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Secondary prevention of diabetes through workplace health screening

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Background	Workplace health screening offers a unique opportunity to assess individuals for type 2 diabetes mellitus.
Aims	To evaluate the association between workplace diabetes screening, subsequent diagnosis and changes in fasting plasma glucose (FPG), glycated haemoglobin (HbA1c) and body mass index (BMI) among individuals who screened positive for diabetes.
Methods	Employees without a prior diagnosis of diabetes participated in workplace health screening by 45 employers throughout the USA. Individuals screened positive for diabetes based on standard criteria (≥126 mg/dL FPG or ≥6.5% [48 mmol/mol] HbA1c). Diabetes diagnoses were identified after screening using claims-based ICD9-CM diagnosis codes. Discrete-time survival analysis estimated the monthly rate of new diabetes cases after screening, relative to the time period before screening. Paired *t*-tests evaluated 1-year changes in blood glucose measures and BMI among individuals with positive screenings.
Results	Of 22 790 participating individuals, 900 (4%) screened positive for diabetes. A significantly greater rate of new diabetes diagnoses was observed during the first month after screening, compared to the 3-month period before screening (odds ratio [OR] 2.65, 95% confidence intervals [CIs] 2.02–3.47). Among 538 individuals with diabetes who returned for workplace screening 1 year later, significant improvements were observed in BMI (mean ± SD = −0.63 ± 2.56 kg/m^2, $P < 0.001$) and FPG levels (mean ± SD = −9.3 ± 66.5 mg/dL, $P < 0.01$).
Conclusions	Workplace screening was associated with a reduction in the number of undiagnosed employees with diabetes and significant improvement in FPG and BMI at 1-year follow-up.
Key words	Diabetes; secondary prevention; workplace health screening.

Introduction

The prevalence of type 2 diabetes mellitus is rapidly increasing in the USA. There has been a nearly 2-fold increase in the past 10 years, with over 20 million adults currently diagnosed [1]. The health and economic burden of type 1 and type 2 diabetes is substantial, placing an increasing burden on limited healthcare resources. Costs from medical expenditure and reduced productivity exceed $245 billion (£182 billion), with one in five healthcare dollars in the USA spent on diabetes patients [2]. The largest components of diabetes-related medical cost are hospital care (43%), prescription drugs used to treat diabetes-related complications (18%), anti-diabetic agents and diabetes supplies (12%), physician office visits (9%) and residential facility stays (8%). For employed populations, indirect costs attributed to diabetes include increased absenteeism ($5 billion; £3.7 billion) and reduced productivity at work due to reasons other than absenteeism ($20.8 billion; £15.5 billion). For those not in the labour force, diabetes-related costs include reduced productivity ($2.7 billion; £2.0 billion), inability to work resulting from a disease-related disability ($21.6 billion; £16 billion) and lost productive capacity due to early mortality ($18.5 billion; £13.8 billion) [2]. Moreover, diabetes is the leading cause of kidney failure and blindness among adults, and the seventh leading cause of death in the USA [3].

Guidelines for diabetes screening from the American Diabetes Association and the US Preventive Services Task Force recommend screening targeted at high-risk groups, such as individuals at least 45 years of age, or adults with hypertension [4,5]. Despite the serious potential consequences of undiagnosed diabetes, less than half of high-risk adults report being screened in the past 3 years [6]. Moreover, although barriers to healthcare access can prevent an individual from being screened or diagnosed, even those with health insurance may not seek recommended screening. Approximately one quarter of insured individuals in the USA with diabetes remain undiagnosed [7].

Diabetes screening may confer health benefits for individuals as well as cost savings for the healthcare system. The effect of screening itself is difficult to directly study in a randomized trial for ethical reasons. However, a simulated study based on a randomized trial of intensive therapy in screen-detected diabetes suggested significant benefits from the early detection and treatment of hyperglycaemia and cardiovascular risk factors [8]. Additionally, higher survival rates have been reported in individuals with diabetes diagnosed during the asymptomatic stage, as compared with individuals diagnosed while symptomatic. Furthermore, early detection has been shown to be associated with lower long-term healthcare costs [9].

Widespread screening may capture more undiagnosed individuals with diabetes and diabetes risk factors [9]. For employed individuals, free or low-cost workplace health screening can be a convenient means to assess risk of diabetes, removing some barriers to healthcare access, such as transportation, operating hours of healthcare facilities, awareness of health resources, patient education and cost [10]. Although workplace screening is becoming increasingly common, few studies have evaluated the effectiveness of widespread diabetes screening in the workplace. Therefore, our objectives were to evaluate: (i) the association between diabetes identification at workplace screening and subsequent claims-based diagnosis and (ii) 1-year changes in fasting plasma glucose (FPG), glycated haemoglobin (HbA1c) and body mass index (BMI) among individuals who screened positive for diabetes.

Methods

The US healthcare system is a hybrid system without universal coverage. Most employees and their families receive health insurance from their employer. The employer pays ~70–80% of the premium, while the employee pays the remainder. Low-income individuals can receive coverage through Medicaid, a joint federal and state programme; each state has the option to charge premiums and establish cost-sharing requirements for enrollees. These costs may include co-payments, co-insurance, deductibles and other similar charges. For individuals 65 years and older, healthcare coverage is provided through a federal programme called Medicare; cost sharing depends upon the type of Medicare coverage [11].

Data in this study were from employees of 45 companies comprising a diverse group of industries located throughout the USA. All employers were self-insured and, therefore, responsible for managing health plans in addition to bearing financial risk. All claims data were provided directly by the health plans. The study sample included individuals with FPG or HbA1c measurements during workplace screening between 1 January 2012 and 31 December 2014. Individuals were continuously enrolled in their healthcare plan from 15 months before, through 3 months after the screening date (Figure 1).

Workplace screenings were conducted by licensed clinical staff from Health Advocate, a manager of screening programmes and other services for small- to large-sized employer groups. Levels of FPG or HbA1c were measured from finger stick or venepuncture samples. Present literature indicates suitable accuracy of both finger stick and venepuncture samples in estimating blood glucose in patients [12]. Individuals were considered to have screened positive for diabetes based on standard criteria from the American Diabetes Association (FPG ≥ 126 mg/dL or HbA1c ≥ 6.5% [48 mmol/mol]). Screening results were provided to participants in the form of a personal report and individuals were offered educational materials or physician referrals based on their results.

Covariates were chosen *a priori* based on risk factors either known to be, or plausibly associated with, diabetes in prior literature. These included age, gender and BMI (kg/m^2). Although information on race and education was not directly available in the data, postal code was utilized to estimate these inputs. This information was used as a proxy for socio-economic status (SES), using data from the 2013 American Community Survey 5-year estimates [13]. Race was based on the percent of individuals of each race in a given postal code area (non-Hispanic White, African American, Asian/Pacific Islander, Other). Education was estimated using the mean number of years of education for individuals within a postal code area.

Diabetes diagnosis in the claims data was based on the presence of at least one International Classification of Diseases, Ninth Revision (ICD-9) diagnosis code for diabetes (250.xx, 357.2x, 362.0x, 366.41, 648.0x). Prediabetes (790.21, 790.22 and 790.29), hyperlipidaemia (272.0–272.4) and hypertension (401.0–401.9) were measured similarly based on ICD-9 diagnosis codes.

Bivariate analyses were conducted using chi-square tests for categorical variables, one-way analysis of variance for normally distributed continuous variables and Kruskal–Wallis tests for non-normal continuous variables. To evaluate association between workplace screening and subsequent diabetes diagnosis, discrete-time survival analysis was used. Incidence was calculated for six 30-day intervals,

the first of which began 90 days before screening. Three odds ratios (ORs) were estimated, each approximating the incidence rate of a diabetes diagnosis for 1-month periods after screening (month 1, month 2, month 3), contrasted with the combined 3-month period before screening. For individuals with multiple screenings, only the first screening was used. Two models were assessed: a model adjusted for demographic factors (age, gender), and a full model, further adjusted for zip code-level variables (education, race), BMI, hypertension, hyperlipidaemia and employer. A random effect for postal code was used to account for correlation of residuals from geographic clustering, and to improve estimates of standard errors when using aggregate data. Additional descriptive statistics using paired *t*-tests were conducted to evaluate any changes in FPG, HbA1c and BMI among a subset of individuals who attended a second workplace screening 1 year after the first screening. All analyses were performed using SAS 9.4 (SAS Institute Inc., Cary, NC). This study was conducted using data obtained in compliance with the Health Insurance Portability and Accountability Act of 1996 and is therefore exempt from institutional review board review. Data were used with permission from selected self-insured employers.

Results

Of the 26 046 individuals who met the enrolment criteria, 2769 had a history of diabetes or pre-diabetes in the 12 months prior to the observation period, which was defined as 3 months prior to, and after, the screening date. Six had a history of gestational or steroid-induced diabetes, 109 were missing postal code information and 5 were younger than 18 years of age, resulting in a final sample of 22 790 participants.

Characteristics of the 22 790 individuals in the study population are presented in Table 1. The mean age was 45.0 ± 11.0 years and women made up 51% of the population. A total of 900 (4%) individuals without a prior history of diabetes screened positive for diabetes. On average, these individuals were significantly more likely to be older, male, have a higher BMI and less likely to have a history of hyperlipidaemia than individuals without diabetes. Screening positive for diabetes was also significantly associated with having fewer years of education, a higher probability of being classified as a non-Hispanic White, and a lower probability of being classified as Asian/Pacific Islander or African American. Among these individuals, mean FPG was 164.6 ± 63.8 mg/dL and mean HbA1c was 8.3 ± 6.6% (67 ± 49 mmol/mol). For individuals who did not screen positive for diabetes, mean levels were 91.0 ± 10.5 mg/dL for FPG, and 5.5 ± 0.3% (37 ± 3.3 mmol/mol) for HbA1c.

Table 2 reports the association between workplace screening and rates of new claims-based diabetes diagnoses after screening. Only results from the full model are described here, as results were similar between the demographic-adjusted model and the full model adjusted for age, gender, education, race, BMI, hypertension and

Table 1. Sample characteristics (n = 22 790)

	Screening status		
	Normal glucose (n = 21 890)	Screened positive for diabetes[a] (n = 900)	P-value
Individual-level characteristics			
Age, years, mean ± SD	44.8 ± 11.0	50.0 ± 9.8	***
Female, n (%)	11 087 (51)	320 (36)	***
BMI, kg/m^2, mean ± SD	28.3 ± 6.0	33.3 ± 7.2	***
Hypertension, n (%)[b]	2674 (12)	118 (13)	NS
Hyperlipidaemia, n (%)[b]	3307 (15)	106 (12)	**
Zip code-level characteristics			
Education, years, mean ± SD	13.5 ± 1.1	13.1 ± 1.0	***
Race, % (IQR, %)			
Non-Hispanic White	77 (56, 87)	78 (58, 91)	**
African American	4 (1.2, 12.7)	2.8 (1, 12)	***
Asian/Pacific Islander	3 (1.0, 6.0)	1 (1, 4)	***
Hispanic	7 (3, 16)	7 (3, 17)	NS
Other	2 (1, 3)	2 (1, 3)	NS
Blood glucose measures			
FPG (mg/dL)	91.0 ± 10.5	164.6 ± 63.8	***
HbA1c (%)	5.5 ± 0.3	8.3 ± 6.6	***
HbA1c (mmol/mol)	37 ± 3.3	67 ± 49	

IQR, interquartile range; NS, not significant.
[a]Defined as a FPG level of ≥126 mg/dL or HbA1c level of ≥6.5% (48 mmol/mol).
[b]Twelve-month claims history.

hyperlipidaemia. As seen in Figure 2, there was a marked increase in diabetes diagnoses after screening among all individuals. Furthermore, there was a significantly higher rate of new diabetes diagnoses (OR [95% CI]: 2.65 [2.02–3.47]) in the first month after workplace screening, compared with the 3-month period before screening.

Among individuals who screened positive for diabetes, rates of new claims-based diagnoses significantly increased during the first month after screening, compared with the 3-month period before screening (OR 6.40 [2.40–17.11]). Reflecting the post-screening depletion of at-risk individuals, rates of new diagnoses for the second and third months gradually decreased and did not significantly differ from the period prior to screening.

For individuals who did not have an elevated FPG or HbA1C at screening, the magnitude of the post-screening diagnostic difference was smaller and not significant (month 1 versus 3 months prior to screening = OR 1.41 [0.94–2.11]). Since this subgroup did not include individuals who screened positive for diabetes, the small at-risk population depleted rapidly, as evidenced by the significantly lower rate of new diagnoses in the second month, compared with the 3-month period prior to screening (OR 0.53 [0.29–0.95]). In the third month, the rate of diabetes diagnosis was no longer significant and began to return to the pre-screening rate (OR 0.69 [0.41–1.17]).

Among the 900 individuals who had diabetes at screening, 538 (60%) had a second workplace screening ~1 year later. Individuals with a second screening were significantly less likely to have a medical claims history of hypertension and hyperlipidaemia, more likely to be classified as White or Other race, and less likely to be classified as African American, Asian/Pacific Islander or Hispanic (Table 3). At the second screening, significant decreases were observed for both mean BMI (mean ± SD = −0.63 ± 2.56 kg/m^2, $P < 0.001$) and FPG levels (mean ± SD = −9.3 ± 66.5 mg/dL, $P < 0.01$). Mean changes for HbA1c were not significant.

Table 2. Association between workplace screening and claims-based diabetes diagnosis after screening

	OR (95% CI)[a]	
	Model 1[b]	Model 2[c]
All individuals (n = 22 790)		
Month 1 after screening	2.64 (2.01–3.45)	2.65 (2.02–3.47)
Month 2	0.83 (0.56–1.24)	0.83 (0.56–1.24)
Month 3	0.83 (0.56–1.24)	0.84 (0.56–1.24)
Individuals with diabetes at screening (n = 900)		
Month 1	5.81 (2.19–15.41)	6.40 (2.40–17.11)
Month 2	1.83 (0.45–7.46)	1.91 (0.47–7.86)
Month 3	1.50 (0.39–5.71)	1.56 (0.41–6.00)
Individuals without diabetes at screening (n = 21 890)		
Month 1	1.41 (0.94–2.11)	1.41 (0.94–2.11)
Month 2	0.53 (0.29–0.95)	0.53 (0.29–0.95)
Month 3	0.69 (0.41–1.17)	0.69 (0.41–1.17)

[a]Represents odds of a diabetes diagnosis in each month after screening compared with the 3-month period before screening.
[b]Adjusted for age and gender.
[c]Adjusted for age, gender, education, race, BMI, hypertension, hyperlipidaemia and employer.

Discussion

This study found that workplace screening for diabetes was associated with a subsequent increase in claims-based diabetes diagnoses. Noticeably, there was a marked increase in diabetes diagnosis in the first month after the screening which tapered off to the pre-screening baseline level by the third month, thereby suggesting a brief but significant association between workplace diabetes screening and physician visits for diabetes. Additionally, individuals who screened positive for diabetes and returned for screening had significant improvements in BMI and FPG levels 1 year later. For individuals without elevated levels of either FPG or HbA1C at screening, a small, non-significant increase in claims-based diabetes diagnoses was observed. Most individuals with a diabetes diagnosis after screening were those who screened positive for diabetes.

Strengths of this study include the large sample size of employees in various industries and regions of the USA. A majority of prior studies have evaluated either diabetes screening rates in workplace screenings or effectiveness of interventions on measures of blood glucose, but few have evaluated both objectives in the same population.

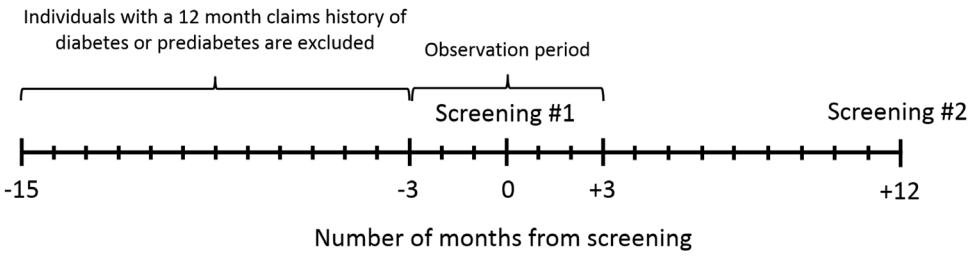

Figure 1. Timeline for study objectives. For Objective 1, new cases of hyperlipidaemia were monitored for a 6-month observation period (3 months before and after screening), using the 12 months prior to this observation period to identify and exclude individuals with a history of hyperlipidaemia. For Objective 2, individuals were followed up for 1 year until a second workplace screening.

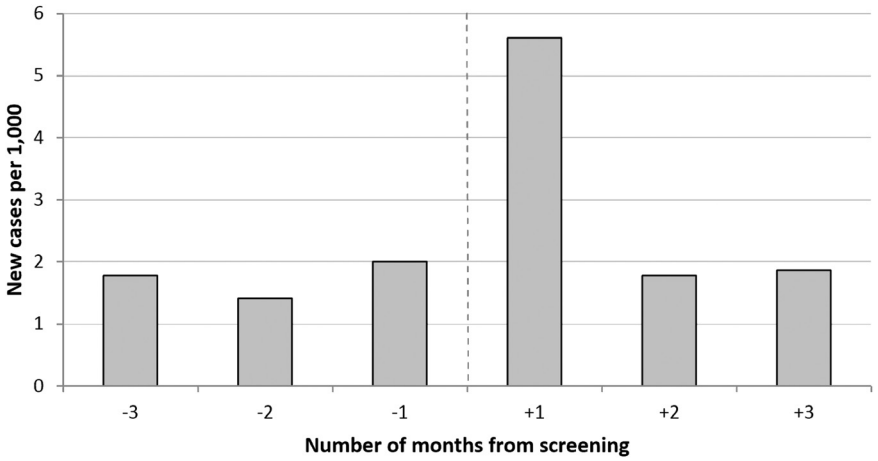

Figure 2. New claims-based diabetes diagnoses among all individuals without a prior diagnosis in the 12 months before the observation period shown in Figure 1.

Table 3. Differences between diabetic individuals with and without follow-up screening (n = 900)[a]

	Individuals without follow-up screening (n = 362)	Individuals with follow-up screening (n = 538)	P-value
Individual-level characteristics			
Age, years, mean ± SD	49.2 ± 10.4	50.5 ± 9.3	<0.05
Female, n (%)	120 (33)	200 (37)	NS
BMI, kg/m^2, mean ± SD	32.7 ± 6.8	34.0 ± 7.6	NS
Hypertension, n (%)[b]	67 (18)	51 (10)	<0.001
Hyperlipidaemia, n (%)[b]	62 (17)	44 (8)	<0.001
Zip code-level characteristics			
Education, years, mean ± SD	13.1 ± 1.0	13.1 ± 0.9	NS
Race, % ± median, %			
Non-Hispanic White	66 ± 27	74 ± 24	<0.001
African American	11 ± 16	8 ± 14	<0.001
Asian/Pacific Islander	4 ± 7	3 ± 6	<0.001
Hispanic	16 ± 19	13 ± 16	<0.01
Other	2 ± 2	3 ± 3	<0.05

[a]Includes non-missing values only.
[b]Twelve-month claims history.

Although some studies have assessed healthcare utilization after a diabetes diagnosis, to our knowledge, none have assessed utilization after screening.

This study has some limitations. Participant bias may skew the study findings. The coefficients of variation for the mean FPG are vastly different between the first and second screening. An examination of employees who returned for the second screening revealed lower rates of hypertension and hyperlipidaemia than their counterparts, suggesting that participants who returned for a second screening may constitute primarily those who are either able or are motivated to appropriately care for their overall health. Future studies with complete follow-up data are needed to ascertain the long-term effect of diabetes screening, if any, on clinical outcomes. As an observational study using claims data, there may be unmeasured and residual confounding. Also, use of workers' postal codes as a proxy for the employee's race and education may not be accurate for an employed population. Additionally, the study population comprised employees from self-insured employers, which could limit generalizability. Lastly, there may be selection bias, as the study population comprised individuals who volunteered for screening, and therefore, may be more likely to engage in health-promoting behaviours than their counterparts.

The incidence of diabetes in this study was 4%. Past literature indicates that diabetes incidence varies from 1 to 7% in commercially insured populations [14,15]. Few studies have evaluated associations between workplace diabetes screening and related outcomes among individuals with diabetes. The collective findings from these studies are mixed [16–19], and an accurate comparison may be difficult due to differences in study design.

As current diabetes guidelines recommend targeted screening, questions remain regarding the role of population-level screening. However, workplace diabetes screening is typically integrated into a more comprehensive screening programme, measuring other biometric risk factors for hypertension, hyperlipidaemia and obesity. Consultation regarding screening results is typically provided and often integrated into a wellness programme [20]. Therefore, workplace diabetes screening must be evaluated in the context of the larger programme. In fact, levels of FPG and HbA1c are not only useful as a screening tool for diabetes, but also may be independently associated with other adverse health conditions such as coronary artery disease [21], atherosclerosis [22] and metabolic syndrome.

There are concerns that most at-risk individuals might not screen positive for diabetes owing to the high specificity of the diabetes screening tests [23]. This large pool of individuals may adopt unhealthy behaviours due to false reassurance of low diabetes risk. However, randomized trials of diabetes screening show little evidence of long-term harm among those who screen negative [24]. Alternatively, there may be psychological distress from screening positive for diabetes, although a prior study suggests these concerns are unwarranted [25]. Regardless, it is important to properly communicate that the single measure of blood glucose can be suggestive of diabetes but does not serve as its diagnosis.

Studies evaluating cost-effectiveness of population-level diabetes screening suggest inconsistent findings [26–28]. However, cost-effectiveness of population-level screening may be underestimated as most of these studies did not consider indirect costs particularly relevant to employers, such as costs from decreased productivity and absenteeism. Moreover, workplace wellness programmes are more consistently associated with positive returns on investment and decreases in direct medical costs and absenteeism [29]. Therefore, self-insured employers may have financial incentives to implement workplace screening. Lastly, as average participation rates in workplace screening are around 46% [20], an increase in participation rates may also increase cost-effectiveness, as individuals not participating in screenings may be at higher risk for diabetes [30] and therefore benefit the most from screening and subsequent intervention.

Workplace health screening in an insured population was associated with a subsequent increase in physician visits with diagnoses for diabetes. Individuals who screened positive for diabetes demonstrated an improvement in BMI and plasma glucose levels after 1 year, although not all employees returned for follow-up. Future studies are needed to evaluate strategies to increase participation rates and to assess the long-term cost-effectiveness of workplace diabetes screenings.

Key points

- Workplace screening for diabetes was associated with a subsequent increase in claims-based diabetes diagnoses in the first month after screening.
- This study demonstrates the real-world benefits of workplace screening in encouraging individuals to seek care and initiate prevention efforts.
- Workplace screening may be associated with improved clinical and other health outcomes among the working population.

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Competing interests

V.B. and I.Y. are employed by West Corporation. Health Advocate is a subsidiary of the West Corporation.

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