



Published in final edited form as:

*J Occup Environ Med.* 2015 November ; 57(11): 1147–1153. doi:10.1097/JOM.0000000000000548.

## Employer-Based Screening for Diabetes and Prediabetes in an Integrated Health Care Delivery System: A Natural Experiments for Translation in Diabetes (NEXT-D) Study

Sara R. Adams, MPH<sup>1</sup>, Deanne M. Wiley, BA<sup>1</sup>, Andromache Fargeix, MPA<sup>2</sup>, Victoria George, MA, MPH<sup>2</sup>, Romain S. Neugebauer, PhD<sup>1</sup>, and Julie A. Schmittdiel, PhD<sup>1</sup>

<sup>1</sup>Division of Research, Kaiser Permanente Northern California, Oakland, CA

<sup>2</sup>Customer Analytics and Reporting, Kaiser Permanente, Program Offices, Oakland, CA

### Abstract

**OBJECTIVE**—To evaluate an employer-based diabetes/prediabetes screening intervention that invited at-risk employees via letters, secure emails, and automated voice messages to complete blood glucose testing at a health plan facility.

**METHODS**—Quasi-experimental cohort study among health plan members insured by two employers that received the intervention and three employers that were selected as control sites.

**RESULTS**—The proportion of at-risk members that completed a screening was higher in the intervention group than in the control group (36% vs. 13%,  $P < .001$ , adjusted for patient characteristics). Among those screened in the intervention group, the presence of obesity, hypertension, hyperlipidemia, and tobacco use were significant predictors of having a result which indicated diabetes or prediabetes ( $P < .05$ , all comparisons).

**CONCLUSIONS**—A low-intensity, employer-based intervention conducted in collaboration with a health care delivery system effectively increased screening for diabetes/prediabetes.

Over 8 million people in the United States have undiagnosed diabetes.<sup>1</sup> In 2010 over 70 million people were unaware that they had prediabetes, a condition characterized by elevated blood glucose levels and an increased risk of developing type 2 diabetes.<sup>2</sup> In order to reduce those numbers, the American Diabetes Association (ADA) and U.S. Preventive Services Task Force (USPSTF) recommend screening asymptomatic adults age 45 years or older and younger adults with risk factors such as being overweight, having hypertension, or having a first-degree relative with diabetes.<sup>3,4</sup> Early detection of diabetes is advantageous because ongoing treatment and support can reduce the risk of long-term complications.<sup>3</sup> For patients with prediabetes, there is mounting evidence that intensive lifestyle interventions can delay or even prevent the onset of type 2 diabetes.<sup>5-8</sup>

**Corresponding Author:** Sara R. Adams, MPH, Division of Research, Kaiser Permanente Northern California, 2000 Broadway, Oakland, CA 94612, Telephone: 510.891.3133; Fax: 510.891.3606; Sara.R.Adams@kp.org.

**Conflicts of Interest:** For the remaining authors none were declared.

While more extensive screening will improve the recognition of diabetes and prediabetes, the issue of follow-up care provides challenges. Identifying diabetes and prediabetes requires a blood glucose test that can be administered by screening programs even outside of the primary care setting. Community-based screening programs have occurred in churches, community centers, dental offices, and pharmacies.<sup>9-11</sup> Similarly, many employee wellness programs provide biometric health screening, including blood glucose testing for diabetes, at the worksite.<sup>12, 13</sup> However, these community- and workplace-based screenings may be poorly targeted (i.e. testing those at low risk) and may not provide the appropriate follow-up care to patients with a positive screen.<sup>3, 9-11</sup> Furthermore, as sharing the screening results with primary care physicians is desirable but logistically challenging,<sup>14</sup> employer-based screening may not activate the health system to provide treatment to patients found to have diabetes or prediabetes. Due to these issues with appropriate testing and follow-up, the ADA maintains that screening should be performed within a health care setting.<sup>3</sup>

The purpose of this paper is to evaluate an employer-based intervention to increase screening for diabetes and prediabetes by inviting at-risk employees to voluntarily report to their health care provider for a blood glucose test. This novel approach, conducted as partnership between two employers and an integrated health care delivery system, allowed for the screening to take place within the health care setting and for the employees' primary care physicians to have access to the results. This low-intensity screening intervention did not provide follow-up care directly, but instead relied on the usual care of the health system to respond to newly identified cases of diabetes and prediabetes.

## Research Design and Methods

### Study design

In 2012, Kaiser Permanente Northern California (KPNC) and two employers implemented a diabetes/prediabetes screening program that provided direct outreach to employees who were at-risk for diabetes or prediabetes. To evaluate the screening program, we conducted a quasi-experimental cohort study<sup>15</sup> that compared the two participating employer sites (i.e., the intervention group) with employer sites that were not part of the intervention (i.e., the control group) on the proportion of at-risk employees who were screened within six months and the proportion of the screened who had elevated blood glucose levels. We selected three non-participating employers as control sites based on their similarity to the intervention sites with regard to industry (public university and county agency) and employee characteristics (mean age, gender, and diabetes prevalence). Both groups received the usual care provided by the health plan, both in terms of blood glucose testing and follow-up care for patients with diabetes or prediabetes. These analyses were conducted as part of the Natural Experiments for Translation in Diabetes (NEXT-D) Study and approved by the KPNC Institutional Review Board.

### Study setting and population

This study was conducted among the current or retired employees of two state universities and three county-level government agencies in Northern California who obtained employer-provided health coverage through KPNC. KPNC is a nonprofit integrated health care

delivery system of 48 medical facilities that provides comprehensive medical care to over 3.5 million members. KPNC members are broadly representative of the local and statewide population.<sup>16</sup>

### Eligibility/ineligibility

Employees were found to be at-risk for diabetes/prediabetes and included in the study if they met at least one of the following criteria: (a) aged 45 or older and had not had a fasting plasma glucose (FPG) test in the past five years, (b) BMI > 25 kg/m<sup>2</sup> and had not had an FPG test in the past five years, or (c) listed on the KPNC hypertension registry and had not completed an FPG test in the previous year. The risk criteria incorporated several elements of the ADA<sup>17</sup> and USPSTF<sup>18</sup> screening criteria that were current at the time, but focused on factors available in the electronic health record (EHR). Members were ineligible if they were less than 18 years old or were already known to have diabetes as indicated by being listed on the KPNC diabetes registry. Age, BMI, and FPG testing status were determined via the EHR. The KPNC diabetes and hypertension registries are created using EHR clinical data (e.g., labs, ICD9 codes, prescriptions, etc.) but are stand-alone databases maintained by the health plan. Members were included in the diabetes registry if they had two or more outpatient diabetes diagnoses or one or more inpatient or emergency department diagnoses, or they were on diabetes medications, except metformin alone, in the previous two years. Members were included in the hypertension registry if they had either two primary care diagnoses of hypertension or a combination of a primary care hypertension diagnosis and a hypertension medication, inpatient hypertension diagnosis, or stroke-related hospitalization in the previous two years. The diabetes and hypertension registries are updated on a quarterly basis. In order to take into account the most recent data available in the EHR, we further excluded members in the intervention group (8%) and control group (7%) if they had any of the following indications of diabetes or prediabetes at any time in the year leading up to the intervention: impaired fasting glucose diagnosis (ICD9 code 790.21), any diabetes diagnosis (ICD9 code 250), A1c ≥ 5.7%, or any diabetes medication (metformin, insulin, sulfonylureas, or thiazolidinediones).

### Intervention

The screening program was developed by two employers and HealthWorks by Kaiser Permanente, a group that supports employers as they pursue workforce health efforts by providing consulting to develop health strategies and programs such as biometric screenings, health promotion classes, online wellness resources, and rewards programs.<sup>19</sup> While the screening program was expected to identify a small number of diabetes cases, the focus of the program was on the larger number of people expected to be identified with prediabetes. At-risk members in the intervention group received letters stating that they were due for a lab test to determine if their blood glucose levels were in the prediabetes range. The letter included lab instructions for the member to present at any KPNC lab to complete an FPG test. Laboratories in the KPNC system are located in the same medical facilities where patients receive care and do not require an appointment. The members were not charged a copay for the visit by the health plan. The letter also reminded the members to fast for 12 hours before completing the FPG test. The letter indicated that patients who know that their blood glucose level is in the prediabetes range may be motivated to take steps to prevent

developing diabetes. Members were also directed to a website that described KPNC resources to support healthy lifestyles, such as telephonic health coaching provided by the KPNC Wellness Coaching Center,<sup>20</sup> online wellness resources, and in-person weight management classes. The letter was written in English or Spanish according to the member's primary language. It was printed on KPNC letterhead, and the printed signature was that of the member's primary care physician. The employer was not listed on the letter, and individual-level responses to the intervention were not reported to the employer by KPNC. The same message was sent via secure email to members who utilized online access to their medical record through [kp.org](http://kp.org). The members who had not completed an FPG or A1c test one month after the letters were sent also received an automated reminder call; those who had not completed a screening within three months received a reminder letter. As physicians may have used the A1c test to screen for diabetes/prediabetes in usual care, we used both FPG and A1c tests to establish who had completed a screening. While FPG and A1c tests have imperfect concordance for the diagnosis of diabetes,<sup>21</sup> the ADA guidelines allow for the use of either test and provide a range of values that indicate diabetes and prediabetes for both tests.<sup>3</sup>

In January 2013, the members who had tested in the prediabetes range (an FPG value between 100 and 125 mg/dL or an A1c value between 5.7 and 6.4%) were sent a letter from KPNC that informed them of their prediabetes status and instructed them to contact their primary care physician with questions. The letter also provided recommendations to be physically active, eat healthy foods, quit tobacco and offered resources to support them in their efforts (e.g., telephonic health coaching).<sup>20</sup>

### Statistical analyses

We compared the baseline characteristics of the intervention and control groups on age, gender, race/ethnicity, and utilization (number of primary care visits in previous year, and whether the patient had completed an FPG or A1c within five years). Using Census 2010 data, we also compared the two groups on geocoded education (the percentage of individuals aged 25 and older with a bachelor's degree in the Census block a patient lives in) and geocoded median household income (the median household income of the Census block a patient lives in). Lastly, we compared the groups on BMI, tobacco use, hypertension diagnosis (ICD9 code 401-405), systolic blood pressure  $\geq 140$  mmHg, hyperlipidemia diagnosis (ICD9 code 272), and having an abnormal cholesterol value (LDL  $\geq 130$ , triglycerides  $\geq 200$ , or HDL  $\leq 60$ ) in the previous year.

The primary outcome measure was the proportion of eligible persons in the intervention and control groups who were screened for diabetes/prediabetes in the six months after the intervention (September 2012 – March 2013). For both groups, the laboratory test had to be ordered by a physician or other care provider; the employees could not self-refer. In the intervention group, we also compared the three at-risk groups on the proportion who completed a screening. As members could qualify for more than one at-risk group, members were assigned to a group by the following hierarchy: listed on the hypertension registry and had not completed an FPG test in the previous year, BMI  $> 25$  kg/m<sup>2</sup> and had not had an FPG test in the past five years, aged 45 or older and had not had an FPG test in the past five

years. In addition, we report the proportion that had blood glucose values in the prediabetes range (defined as above) or diabetes range (defined as an FPG > 125mg/dl or A1c > 6.4%) in the six-month observation period. While not a primary outcome of this intervention, we also examined the rate of follow-up among the members in the intervention group who had a positive screen for prediabetes or diabetes and who had continuous health plan enrollment for the following year. We examined the EHR data for a record of a repeated blood glucose test (FPG or A1c), a diabetes or impaired fasting glucose diagnosis (ICD9 code 250 or 790.21, respectively), a related clinical progress note (e.g. a clinical note referring to prediabetes, diabetes, health behavior, and self-management), or a referral to or participation in a related KPNC service (e.g. in-person lifestyle class, telephonic health coaching, or nutritional counseling) in the year following the elevated lab.

Two sample *t* tests and Pearson chi-square tests of independence were used to compare the intervention and control groups on baseline characteristics and study outcomes. In order to compare the primary outcome in the two groups while adjusting for potential differences in baseline characteristics, we performed a logistic regression model with the following independent variables: indicator for the intervention/control group, age, gender, race/ethnicity, FPG/A1c within 5 years, number of primary care visits in previous year, geocoded education, geocoded income, BMI, tobacco use, hypertension diagnosis, high systolic blood pressure ( $\geq 140$  mmHg), hyperlipidemia diagnosis, and abnormal cholesterol levels (LDL  $\geq 130$ , triglycerides  $\geq 200$ , or HDL  $\leq 60$ ). To examine the baseline characteristics associated with responding to this outreach method, we implemented a multivariate relative risk model for predicting screening adjusting for the baseline characteristics described above among the patients in the intervention group with non-missing covariates. Since the outcome was not rare, a modified Poisson regression was used to estimate risk ratios, rather than using a logistic regression to estimate the odds ratios.<sup>22-24</sup> We also evaluated and ranked the relative importance of each individual patient characteristic (e.g. age or race) in predicting the diabetes or prediabetes risk of patients in the intervention arm. Since we did not know the diabetes or prediabetes status of everyone in the intervention arm because not all members in the intervention arm were screened, we implemented inverse probability of treatment and censoring weighted estimation of variable importance.<sup>25-28</sup> This approach aims to evaluate the independent impact of each individual baseline characteristic by controlling for, not only, potential confounding from all other remaining baseline characteristics, but also, potential selection bias<sup>29</sup> due to differential screening rates. All tests were two-sided with an alpha level of 0.05 to determine statistical significance. SAS software version 9.3 (SAS Institute Inc., Cary, NC) was used for all data management and analysis.

## Results

A total of 684 members at the intervention sites and 1,050 members at the control sites met the inclusion criteria for being at-risk and were included in the analysis. The intervention and control groups had similar mean age (51 vs. 53 years,  $P = .06$ ), gender distribution (56% female vs. 53%,  $P = .15$ ), prevalence of overweight/obesity (75% vs. 74%,  $P = .18$ ), and prevalence of hypertension (35% vs. 35%,  $P = .76$ , Table 1). The intervention and control groups had significant differences in race/ethnicity (53% vs. 73% White,  $P < .001$ ),

geocoded education (see Table 1 for distribution,  $P < .001$ ), and geocoded Census block-level annual household income (47% with \$80,000 or more vs. 35%,  $P < .001$ ).

In the six months following the outreach, the proportion of patients who came in for screening was significantly higher in the intervention group than in the control group. More than a third (36%) of the members in the intervention group were screened with an FPG or A1c test, compared to 13% in the control group ( $P < .001$ , adjusted for patient characteristics, Figure 1). We also examined the screening rates in the intervention group stratified by the three risk-based criteria used to identify members for this study. The group that had hypertension and no FPG within one year came in for screening at a higher rate (64%) than the groups who had not had an FPG within five years and who were aged 45 (21%) or who had BMI > 25 (23%,  $P < .001$ , Figure 1).

Among the screened, approximately one third of both the intervention and control groups had a FPG or A1c value in the prediabetes range (33% vs. 34%,  $P = .68$ , adjusted for patient characteristics, Figure 2). A small number of members in the intervention group ( $n = 6$ ) and control group ( $n = 6$ ) had these values in the diabetes range (2% vs. 4%,  $P = .33$ , adjusted for patient characteristics). A comparison of the at-risk groups revealed that they had similar rates of positive screening for diabetes and prediabetes: 28% of the age 45 group, 34% of the BMI > 25 group, and 39% of the hypertension group had a lab in the diabetes or prediabetes range ( $P = .43$ , Figure 2).

After multivariate risk adjustment, members in the intervention group age 60 or older and Asians were more likely to complete a screening after receiving the screening invitation (Table 2). Members with at least one FPG or A1c test in the previous five years and those with at least one primary care visits in the previous year (vs. those with no visits) were more likely to complete a screening. Hypertension status and having a high BMI were not significant predictors of being screened. After multivariate adjustment and weighting for the inverse probability of being screened, predictors of an elevated FPG or A1c level included high versus normal weight, hypertension, hyperlipidemia, current tobacco use, FPG or A1c measured during the previous five years, and two or more primary care visits in the previous year.

Although the screening intervention was not designed to provide follow-up care directly, we also examined the rates of follow-up treatment and diagnosis provided to the members in the intervention group with a positive screen ( $n = 86$ ). Two-thirds (66%) of these employees had evidence of a clinical response within 12 months: 20% received a diagnosis of diabetes or impaired fasting glucose, 34% had their FPG or A1c levels retested, and 50% had a clinical note in their EHR record that related to diabetes or prediabetes (data not shown).

## Conclusions

This employer-based screening program conducted as a partnership with a health care provider roughly tripled the screening rate observed in a similar usual-care population. This low-intensity intervention targeted patients based on demographic, clinical, and utilization data that were available through the EHR, and contacted patients in the intervention group

by sending letters, secure emails, and voice messages using existing health plan personnel resources. These practical approaches to screening for diabetes/prediabetes could easily be replicated by other health care systems seeking to increase screening, particularly among employer-based populations.

Given employers' current interest in diabetes prevention, workforce prompts for diabetes screening in the health care setting in the manner described here may be an effective avenue to increase screening rates. Employer-based prompts for screening may reach people who are not currently being screened in the primary care setting, as many people, especially relatively healthy people, do not visit a primary care provider every year. Collaboration with a health plan allowed the employers in this study to increase screening within a health care setting, which the ADA recommends so that patients are more likely to receive the appropriate follow-up testing and care.<sup>3</sup> In our examination of follow-up treatment and diagnosis in the year following a positive screen, two-thirds of patients in the intervention group received a clinical response that was documented in the EHR. The rate of follow-up for this cohort was in line with a previous study of prediabetes recognition and treatment in the entire KPNC population, although that study was limited to a six month observation period.<sup>30</sup> While there are various KPNC resources available to patients to support lifestyle modification (e.g. nutritional services, telephonic health coaching, and in-person classes), at the time of this intervention KPNC did not have a standard protocol for referring patients with prediabetes for services.

This intervention attempted to lower barriers to screening. Members were not required to make an appointment or obtain pre-approval to complete the screening. Members were not charged a copay for the visit. KPNC laboratories are collocated with other medical offices; therefore patients could have elected to combine the diabetes/prediabetes screening with an unrelated visit to the medical center. Nevertheless, getting to the laboratory and fasting prior to the FPG test may have been significant barriers to completing the screening.

Despite the intervention's success in improving screening rates, two-thirds of the members at-risk for prediabetes in the intervention group did not complete a glucose screening within six months. Efforts to reduce the number of undetected diabetes and prediabetes cases will require a multipronged approach that includes increasing screening in the primary care setting and providing more outreach programs to reach the people not screened through primary care. More research is needed on outreach programs that will effectively and efficiently achieve greater screening rates. This study found that a low-intensity intervention that involved standard health plan communication mechanisms was effective in improving screening rates especially among members who were older and more engaged with the health care system (i.e. those with one or more primary care visit in the previous year and those who had had an FPG or A1c within five years). A more intensive outreach program may be needed to get younger members and members less engaged with the health care system to complete a blood glucose test.

Approximately one-third of those screened in both the intervention and control groups had a positive test for prediabetes. A similar proportion of positive tests for prediabetes was reported in a predictive model of the 2014 ADA screening guidelines applied to the 2010

U.S. population. That study found that of the 86.3 million who met the 2014 ADA screening criteria, an estimated 39% (33.9 million) would have prediabetes.<sup>31</sup> As more outreach programs are developed that target specific groups for screening, one measure of efficiency may be to increase the proportion of positive screens. The results of this study indicate that targeting patients with risk factors such as being obese, having comorbidities such as hypertension or hyperlipidemia, and having certain health behaviors, such as tobacco use and infrequent primary care visits, would increase the proportion with positive screens.

There are several limitations that should be noted. We were not able to conduct a cost-benefit analysis of this intervention. In addition, we were not able to incorporate any secular trends in screening rates. We categorized screening results based on one lab value, but it is worth noting that the ADA recommends that the test be repeated before making a diagnosis.<sup>3</sup> Another potential limitation of this intervention is that the selection criteria identify so many patients that the outreach is not scalable to the entire population. Almost a quarter of the employee population qualified, and extending this outreach to the entire KPNC population would require sending more than 400,000 letters along with the other communications. The infrastructure to provide the outreach and complete the screening would need to be built up to accommodate a full implementation of this intervention.

Targeted risk-based screening for prediabetes is a critical first step to preventing type 2 diabetes. Employer-health plan partnerships can be an effective way to increase screening rates in employees with risk factors for type 2 diabetes. Future research should focus on disseminating and implementing diabetes/prediabetes screening programs on a wider basis, and continue to explore the best methods to encourage screening among patients who do not respond to low-intensity outreach.

## Acknowledgements

The authors thank Karen Hansen of Kaiser Permanente Division of Research and Clara Maxim, student at Head Royce School, for help with preparing the references.

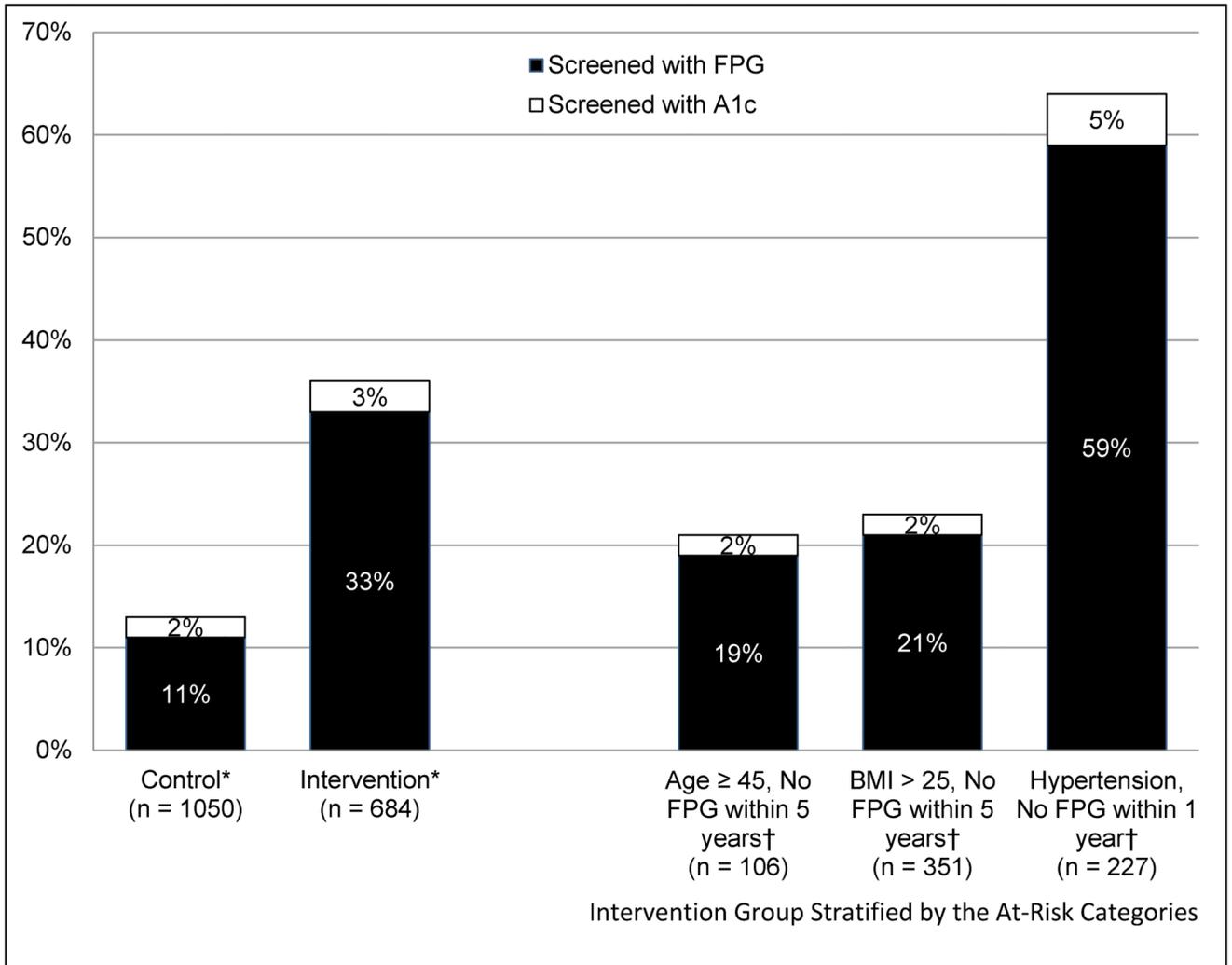
**Source of Funding:** This study was funded by the Centers for Disease Control and the NIDDK [U58 DP002721]. Dr. Schmittiel was also supported by the Health Delivery Systems Center for Diabetes Translational Research (CDTR) [NIDDK grant 1P30-DK092924]. The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the funding organizations.

## References

1. Centers for Disease Control and Prevention. National Diabetes Statistics Report: Estimates of Diabetes and Its Burden in the United States, 2014. U.S. Department of Health and Human Services, Center for Disease Control and Prevention; Atlanta, GA: 2014.
2. Centers for Disease Control and Prevention. Awareness of prediabetes—United States, 2005–2010. *MMWR Morb Mortal Wkly Rep.* 2013;209–212. [PubMed: 23515058]
3. American Diabetes Association. Standards of medical care in diabetes—2014. *Diabetes Care.* 2014; 37:S14–80. [PubMed: 24357209]
4. U.S. Preventive Services Task Force. [Accessed 3 November 2014] Draft recommendation statement: abnormal glucose and type 2 diabetes mellitus in adults: Screening [Internet]. <http://www.uspreventiveservicestaskforce.org/Page/Document/RecommendationStatementDraft/screening-for-abnormal-glucose-and-type-2-diabetes-mellitus>

5. Knowler WC, Barrett-Connor E, Fowler SE, et al. Diabetes Prevention Program Research Group. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med.* 2002; 346:393–403. [PubMed: 11832527]
6. Tuomilehto J, Lindstrom J, Eriksson JG, et al. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. *N Engl J Med.* 2001; 344:1343–1350. [PubMed: 11333990]
7. Pan XR, Li GW, Hu YH, et al. Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance. The Da Qing IGT and Diabetes Study. *Diabetes Care.* 1997; 20:537–544. [PubMed: 9096977]
8. Selph, S.; Dana, T.; Blazina, I.; Bougatsos, C.; Patel, H.; Chou, R. Screening for Type 2 Diabetes Mellitus: Systematic Review to Update the 2008 U.S. Preventive Services Task Force Recommendation. Agency for Healthcare Research and Quality; Rockville, MD: 2014.
9. Davidson MB, Duran P, Lee ML. Community screening for pre-diabetes and diabetes using HbA1c levels in high-risk African Americans and Latinos. *Ethn Dis.* 2014; 24:195–199. [PubMed: 24804366]
10. AlGhamdi AS, Merdad K, Sonbul H, Bukhari SM, Elias WY. Dental clinics as potent sources for screening undiagnosed diabetes and prediabetes. *Am J Med Sci.* 2013; 345:331–334. [PubMed: 23531966]
11. Willis A, Rivers P, Gray LJ, Davies M, Khunti K. The effectiveness of screening for diabetes and cardiovascular disease risk factors in a community pharmacy setting. *PLoS One.* 2014; 9:e91157. [PubMed: 24690919]
12. Mattke, S.; Liu, H.; Caloyeras, JP., et al. Workplace Wellness Programs Study: Final Report. RAND Corporation; Santa Monica, CA: 2013.
13. Kaiser Family Foundation. Employer Health Benefits: 2014 Annual Survey. Henry J. Kaiser Family Foundation & Health Research and Educational Trust; Menlo Park, CA: Sep. 2014
14. Biometric health screening for employers: consensus statement of the health enhancement research organization, American College of Occupational and Environmental Medicine, and care continuum alliance. *J Occup Environ Med.* 2013; 55:1244–1251. [PubMed: 24029923]
15. Gregg EW, Ali MK, Moore BA, et al. The importance of natural experiments in diabetes prevention and control and the need for better health policy research. *Prev Chronic Dis.* 2013; 10:E14. [PubMed: 23369767]
16. Gordon, NP. [Accessed 5 November 2014] Similarity of the Adult Kaiser Permanente Membership in Northern California to the Insured and General Population in Northern California: Statistics from the 2007 California Health Interview Survey [Internet]. [http://www.dor.kaiser.org/external/chis\\_non\\_kp\\_2007/](http://www.dor.kaiser.org/external/chis_non_kp_2007/)
17. American Diabetes Association. Standards of medical care in diabetes—2010. *Diabetes Care.* 2010; 33:S11–61. [PubMed: 20042772]
18. U.S. Preventive Services Task Force. Screening for type 2 diabetes mellitus in adults: U.S. Preventive Services Task Force recommendation statement. *Ann Intern Med.* 2008; 148:846–854. [PubMed: 18519930]
19. Kaiser Permanente. [Accessed 5 November 2014] Workforce Health [Internet]. <https://businessnet.kaiserpermanente.org/health/plans/ca/workforcehealth/>
20. Adams SR, Goler NC, Sanna RS, et al. Patient satisfaction and perceived success with a telephonic health coaching program: the Natural Experiments for Translation in Diabetes (NEXT-D) Study, Northern California, 2011. *Prev Chronic Dis.* 2013; 10:E179. [PubMed: 24176083]
21. The International Expert Committee. International Expert Committee report on the role of the A1C assay in the diagnosis of diabetes. *Diabetes Care.* 2009; 32:1327–1334. [PubMed: 19502545]
22. Knol MJ, Le Cessie S, Algra A, Vandenbroucke JP, Groenwold RH. Overestimation of risk ratios by odds ratios in trials and cohort studies: alternatives to logistic regression. *CMAJ.* 2012; 184:895–899. [PubMed: 22158397]
23. Zou G. A modified poisson regression approach to prospective studies with binary data. *Am J Epidemiol.* 2004; 159:702–706. [PubMed: 15033648]
24. McNutt LA, Wu C, Xue X, Hafner JP. Estimating the relative risk in cohort studies and clinical trials of common outcomes. *Am J Epidemiol.* 2003; 157:940–943. [PubMed: 12746247]

25. Curtis LH, Hammill BG, Eisenstein EL, Kramer JM, Anstrom KJ. Using inverse probability-weighted estimators in comparative effectiveness analyses with observational databases. *Med Care*. 2007; 45:S103–107. [PubMed: 17909367]
26. Van der Laan, MJ. Statistical inference for variable importance. Aug. 2005 U.C. Berkeley Division of Biostatistics Working Paper Series: Working Paper 188
27. Bembom O, Petersen ML, Rhee SY, et al. Biomarker discovery using targeted maximum-likelihood estimation: application to the treatment of antiretroviral-resistant HIV infection. *Stat Med*. 2009; 28:152–172. [PubMed: 18825650]
28. Chambaz A, Neuvial P, van der Laan MJ. Estimation of a non-parametric variable importance measure of a continuous exposure. *Electron J Stat*. 2012; 6:1059–1099. [PubMed: 23336014]
29. Hernan MA, Hernandez-Diaz S, Robins JM. A structural approach to selection bias. *Epidemiology*. 2004; 15:615–625. [PubMed: 15308962]
30. Schmittiel JA, Adams SR, Segal J, et al. Novel use and utility of integrated electronic health records to assess rates of prediabetes recognition and treatment: brief report from an integrated electronic health records pilot study. *Diabetes Care*. 2014; 37:565–568. [PubMed: 24271190]
31. Dall TM, Narayan KM, Gillespie KB, et al. Detecting type 2 diabetes and prediabetes among asymptomatic adults in the United States: modeling American Diabetes Association versus US Preventive Services Task Force diabetes screening guidelines. *Popul Health Metr*. 2014; 12:12. [PubMed: 24904239]

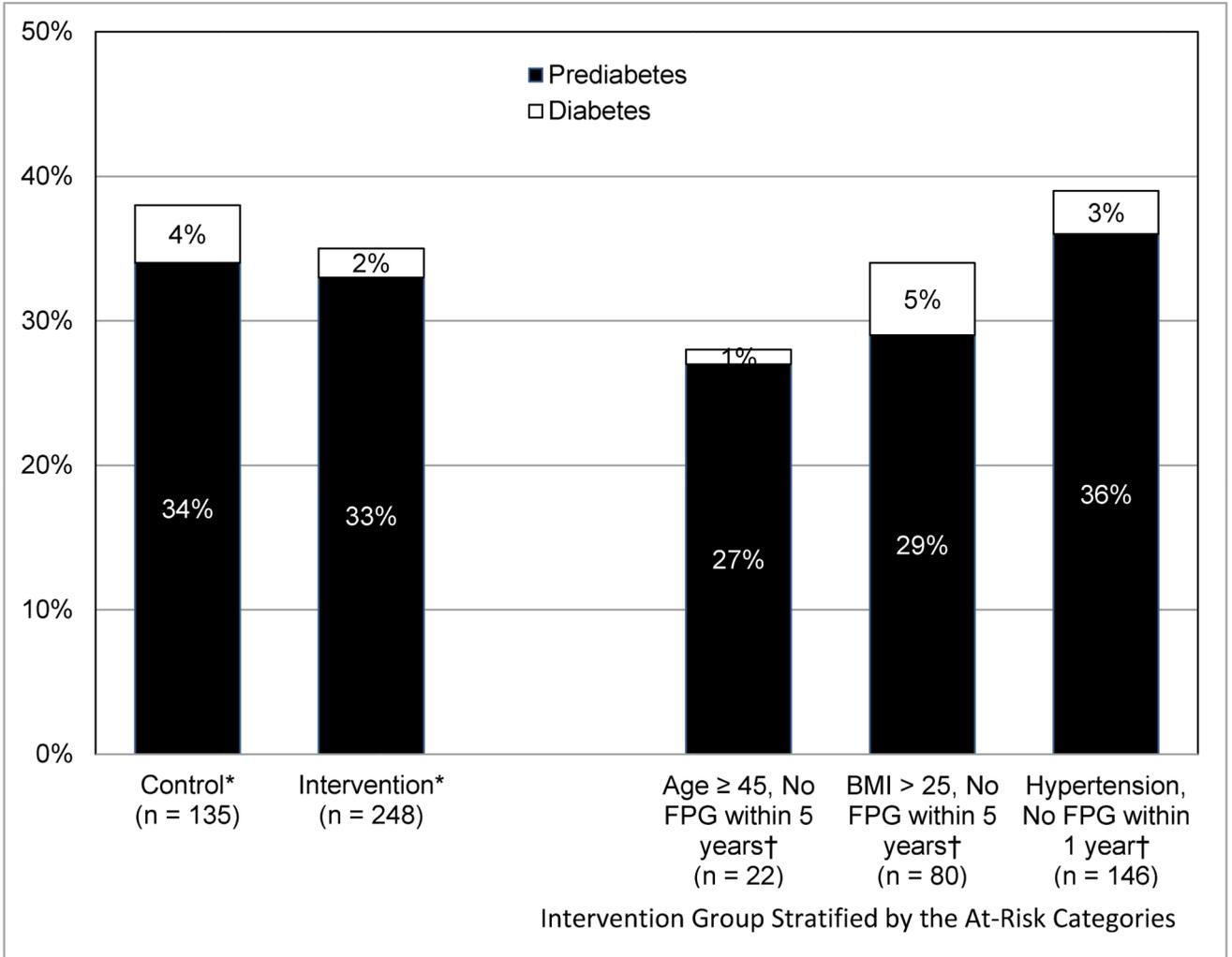


**Figure 1.**

Proportion screened within six months for the intervention and control groups and for the intervention group stratified by the at-risk categories

\* Adjusting for age, sex, race/ethnicity, FPG/A1c within 5 years, number of primary care visits in previous year, geocoded education, geocoded income, BMI, tobacco use, hypertension diagnosis, high systolic blood pressure, hyperlipidemia diagnosis, and abnormal cholesterol levels, the tests for the differences in proportions between the intervention and control groups were  $P < .001$  for screened with FPG or A1c;  $P < .001$  screened with FPG;  $P = .21$  screened with A1c only.

†  $\chi^2$  test for the difference in proportions between the at-risk groups for members in the intervention group: screened with FPG or A1c,  $P < .001$ ; screened with FPG only,  $P < .001$ ; screened with A1c only,  $P = .04$ .



**Figure 2.**

Proportion with a blood glucose test in the diabetes or prediabetes range among those screened within six months for the intervention and control groups and for the intervention group stratified by the at-risk categories

\* Adjusting for age, sex, race/ethnicity, FPG/A1c within 5 years, number of primary care visits in previous year, geocoded education, geocoded income, BMI, hypertension diagnosis, high systolic blood pressure, hyperlipidemia diagnosis, and abnormal cholesterol levels, the tests for the differences in proportions between the intervention and control groups were  $P = .68$  for screened in prediabetes or diabetes range;  $P = .84$  for screened in the prediabetes range;  $P = .33$  for screened in the diabetes range.

†  $\chi^2$  test for the difference in proportions between the at-risk groups for the intervention group: prediabetes,  $P = .49$ ; diabetes,  $P = .62$ ; diabetes or prediabetes,  $P = .43$ .

**Table 1**

Baseline characteristics of the intervention and control groups

	Intervention	Control	<i>P</i> value*
<i>n</i>	684	1050	
Age, mean (SD)	51 (17)	53 (16)	.06
Female, n (%)	384 (56)	552 (53)	.15
Race/ethnicity, n (%)			<.001
Asian	60 (9)	52 (5)	
African-American	71 (10)	52 (5)	
Hispanic	100 (15)	80 (8)	
White	363 (53)	763 (73)	
Other/unknown	90 (13)	103 (10)	
FPG or A1c within five years, n (%)	216 (32)	304 (29)	.24
Primary care visits in prior year, n (%)			.24
0	247 (36)	330 (31)	
1	170 (25)	286 (27)	
2-3	162 (24)	266 (25)	
4 or more	105 (15)	168 (16)	
Geocoded education, n (%)			<.001
Less than 15% with bachelor's degree or more	122 (18)	126 (12)	
15-29% with bachelor's degree or more	233 (34)	393 (37)	
30-44% with bachelor's degree or more	154 (23)	305 (29)	
45% or more with bachelor's degree or more	172 (25)	222 (21)	
Geocoded annual household income, n (%)			<.001
Less than \$50,000	125 (18)	246 (23)	
\$50,000 to less than \$80,000	236 (35)	431 (41)	
\$80,000 to less than \$120,000	245 (36)	319 (30)	
\$120,000 or more	75 (11)	50 (5)	
BMI (kg/m <sup>2</sup> )			
Mean (SD)	29.5 (6.3)	29.4 (6.5)	.64
Normal (BMI < 25 kg/m <sup>2</sup> ), n (%)	126 (18)	220 (21)	.18
Overweight (BMI 25- < 30 kg/m <sup>2</sup> ), n (%)	264 (39)	412 (39)	
Obese (BMI ≥ 30 kg/m <sup>2</sup> ), n (%)	246 (36)	367 (35)	
Missing, n (%)	48 (7)	51 (5)	
Current tobacco user, n (%)	51 (7)	73 (7)	.69
Hypertension diagnosis, n (%)	242 (35)	364 (35)	.76
Systolic blood pressure ≥ 140 mmHg, n (%)	108 (16)	167 (16)	.95
Hyperlipidemia diagnosis, n (%)	119 (17)	187 (18)	.83
Abnormal cholesterol level <sup>†</sup> , n (%)	154 (23)	251 (24)	.50

\* Determined by a  $\chi^2$  test for the difference in proportions or a  $t$  test for the difference in means.

† Abnormal cholesterol level was defined as LDL  $\geq$  130, triglycerides  $\geq$  200, or HDL  $\leq$  60.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

**Table 2**

Multivariate relative risk models for completing a screening in the intervention group given the baseline characteristics of patients and estimates of the relative importance of each baseline characteristic in having a test in the diabetes or prediabetes range

Patient Characteristics	Completing a screening		Having a test in the diabetes or prediabetes range*	
	Relative risk	P value	Relative risk	P value
Age				
40-59 vs. 18-39	1.2	.22	1.1	.75
60+ vs. 18-39	1.6	.01	1.0	.96
Female	1.1	.30	1.3	.20
Race/ethnicity				
African-American vs. Asian	0.5	.01	0.7	.36
Hispanic vs. Asian	0.7	.02	1.0	.89
White vs. Asian	0.7	.01	0.7	.13
Other/unknown vs. Asian	0.5	.01	0.5	.17
FPG/A1c within five years	1.4	.01	0.7	.03
Primary care visits in prior year				
1 vs. 0	1.6	.004	0.7	.11
2-3 vs. 0	1.6	.003	0.6	.054
4 or more vs. 0	1.6	.01	0.5	.02
Geocoded education				
< 15% vs. 45% with bachelor's degree or more	0.9	.78	0.8	.48
15 - 29% vs. 45% with bachelor's degree or more	1.1	.47	0.9	.74
30 - 44% vs. 45% with bachelor's degree or more	0.9	.67	1.3	.18
Geocoded annual household income				
< \$50,000 vs. \$120,000	0.7	.07	0.8	.43
\$50 - < \$80,000 vs. \$120,000	0.8	.15	0.8	.29
\$80 - < 120,000 vs. \$120,000	0.8	.13	0.9	.58
BMI				
Overweight (BMI 25- < 30 kg/m <sup>2</sup> ) vs. BMI < 25 kg/m <sup>2</sup>	1.1	.40	1.0	.99
Obese (BMI ≥ 30 kg/m <sup>2</sup> ) vs. BMI < 25 kg/m <sup>2</sup>	1.1	.61	2.0	.006
Current tobacco user	0.7	.10	3.1	<.001
Hypertension diagnosis	1.3	.11	1.8	.002
Systolic blood pressure ≥ 140 mmHg	0.9	.63	0.9	.67
Hyperlipidemia diagnosis	1.0	.85	1.8	<.001
Abnormal cholesterol level <sup>†</sup>	1.0	.96	0.9	.36

\* Weighted by the inverse probability of completing a blood glucose test.

† Abnormal cholesterol level was defined as LDL  $\geq$  130, triglycerides  $\geq$  200, or HDL  $\leq$  60.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript