the same covariates in the adjusted productivity outcome models for the adjusted cost analyses.

We estimated employer perspective (health care system) total annual indirect costs from lost productivity due to DM per 1000 employees, using the estimated difference in average hours per week of absenteeism, presenteeism and LPT of respondents in the 2010 survey, a diabetes prevalence rate of 7.2%, and mean Bureau of Labor Statistics (BLS) 2014 hourly wage estimates from HR-provided job titles for survey respondents. Total annual indirect costs were inflated to 2016 \$US at a 3% discount rate.

Data aggregation and analyses using the SRRCA was conducted using SAS 9.2®. Subsequent outcomes and cost analyses for this paper were conducted using SAS 9.4®.

Results

Table 1 summarizes our VBD survey respondent sample, stratified by patients with and without DM. Across GHC and KPCO, there were 3,891 respondents to the baseline survey in 2010 who consented to have both their human resource and medical record data included in the study. Of these, 174 were missing gender, age, annual household income or work schedule/full-time equivalent information at the time of the survey and were excluded from the analysis, resulting in an analytic sample size of 3,717 respondents. Within this cohort, 266 (7.2%) were identified as having DM at baseline based on SUPREME-DM classification. Compared to respondents without DM, respondents with DM were more likely to be older, non-White Hispanic, report higher rates of divorce or separation from a spouse, lower annual household income, higher rates of union membership and longer periods of health plan enrollment.

Respondents with DM reported higher rates of current or prior smoking history. Average monthly medical costs at baseline (2010 utilization data) were \$1,298 and \$636 for respondents with and without DM, respectively.

Productivity Outcomes

Table 2 presents the marginal mean by DM status and adjusted difference between groups for the hours lost per week for each of the productivity outcomes. The adjusted difference between groups was 0.14 hours (95% CI −0.38, 0.65; p=0.6) for absenteeism, 0.42 hours

(95% CI 0.17, 0.67; $p<0.01$) for presenteeism, and 0.56 hours (95% CI -0.05 , 1.17; $p=0.07$) for lost productivity due to illness.

Crude and adjusted odds ratios of binary productivity outcome measures are listed in table 3. Respondents with DM were at increased odds for missed productivity due to presenteeism (adjusted OR 1.77 (95% CI 1.36, 2.31); $p<0.001$), and LPT (adjusted OR 1.54 (1.17, 1.99); $p<0.001$).

Cost Analyses

Table 4 summarizes the unadjusted and adjusted mean monthly total direct healthcare utilization costs (derived from the SRRCA) over the 2010–2013 study period for respondents with and without DM. Respondents with DM had significantly higher unadjusted monthly costs compared to respondents without DM (\$1230 vs \$634; $p<0.001$). After controlling for clinical, demographic and employment characteristics, monthly healthcare costs remained about double among those with DM (\$1007 vs \$539; $p<0.001$), with an estimated adjusted mean difference of \$468 (95%CI \$351, \$621).

Table 5 summarizes the results of the analysis of the cost of lost productivity due to diabetes, from the employer perspective. Total annual productivity hours lost (for employees with diabetes, relative to those without) for a large employer (1,000 insured beneficiaries) were 524.2, 1572.5 and 2096.6 hours of absenteeism, presenteeism and total LPT, respectively. Using an average hourly wage of \$32.81, these lost productivity estimates translate to total annual indirect costs of approximately \$15,738, \$47,215 and \$62,953 due to absenteeism, presenteeism and LPT, respectively for 1,000 insured employees.

Discussion

Our goal was to characterize costs of health care services and lost workplace productivity associated with DM among a healthcare employed population by linking several unique, comprehensive data sources – including employment characteristics, BLS wage/salary information, survey data, and EHR and claims data. After adjustment for demographic and employment characteristics a DM diagnosis does not increase the odds of absenteeism. Therefore, DM is not an independent predictor of time away from work for illness. Similarly, many studies utilizing both self-reported absenteeism measures and calculated absenteeism from administrative databases show no significant association between DM and absenteeism.^{6,27}

Other studies have found DM to be associated with lost productivity among employees with other chronic conditions, including depression,^{27–29} hypertension,⁶ and obesity^{10,30}.

Compared to individuals without DM, those with DM were had increased odds of reporting any lost productivity (LPT), due to significantly higher odds of lost productivity due to presenteeism. Our results are consistent with prior studies that have shown health care industry workers report higher rates of presenteeism than absenteeism.^{5,16,27}

Individuals with DM had significantly higher mean total monthly healthcare costs compared to respondents without DM. After controlling for clinical, demographic and employment

characteristics, total average monthly healthcare costs were \$467 higher (approximately 1.9 times higher) for respondents with DM than respondents without DM. These results are consistent with other research. The American Diabetes Association (ADA) found that individuals with DM incur, on average, \$9600 (approximately 2.3 times) the annual medical expenditure compared to individuals without diabetes.¹ Pagano et al (2016) observed excess healthcare costs among individuals with diabetes compared to those without diabetes, largely due to the presence of complications associated with DM.³¹ In a matched cohort study of adults in Ontario, Canada, Rosella et al (2016) has shown annual healthcare costs among individuals with incident DM are approximately C\$10,000 higher than patients without diabetes.³² This study highlights individuals with and without DM working in healthcare settings experience comparable differences in healthcare costs, controlling for specific employee characteristics unique to the VBD survey.

Across our two large healthcare employee groups, in addition to the increased medical costs, total corporate indirect costs of lost worker productivity associated with DM can exceed \$60,000 annually across a workforce of 1000 insured employees. Several studies have shown that lifestyle interventions, including universal screening, obesity prevention and other targeted interventions are cost-effective in reducing healthcare expenditure related to DM.³³ Taken together, these results suggest that employers may benefit financially from investing in prevention and/or care management programs for employees with DM, along with the potential improvements in workforce health and productivity.

Limitations

There are several limitations to our data structure and analytic approach. First, selection bias may have occurred among respondents who chose to participate in the VBD survey, resulting in a non-random sample of the employee populations at KPWA and KPCO.

Because of the high correlation of diabetes and obesity rates among respondents, BMI and obesity measures were not included in the models. Additional comorbid conditions, while available in the VDW, were not captured in these analyses, limiting our ability to control for potential confounders that may influence the relationship between DM, total healthcare costs, and worker productivity outcomes.

Another limitation is that self-reported data, which requires respondents to remember past events, has inherent recall bias. This study relied heavily on self-reported data, including measures related to and health-related absenteeism, presenteeism and loss productivity events. While the recall period was only two weeks, misclassification of self-reported productivity outcomes is possible.

The SRRCA calculates relative cost estimates rather than absolute.²⁴ Further, The SRRCA does not capture indirect healthcare costs, including opportunity costs associated with obtaining care or measures of patient out of pocket costs. However, the utility of the SRRCA for our analysis is the relative cost estimates allow for comparisons within and across systems.²⁴

The relationship between absenteeism and presenteeism is more nuanced than presented in our research. Presenteeism is increasing among the US workforce³⁴, and many occupational, demographic and economic factors influence employee decisions to elect to take a sick day versus coming to work sick^{34–37}. While workers in the health care industry are more likely to report events of presenteeism than absenteeism^{5,16}, studies have shown that presenteeism can be correlated with future absenteeism^{14,15}. Further research should include methodologies to examine additional factors influencing presenteeism and absenteeism outcomes among employees in the healthcare industry and others.

Conclusion

Our results suggest that health care employees with DM may experience higher rates of presenteeism and lost productivity while working compared to respondents without DM. Employees with DM incur significantly greater health care costs than employees without diabetes. Linking patient reported data on worker productivity outcomes to clinical and human resources data provides a detailed understanding of the association between diabetes and both productivity loss and health care costs among employees of two large, managed care organizations.

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References

1. American Diabetes A Economic Costs of Diabetes in the U.S. in 2017. *Diabetes care*. 2018;41(5): 917–928. [PubMed: 29567642]
2. Ng YC, Jacobs P, Johnson JA. Productivity losses associated with diabetes in the US. *Diabetes care*. 2001;24(2):257–261. [PubMed: 11213875]
3. Valdmanis V, Smith DW, Page MR. Productivity and economic burden associated with diabetes. *Am J Public Health*. 2001;91(1):129–130. [PubMed: 11189805]
4. Ramsey S, Summers KH, Leong SA, Birnbaum HG, Kemner JE, Greenberg P. Productivity and medical costs of diabetes in a large employer population. *Diabetes care*. 2002;25(1):23–29. [PubMed: 11772896]
5. Tunceli K, Bradley CJ, Nerenz D, Williams LK, Pladevall M, Elston Lafata J. The impact of diabetes on employment and work productivity. *Diabetes care*. 2005;28(11):2662–2667. [PubMed: 16249536]
6. Krstovic-Spremo V, Racic M, Joksimovic BN, Joksimovic VR. The effects of diabetes mellitus and hypertension on work productivity. *Acta Med Acad*. 2014;43(2):122–133. [PubMed: 25529517]
7. Alonso-Moran E, Orueta JF, Nuno-Solinis R. Incidence of severe hypoglycaemic episodes in patients with type 2 diabetes in the Basque country: impact on healthcare costs. *BMC health services research*. 2015;15:207. [PubMed: 26012499]
8. Brod M, Christensen T, Bushnell DM. The impact of non-severe hypoglycemic events on daytime function and diabetes management among adults with type 1 and type 2 diabetes. *Journal of medical economics*. 2012;15(5):869–877. [PubMed: 22510017]
9. Brod M, Christensen T, Thomsen TL, Bushnell DM. The impact of non-severe hypoglycemic events on work productivity and diabetes management. *Value in health : the journal of the International Society for Pharmacoeconomics and Outcomes Research*. 2011;14(5):665–671. [PubMed: 21839404]

10. Brod M, Wolden M, Christensen T, Bushnell DM. A nine country study of the burden of non-severe nocturnal hypoglycaemic events on diabetes management and daily function. *Diabetes, obesity & metabolism*. 2013;15(6):546–557.
11. Geelhoed-Duijvestijn PH, Pedersen-Bjergaard U, Weitgasser R, Lahtela J, Jensen MM, Ostenson CG. Effects of patient-reported non-severe hypoglycemia on healthcare resource use, work-time loss, and wellbeing in insulin-treated patients with diabetes in seven European countries. *Journal of medical economics*. 2013;16(12):1453–1461. [PubMed: 24144009]
12. Willis WD, Diago-Cabezudo JJ, Madec-Hily A, Aslam A. Medical resource use, disturbance of daily life and burden of hypoglycemia in insulin-treated patients with diabetes: results from a European online survey. *Expert review of pharmacoeconomics & outcomes research*. 2013;13(1):123–130. [PubMed: 23402452]
13. United States Bureau of Labor Statistics. Current Population Survey. Absences from work of employed full-time wage and salary workers by occupation and industry. 2015; <http://www.bls.gov/cps/cpsaat47.htm>. Accessed October 23, 2016.
14. Bergström G, Bodin L, Hagberg J, Aronsson G, Josephson M. Sick leave presenteeism today, sickness absenteeism tomorrow? A prospective study on sickness presenteeism and future sickness absenteeism. *Journal of Occupational and Environmental Medicine*. 2009;51(6):629–638. [PubMed: 19448572]
15. Bergström G, Bodin L, Hagberg J, Lindh T, Aronsson G, Josephson M. Does sickness presenteeism have an impact on future general health? *International archives of occupational and environmental health*. 2009;82(10):1179–1190. [PubMed: 19504117]
16. Aronsson G, Gustafsson K, Dallner M. Sick but yet at work. An empirical study of sickness presenteeism. *Journal of epidemiology and community health*. 2000;54(7):502–509. [PubMed: 10846192]
17. Elstad JJ, Vabø M. Job stress, sickness absence and sickness presenteeism in Nordic elderly care. *Scandinavian Journal of Public Health*. 2008;36(5):467–474. [PubMed: 18635730]
18. Standish D Relationship Between Workplace Productivity and Physical Activity Among an Employed Healthcare Workforce 2016.
19. Stewart WF, Ricci JA, Leotta C, Chee E. Validation of the work and health interview. *Pharmacoeconomics*. 2004;22(17):1127–1141. [PubMed: 15612831]
20. Abegglen S, Hoffmann-Richter U, Schade V, Znoj HJ. Work and Health Questionnaire (WHQ): A Screening Tool for Identifying Injured Workers at Risk for a Complicated Rehabilitation. *J Occup Rehabil*. 2017;27(2):268–283. [PubMed: 27393558]
21. Henrikson NB, Anderson ML, Hubbard RA, Fishman P, Grossman DC. Employee knowledge of value-based insurance design benefits. *Am J Prev Med*. 2014;47(2):115–122. [PubMed: 24951038]
22. Nichols GA, Desai J, Elston Lafata J, et al. Construction of a multisite DataLink using electronic health records for the identification, surveillance, prevention, and management of diabetes mellitus: the SUPREME-DM project. *Prev Chronic Dis*. 2012;9:E110. [PubMed: 22677160]
23. Nichols GA, Schroeder EB, Karter AJ, et al. Trends in diabetes incidence among 7 million insured adults, 2006–2011: the SUPREME-DM project. *Am J Epidemiol*. 2015;181(1):32–39. [PubMed: 25515167]
24. O’Keeffe-Rosetti MC, Hornbrook MC, Fishman PA, et al. A standardized relative resource cost model for medical care: application to cancer control programs. *J Natl Cancer Inst Monogr*. 2013;2013(46):106–116. [PubMed: 23962514]
25. Basu A, Manning WG. Estimating lifetime or episode-of-illness costs under censoring. *Health economics*. 2010;19(9):1010–1028. [PubMed: 20665908]
26. Manning WG, Basu A, Mullahy J. Generalized modeling approaches to risk adjustment of skewed outcomes data. *Journal of health economics*. 2005;24(3):465–488. [PubMed: 15811539]
27. Lavigne JE, Phelps CE, Mushlin A, Lednar WM. Reductions in individual work productivity associated with type 2 diabetes mellitus. *Pharmacoeconomics*. 2003;21(15):1123–1134. [PubMed: 14596631]
28. Vamos EP, Mucsi I, Keszei A, Kopp MS, Novak M. Comorbid depression is associated with increased healthcare utilization and lost productivity in persons with diabetes: a large nationally

- representative Hungarian population survey. *Psychosomatic medicine*. 2009;71(5):501–507. [PubMed: 19528291]
29. Hyun Kyung L, Lee SH. Depression, diabetes, and healthcare utilization: results from the Korean longitudinal study of aging (KLoSA). *Iranian journal of public health*. 2014;43(1):6. [PubMed: 26060674]
30. Cawley J, Rizzo JA, Haas K. The association of diabetes with job absenteeism costs among obese and morbidly obese workers. *Journal of occupational and environmental medicine*. 2008;50(5): 527–534. [PubMed: 18469621]
31. Pagano E, De Rosa M, Rossi E, et al. The relative burden of diabetes complications on healthcare costs: The population-based CINECA-SID ARNO Diabetes Observatory. *Nutrition, Metabolism and Cardiovascular Diseases*. 2016;26(10):944–950.
32. Rosella L, Lebenbaum M, Fitzpatrick T, et al. Impact of diabetes on healthcare costs in a population-based cohort: a cost analysis. *Diabetic Medicine*. 2016;33(3):395–403. [PubMed: 26201986]
33. Saha S, Gerdtham UG, Johansson P. Economic evaluation of lifestyle interventions for preventing diabetes and cardiovascular diseases. *Int J Environ Res Public Health*. 2010;7(8):3150–3195. [PubMed: 20948954]
34. Gosselin E, Lemyre L, Corneil W. Presenteeism and absenteeism: Differentiated understanding of related phenomena. *Journal of occupational health psychology*. 2013;18(1):75. [PubMed: 23276197]
35. Johns G Attendance dynamics at work: The antecedents and correlates of presenteeism, absenteeism, and productivity loss. *Journal of Occupational Health Psychology*. 2011;16(4):483. [PubMed: 21875212]
36. Johns G Presenteeism in the workplace: A review and research agenda. *Journal of Organizational Behavior*. 2010;31(4):519–542.
37. Aronsson G, Gustafsson K. Sick leave presenteeism: prevalence, attendance-pressure factors, and an outline of a model for research. *Journal of Occupational and Environmental Medicine*. 2005;47(9): 958–966. [PubMed: 16155481]

Table 1-

VBD Respondent Clinical and Demographic Characteristics by Diabetes Status

Table 1- VBD Respondent Clinical and Demographic Characteristics	Diabetes n= 266 (7.2%)	No Diabetes n= 3451 (92.8%)	p-value
Male	62 (23%)	690 (20%)	0.19
Age			
18–34	15 (6%)	658 (19%)	<0.01
35–44	47 (18%)	823 (24%)	
45–54	72 (27%)	1016 (29%)	
55–64	124 (47%)	883 (26%)	
65+	8 (3%)	71 (2%)	
Race			
White	189 (71%)	2887 (84%)	<0.01
Black	24 (9%)	136 (4%)	
Alaskan/Native American	7 (3%)	16 (0%)	
Asian	21 (8%)	197 (6%)	
Hawaiian/Pacific Islander	5 (2%)	29 (1%)	
Other/Unknown	20 (8%)	186 (5%)	
Hispanic	26 (10%)	203 (6%)	0.01
Marital Status			
Married or living with partner	170 (64%)	2496 (72%)	<0.01
Divorced, Separated or Widowed	74 (28%)	582 (17%)	
Never Married	22 (8%)	373 (11%)	
Children under age 18 living in home			
No children/Unknown	179 (67%)	2118 (61%)	0.01
1 child	48 (18%)	551 (16%)	
2 children	24 (9%)	567 (16%)	
3 or more children	15 (6%)	215 (6%)	
Annual household income			
\$50,000 or less	71 (27%)	618 (18%)	<0.01
\$50,000-\$99,000	134 (50%)	1402 (41%)	
\$100,000 or more	61 (23%)	1431 (41%)	
Union Membership	156 (59%)	1722 (50%)	0.01
Days Worked Per Week, Mean (Std)	4.82 (0.63)	4.74 (0.66)	0.06
Hours Worked Per Day, Mean (Std)	8.76 (3.41)	8.74 (2.97)	0.94
Physical activity at work			
Mostly Sitting, Standing or Walking	253 (95%)	3316 (96%)	0.13
Mostly Heavy Labor/Physically Demanding Work	10 (4%)	90 (3%)	
Don't Know/Aren't Sure/Unknown	3 (1%)	45 (1%)	
Work in Clinical Setting	106 (40%)	1541 (45%)	0.13

Table 1- VBD Respondent Clinical and Demographic Characteristics	Diabetes n= 266 (7.2%)	No Diabetes n= 3451 (92.8%)	p-value
Smoking Status			
Current Smoker	30 (11%)	275 (8%)	0.03
Former Smoker	72 (27%)	786 (23%)	
Never Smoked/Unknown	164 (62%)	2390 (69%)	
Years Enrollment in current Health Plan, Mean (Std)	7.52 (1.01)	7.35 (1.21)	0.01
Total Monthly Healthcare Costs (2010), Mean (Std)	1298.1 (8947.05)	636.16 (3286.89)	<0.01

¹ Chi-squared tests for all categorical variables and T-tests for continuous variables

² Perneger scoring method³⁷: Impute missing items with population mean for that site and year. Scale missing if >3 items require imputation

Table 2-

Lost productivity by diabetes status, hours per week

	Diabetes n= 266	No Diabetes n= 3,451	Adjusted ³ Difference	
Productivity Measures ¹	Mean ³ (95% CI)	Mean ³ (95% CI)	Mean Difference (95% CI)	p-value
Absenteeism	1.24 (0.74, 1.74)	1.10 (0.97, 1.24)	0.14 (−0.38, 0.65)	0.60
Presenteeism	1.11 (0.87, 1.35)	0.69 (0.62, 0.75)	0.42 (0.17, 0.67)	<0.01
LPT ²	2.35 (1.77, 2.93)	1.79 (1.63, 1.95)	0.56 (−0.05, 1.17)	0.07

¹ Each productivity measure represents the number of lost hours per week

² LPT=Lost Productive Time

³ Marginal mean, computed from generalized linear model with identity link and normal errors, adjusted for age, gender, race, ethnicity, annual household income, marital status, number of children <18 years of age, union membership, work environment (clinical or administrative), work schedule (including days worked per week and hours worked per day), coinsurance, smoking status, self-reported physical activity, and total number of years enrolled in health plan.

Table 3-

Odds Ratio for report of lost productivity, related to diabetes

Table 3 – Estimation of Productivity Measures among Diabetic Respondents compared to Non-Diabetic Respondents						
	Diabetes N= 266	No Diabetes N= 3,451	Unadjusted		Adjusted ²	
	n (%)	n (%)	OR ¹ (95% CI)	p-value	OR ¹ (95% CI)	p-value
Absenteeism	43 (16.2%)	443 (12.8%)	1.31 (0.93, 1.84)	0.13	1.23 (0.86, 1.76)	0.25
Presenteeism	113 (42.5%)	1097 (31.8%)	1.59 (1.23, 2.04)	<0.01	1.77 (1.36, 2.31)	<0.01
Lost Productivity Time	120 (45.1%)	1248 (36.2%)	1.45 (1.13, 1.87)	<0.01	1.54 (1.17, 1.99)	<0.01

¹ Odds ratio, with respondents without diabetes as the referent group

² Adjusted for age, gender, race, ethnicity, annual household income, marital status, number of children <18 years of age, union membership, work environment (clinical or administrative), work schedule (including days worked per week and hours worked per day), coinsurance, smoking status, self-reported physical activity, and total number of years enrolled in health plan.

Table 4-

Monthly Average Total Healthcare Utilization Costs Paid of Diabetic Respondents compared to Non-Diabetic Respondents (2010–2013)

	No Diabetes Total Costs (\$US)	Diabetes Total Costs (\$US)	Cost Difference Costs (\$US)	p-value
Unadjusted Average Total Costs	634 (596, 675)	1230 (1074, 1409)	596 (478, 734)	<0.01
Adjusted Average Total Costs²	539 (435, 669)	1007 (786, 1290)	468 (351, 621)	<0.01

¹ Difference in cost difference based on log values.

² Adjusted for age, gender, race, ethnicity, education, annual household income, marital status, number of children <18 years of age, union membership, work environment (clinical or administrative), work schedule (including days worked per week and hours worked per day), physical health and mental health composite scores, smoking status, and self-reported physical activity.

Table 5-**Aggregate Lost Productivity Cost Analysis Estimate for Employer**

	Absenteeism	Presenteeism	Lost Productive Time
Difference in lost productivity ¹ (hours/week/employee)	0.14	0.42	0.56
Total hours lost due to diabetes ²			
Per week (hours)	10.1	30.2	40.3
Annual (hours per 52 weeks)	524.2	1572.5	2096.6
Total Annual Employer Indirect Costs of diabetes due to Lost Productivity Time ^{3,4}	\$15,738	\$47,215	\$62,953

¹ For those with diabetes, relative to those without diabetes, see table 2

² Based on a population of 1000 employees, with a 7.2% prevalence of diabetes.

³ Based on 2014 Bureau of Labor Statistics average mean hourly wage (\$32.81) for job titles and descriptions in VBD HR Cohort.

⁴ Inflated to \$US 2016 at 3%