

Identifying Individuals at Risk for the Development of Type 2 Diabetes Mellitus

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Objective: To describe a population-based approach to the identification of individuals at high risk for the development of type 2 diabetes mellitus (DM).

Study Design: A prospective analysis of the incidence of DM in low- and high-risk groups.

Patients and Methods: Questions associated with the risk of developing DM were incorporated into a health risk assessment (HRA), and health plan members were invited to complete the HRA as part of worksite health promotion efforts or medical clinic visits. Points were applied to the risk factors for DM, and individual HRA responders were assigned to low- or high-risk groups. A total of 16 427 members completed the HRA. To assess the incidence of new cases of DM, follow-up time was up to 4.8 years (mean, 2.55 years). New-onset DM cases were identified using *International Classification of Diseases, Ninth Revision*, coding for DM during the timeframe subsequent to HRA completion.

Results: The incidence of new DM at the end of the study was 3.5% in the high-risk group and 0.7% in the low-risk group ($P < .001$).

Conclusions: Identification of individuals at risk for DM using this HRA approach increases by 5-fold the likelihood that the targeted risk reduction efforts will reach the right individuals. This approach allows for resource-efficient targeted intervention efforts designed to reduce the incidence of new DM cases.

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Diabetes mellitus (DM) has reached epidemic proportions, with the adult prevalence in the United States predicted to increase from 7.4% in 1995 to approximately 9% by 2025.¹ Along with the rise in the prevalence of DM, the consequent morbidity, mortality, and economic impact also increase.^{2,3} Approximately one third of all people with DM may be undiagnosed.² Furthermore, owing to the subtle onset of the disease, by the time the diagnosis is made, many patients have had DM for 9 to 12 years, resulting in the presence of complica-

tions in as many as 39% of patients with newly diagnosed DM.⁴ Also, individuals who are at risk for DM are at similar risk for cardiovascular disease and peripheral vascular disease as those who have DM.⁵

Given that type 2 DM, although in most cases controllable, is irreversible, the greatest opportunity to address the burden of DM is to focus on primary prevention. As a chronic disease, the natural progression of the development of DM is greatly impacted by modifiable risk factors, particularly obesity and physical inactivity. Both obesity and physical inactivity contribute to insulin resistance, the primary contributing factor for the development of type 2 DM, and its long-term complications.⁶ During the past several years, compelling evidence⁶⁻¹⁰ has emerged strongly suggesting that increased levels of physical activity or weight loss, alone or in combination, at any stage in the development of DM can potentially prevent or delay progression to subsequent stages for those at risk for this chronic disease. Lifestyle interventions, specifically, increased physical activity and modest weight reduction, have resulted in a reduction in the incidence of type 2 DM by as much as 58%.^{10,11} In the Diabetes Prevention Program,¹¹ the findings held true across all populations, with even more significant results in those 60 years and older, in whom the reduction in the development of type 2 DM was 71%. Specifically, increasing physical activity improves insulin sensitivity acutely,¹² and caloric restriction decreases hyper-

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glycemia dramatically.¹³ Thus, behavioral interventions such as restricting caloric intake, reducing dietary fat intake, and increasing physical activity are central in DM prevention efforts.^{10,11,14-20} Despite evidence linking lifestyle with the incidence of DM, a challenge remains in the identification of individuals at high risk for developing DM in a way that allows for proactive outreach to engage them in risk reduction interventions. With the costs of healthcare continually rising and the need to do more with less, it is important to maximize already-limited resources. A systematic, population-based approach²¹ allows for prioritization of need and appropriate allocation of those resources. Furthermore, a closed-loop approach²¹⁻²⁴ allows for those identified as being at greatest risk to be connected to their healthcare provider for further assessment and potential diagnosis.

The primary purpose of this project is to describe a population-based risk assessment approach designed to identify individuals at high risk for DM and to involve them in interventions aimed at risk reduction. An additional objective is to present a population profile of those at high risk for DM.

METHODS

The subject sample was limited to all members of HealthPartners, a not-for-profit managed care organization (MCO) in the upper midwestern United States, who had completed a health risk assessment (HRA) between November 1, 1995, and September 8, 1999, and who had been enrolled as a member of the health plan for at least 6 months. A comprehensive and automated HRA was completed via self-report using telephone-based integrated voice response system technology. Members who completed the HRA had done so as part of worksite health promotion programs, medical clinic visits, or enrollment in senior benefit products. All HRA records available on September 8, 1999 ($n = 16\,427$) were used in this evaluation. Because individuals completed the HRA at various times between 1995 and 1999, variability exists in the follow-up period to track new cases of DM at the individual level. Individual follow-up ranged from 0.17 to 4.83 years, with a mean of 2.55 years. Follow-up time in person-years is defined as the time, in months, between HRA completion and September 8, 1999, divided by 12 for each individual. The 16 427 HRA completers had total follow-up of 41 935 person-years. The reporting of person-years is considered meaningful

in the context of this report because self-reported HRA data are collected over an extended period and therefore reflect a variable follow-up period at the individual level. Especially in cases in which HRA data were collected early and longer follow-up was available, the potential for development of DM during follow-up is higher than for those who more recently completed the HRA and self-reported not having DM.

To be classified as having a diagnosis of DM, an individual's administrative claims data were checked for the presence of *International Classification of Diseases, Ninth Revision*, codes ranging from 250 to 250.99, and the pharmacy claims databases were checked for DM-related prescriptions (eg, glucagon, insulin, sulfonylurea, thiazolidinedione, and biguanide) between 1995 and 1999. To avoid the possibility of "error in coding" or "diagnostic rule out," a member had to have at least 2 occurrences of an *International Classification of Diseases, Ninth Revision*, code of 250 to 250.99; at least 2 filled prescriptions for a DM-related drug; or 1 occurrence of a diagnostic code and 1 filled prescription for a DM-related drug. Self-reported DM was recorded if the member answered "yes" to the question "Has a physician told you that you have the condition of DM?" The year of the survey was noted as the time of self-reported DM. Except for membership that was described by the number of member-months in a particular year, all other time-sensitive data elements in the analysis file were marked by the calendar year of the occurrence, ie, the year of the survey, the year the member self-reported DM, and the year in which the member was first classified as having a diagnosis of DM.

To be defined as a newly diagnosed case of DM, the member had to self-report not having DM and had to receive a diagnosis of DM during or after the year of the survey. Nine of the 10 risk factors included in the HRA were identified based on the 1995 American Diabetes Association (ADA) position statement^{25,26} on screening for type 2 DM. Family history of hypertension was added based on a study by Wing and associates²⁷ indicating a correlation to the development of type 2 DM with this risk factor. These authors found that women with a family history of hypertension had higher fasting insulin levels and a higher glucose-insulin ratio in the fasting state and were more likely to develop type 2 DM. This finding remained significant after adjusting for body mass index (BMI) ($P = .01$).

Obesity was defined as a BMI ≥ 27.8 kg/m² for men and ≥ 27.3 kg/m² for women according to a 1985

Table 1. Diabetes Mellitus Risk Assessment Variables

Risk	Question	Risk Definition
Overweight	“Enter your weight in pounds and your height in feet and inches.”	BMI ≥ 27.8 kg/m ² (men) or ≥ 27.3 kg/m ² (women)
Physical inactivity—sedentariness	“How many times in an average week do you engage in vigorous, leisure-time exercise that lasts for 15 min or longer and causes you to breathe heavily and your heart to beat faster?”	0 d/wk of mild or strenuous activity for 30 or 15 min, respectively (ACSM)
Age		>65y
Race/ethnicity	Included in the latest version of the HRA only: “How would you describe your race? American Indian or Alaskan native, Asian or Pacific Islander, black or African American, white, Hispanic or Latino, or other/biracial?”	Nonwhite
Family history of diabetes mellitus	“Does your natural brother or sister or a parent have or have they had diabetes mellitus?”	Yes, sibling or parent
Family history of hypertension ²⁷	“Does your natural brother or sister or a parent have or have they had high blood pressure?”	Yes ²⁷
Hypertension	“Has a physician told you that you have high blood pressure?”	Yes
Hypercholesterolemia	“Has a physician told you that you have high cholesterol?”	Yes
Gestational diabetes mellitus	“Have you been diagnosed as having diabetes mellitus during pregnancy?”	Yes
Delivered a baby >9 lb	“Have you delivered a baby weighing >9 lb?”	Yes

ACSM indicates American Council of Sports Medicine; BMI, body mass index; HRA, health risk assessment.

National Institutes of Health Consensus Development Conference.²⁸ For the purposes of risk assessment with the intent of reducing risk through behavioral interventions, no differentiation was made between overweight and obesity. Because physical inactivity and cardiorespiratory fitness have both been related to higher likelihood of DM,^{8,9,20,29} cardiorespiratory fitness was estimated using the prediction equation of Ainsworth and colleagues³⁰ and is expressed as maximum oxygen consumption in milliliters per kilogram per minute. Both BMI and predicted maximum oxygen consumption (VO_{2max}) were calculated automatically using an algorithm that was programmed into the HRA database. The specific questions associated with all of the risk factors were integrated into a more comprehensive HRA that provided additional insight into the member’s health risk and interest in health improvement (**Table 1**).

The 10 risk factors were assigned a score, with weighting applied according to available evidence and expert consensus statements found in the literature.^{25,27,31} In determining the scores, emphasis was placed on the modifiable risk factors, with a focus on risk reduction. The DM risk score for an individual was computed as the sum of all risk factor scores (**Table 2**). The authors considered 2 thresholds of high risk (score ≥ 5 and ≥ 6) to gain a better understanding of the possible number of cases identified and the potential incremental impact on intervention resources as part of the risk reduction follow-up activities.

To allow for proactive outreach to individuals prepared to engage in programs that match their interest and need, questions about the member’s “willingness to communicate” and “readiness to change” were included in the HRA.^{32,33} Readiness to change was determined by answering “yes” to the

Table 2. Diabetes Mellitus Risk Scoring Algorithm

Risk Factor ²⁵	Score ²⁵
Overweight	3
Physical inactivity—sedentariness	1
Age	2
Race	1
Family history of diabetes mellitus	1
Family history of hypertension ²²	1
Hypertension	2
Hypercholesterolemia	2
Gestational diabetes mellitus	5
Delivered a baby >9 lb	1

question “Are you ready to make changes or seek help in the following areas to reduce your health risks?” Willingness to communicate was determined by answering “yes” to the question “Do you want to receive information based on your survey results?”³³ All respondents to the HRA who indicated a willingness to communicate were contacted by counselors on the Partners for Better Health Phonenumber to invite them to participate in risk reduction activities.

Analyses included descriptive characteristics of the population using percentages, averages, and other measures of central tendency. Comparisons between risk groups were conducted using χ^2 tests.

Table 3. Prevalence of Diabetes Mellitus and Diabetes Mellitus Risks in the Sample

Variable	Cases, No. (%) (n = 16 427)	Person-Years, No. (%) (n = 41 935)
Self-reported diabetes mellitus		
No	15 878	40 535
Yes	549 (3.3)	1400 (3.3)
Had a diabetes mellitus diagnosis		
No	15 748	40 159
Yes	679 (4.1)	1776 (4.2)
Diabetes mellitus risk (points)		
Low (<5)	11 788	30 505
High (≥ 5)	4639 (28.2)	11 430 (27.3)
Low (<6)	13 492	35 027
High (≥ 6)	2935 (17.9)	6908 (16.5)

RESULTS

The subject sample, mostly employed HealthPartners members, was a relatively healthy population of primarily young, white, educated women. Mean age was 42.5 years (range, 19-91 years). Of all responders, 37.8% were male, 91.5% were white, 71.9% had attended at least some college, and 2.7% were older than 65 years.

The prevalence of DM and DM risk in the study population at the time of HRA completion is shown in **Table 3**. Based on cases, 3.3% of those who responded to the survey had self-reported DM, whereas 4.1% had a DM diagnosis. If DM risk is defined by a risk score ≥ 5 , then 28.2% of those surveyed were identified as being at high risk. Alternatively, if DM risk is defined by a risk score ≥ 6 , then 17.9% of those surveyed were identified as being at high risk. Although the selection of a score of 5 or 6 was arbitrary, because the results were so significant, further analysis was not done to determine results at other thresholds. The decision to use one threshold over another will come down to available resources.

As shown in **Table 4**, of the 549 individuals who self-reported DM, 102 (18.6%) did not have a diagnosis of DM. These could have been individuals with DM who did not seek medical care, who were not taking medications, and/or who managed their DM by following recommendations for lifestyle-based approaches to care. The MCO did not have access to this level of data, so a clear determination could not be made. There were 45 individuals with diagnosed DM who did not self-report DM. These could have been individuals who were told that they have a “touch of sugar” or that they have “high blood glucose” without being told that they actually have DM. There were 187 patients who self-reported no DM and were diagnosed later as having DM and thus were cases of new DM. This represents a rate of 1.2% of new DM during follow-up of 2.55 years.

Numbers of new cases of DM in the high- and low-risk groups are given in **Table 5**. Person-years are used because the duration, as well as the occurrence,

of the observation is of importance. Using the definition of high risk as ≥ 5 points, the incidence of new DM in this group at the end of the study was 3.5% vs 0.7% in the low-risk group ($P < .001$). Using the definition of high risk as ≥ 6 points, the incidence of new DM in this group at the end of the study was 4.6% vs 0.9% in the low-risk group ($P < .001$). This suggests that the likelihood of developing DM for individuals at high risk is 5 to 6 times greater than for those in the low-risk group.

A total of 4639 individuals (28.2%) were characterized as being at high risk (risk score ≥ 5) for the development of DM. To better understand the prevalence of risk factors among individuals in this group, regardless of who would develop DM during the evaluation, we counted the occurrences of each risk factor. This analysis is given in **Table 6** and outlines the impact of obesity, family history of DM as well as hypertension, and preexisting chronic conditions: 92.4% of those with a risk score ≥ 5 were overweight, making this the most prevalent modifiable risk factor in the high-risk group; 52.4% had a family history of DM; 50.4% had a family history of hypertension; and 46.9% had a personal history of hypercholesterolemia.

Using a score of ≥ 5 to define individuals at high risk, **Table 7** presents the profile of those identified as being at high risk for DM who subsequently developed the disease. As expected, age is a strong risk factor. Compared with their low-risk counterparts, the high-risk group was, on average, close to 10 years older. In addition, the profiles of family history and individual medical history of chronic disease for the high-risk subgroup that developed

Table 4. Agreement Between Self-reported Diabetes Mellitus (DM) and Diagnosed DM

	Cases, No. (%)	Person-Years, No. (%)
Self-reported DM		
DM diagnosis	447 (81.4)	1104 (78.9)
No DM diagnosis	102 (18.6)	295 (21.1)
No self-reported DM		
No DM diagnosis	15 646 (98.5)	39 864 (98.3)
DM diagnosis	45 (0.3)	91 (0.2)
New DM	187 (1.2)	580 (1.4)

DM seemed less favorable compared with those of their low-risk counterparts.

In terms of modifiable risk factors, there seems to be significant differences between the 2 groups. The average BMI was 24.7 kg/m² for those at low risk and 32.3 kg/m² for those at high risk who developed DM. Obesity was more common among those at high risk. Among those in the high-risk group who developed DM, 79.0% were classified as obese, whereas 18.2% of those in the low-risk group were classified as obese. Considering cardiorespiratory fitness, the estimated fitness profile was more favorable in the low-risk group, with a mean estimated maximum oxygen consumption of 36.0 mL/kg per minute compared with 27.9 mL/kg per minute for the high-risk group. Moreover, according to age- and sex-specific norms for increased risk,³⁴ the high-risk group experienced a 4-fold higher proportion of individuals below established norms for healthy levels of cardiorespiratory fitness compared with the low-risk group (56.5% vs

Table 5. Disease Outcomes of Those at High or Low Risk for Diabetes Mellitus (DM)

DM Risk (points)	Cases of New DM, No. (%)		Person-Years of New DM, No. (%)		P
	Yes	No	Yes	No	
High (≥ 5)	124 (2.9)	4100	369 (3.5)	10 079	<.001
Low (<5)	63 (0.5)	11 546	210 (0.7)	29 785	
High (≥ 6)	97 (3.7)	2508	284 (4.6)	5889	<.001
Low (<6)	90 (0.7)	13 138	296 (0.9)	33 974	

Table 6. Occurrence of Individual Risk Factors in Those at High Risk for Diabetes Mellitus (Risk Score ≥ 5)

Risk Factor	Cases, No. (%) (n = 4639)
Overweight	4287 (92.4)
Family history of diabetes mellitus	2432 (52.4)
Family history of hypertension	2339 (50.4)
Hypercholesterolemia	2179 (46.9)
Hypertension	1834 (39.5)
Physical inactivity	459 (9.9)
Age (>65 y)	345 (7.4)
Delivered a baby >9 lb*	130 (2.8)
Race*	103 (2.2)
Gestational diabetes mellitus*	48 (1.0)

*Asked of 18.9% of the sample because the question was only part of later versions of the health risk assessment.

14.2%, respectively). On the other hand, self-reported mild physical activity did not reveal this degree of difference, whereas the difference was more pronounced with vigorous physical activity reporting. Because previous research²⁹ has shown a significant difference between cardiorespiratory fitness level for those with and without diagnosed DM, one recommendation for high-risk individuals may be to establish a personalized, formal exercise prescription based on current levels of clinical risk and functional status.

Because the DM algorithm is imbedded in an HRA, additional information is available to further stratify the population based on other factors, such as self-reported heart disease, the presence of ≥ 1 chronic conditions, and a family history of obesity or heart disease. In addition, 4.0% of the high-risk group reported being in poor health compared with 1.2% of the low-risk group, and 25.8% of the high-risk group reported problems due to physical health compared with 15.2% of the low-risk group; 67.0% of those in the high-risk group indicated that they were ready to make a change. Furthermore, 76% of those at high risk indicated a willingness to communicate about opportunities to improve their health.

DISCUSSION

The use of HRAs has become a core component of health promotion programming and has become an absolutely essential part of the approach to address behavioral changes as part of population health improvement.³⁵ As implemented, it provides an assessment of behavior, health risks, knowledge, attitudes, readiness to change, and interests regarding an individual's health-related concerns and issues.^{35,36} Historically, HRAs have been implemented through worksite health promotion programs, and they are often used by MCOs as a marketing tool with their large-employer groups. More recently, however, HRAs have been incorporated into methods of prioritization and decision making for health improvement strategies of defined populations by connecting individual-level HRA results to the healthcare provider for disease management-related issues and providing a means for proactive follow-up with interventions designed to reduce modifiable risk factors.³⁵

Although it is true that this questionnaire is similar to that proposed by the ADA, there is a fundamental difference: the focus on behavioral and modifiable risk factors. The primary intent of the questionnaire proposed by the ADA is to identify people with undiagnosed DM. The questionnaire proposed herein focuses more on behavioral and modifiable risk factors, with the primary intent being to identify individuals at high risk and to engage them in risk reduction programs. Furthermore, because this questionnaire is imbedded in an HRA that is linked to the healthcare system, it allows for prompt feedback and follow-up with the individual at risk.

This closed-loop approach allows an MCO to assess its members on a population basis and to connect them with their healthcare provider for follow-up. It combines the need to assess risk in the population with the need to identify individuals who carry the risk, identifies risk factors most prevalent in those at high risk, and offers an approach for proactive outreach. This evaluation suggests that the likelihood of developing DM among those identified as being at high risk using this risk assessment tool is 5 to 6 times greater than for those in the low-risk group.

Thresholds of ≥ 5 points and ≥ 6 points were considered, and this MCO has chosen ≥ 5 points as its threshold for determining high risk. The decision to use one threshold over another, again, comes down to available resources. They are equally significant in the identification of high risk, but using ≥ 5 points

Identifying Type 2 Diabetes Risk

Table 7. Profile of Members at High Risk (Risk Score ≥ 5) Who Developed Diabetes Mellitus (DM) vs the Low-Risk Group That Did Not Develop DM

Variable	High-Risk Group			Low-Risk Group		
	Total No.	With Risk Factor, No. (%)	Mean	Total No.	With Risk Factor, No. (%)	Mean
Nonmodifiable						
Age (range, 19-91 y), y	124		51.9	11 592		40.4
Age >65 y	124	11 (8.9)		11 592	127 (1.1)	
White race*	14	14 (100.0)		1890	1745 (92.3)	
Delivered a baby >9 lb*	14	0		1890	110 (5.8)	
Had gestational DM*	14	0		1890	0	
≥ 1 chronic conditions	124	99 (79.8)		11 592	1078 (9.3)	
Self-report heart disease	124	19 (15.3)		11 592	151 (1.3)	
Family history of DM	124	68 (54.8)		11 592	1785 (15.4)	
Family history of heart disease	124	77 (62.1)		11 592	3756 (32.4)	
Family history of hypertension	124	61 (49.2)		11 592	3628 (31.3)	
Family history of obesity	110	27 (24.5)		9702	1077 (11.1)	
Modifiable						
BMI, kg/m ²	124		32.3	11 521		24.7
Obese (≥ 27.8 kg/m ² for men or ≥ 27.3 kg/m ² for women)	124	98 (79.0)		11 521	2097 (18.2)	
Maximum oxygen consumption, mL/kg per min (VO _{2max})	124		27.9	11 510		36.0
Maximum oxygen consumption < age-sex cutoff value (VO _{2max})	124	70 (56.5)		11 510	1634 (14.2)	
4+ times/wk mild exercise	68	26 (38.2)		7073	2857 (40.4)	
3+ times/wk vigorous exercise	124	39 (31.5)		11 592	5460 (47.1)	
Self-report hypertension	124	71 (57.3)		11 592	301 (2.6)	
Self-report hyperlipidemia	124	66 (53.2)		11 592	707 (6.1)	
Self-reported poor health	124	5 (4.0)		11 592	128 (1.1)	
Problems due to physical health	124	32 (25.8)		11 592	1762 (15.2)	
Ready for change	124	77 (62.1)		11 592	6712 (57.9)	
Want to receive information based on survey result	124	91 (73.4)		11 589	7602 (65.6)	

BMI indicates body mass index.

*Asked of 18.9% of the sample because the question was only part of later versions of the health risk assessment.

captures a larger number of individuals and thus offers an opportunity to provide lifestyle interventions to a larger population.

Beyond identifying individuals at risk for DM, this HRA also identifies the specific factors that increase the risk and thereby creates a method for identifying those who may mitigate their risk through behavior modification or clinical treatment plans. For exam-

ple, those in the high-risk group who developed DM were 6.6 BMI units higher than those at low risk for DM. Knowing that obesity is a driver of risk in individuals who have the risk presents an opportunity for interventions focused on reducing this modifiable risk factor. Because the HRA also provides insight into who is willing to be contacted, proactive outreach strategies can be initiated to lower the risk

in those who are ready. Fairly high readiness to change coupled with an even higher willingness to communicate indicates a real opportunity for proactive 2-way communication regarding interventions designed to improve health.³²

Based on these data, focusing on individuals who are overweight or physically inactive will reach most high-risk individuals in this population. Further prioritization can occur if they are stratified by the presence of ≥ 1 of the following: family history of DM, family history of hypertension, diagnosis of hypertension, or diagnosis of hypercholesterolemia. In addition, those in the high-risk group were more likely to attribute problems to physical and emotional health, indicating opportunities for improving quality of life as the other modifiable risk factors are improved. Clinical management of the other risk factors remains necessary, and a comprehensive multidisciplinary team approach is essential to address the needs of the whole patient. To optimize success in the interventions, behavior change programs need to include easy access, convenience, long-term follow-up, and continued participation.³⁷ Coordinating care with the provider is also necessary to allow for reinforcement of positive behavior changes, especially in those with elevated risks.²¹ An example of one such program is the previously described weight management course through the Partners for Better Health PhoneLine.³⁸ This program has been shown to be effective, resulting in a decrease in body weight of 1 to 2 BMI units in 6 months.³⁸ This health plan-based, centrally located resource is easily accessible to members and is systematically linked to the HRA database, allowing for individualized proactive follow-up by certified diabetes educators once the HRA is completed. The results of the HRA and the interaction with the telephone-based counselor are documented and become part of the medical record, and a communication is sent to the provider, ensuring continuity of care.³⁹

Study Limitations

Several caveats must be considered when interpreting these results. The use of administrative claims data created limitations, such as the absence of clinical detail and validation of its accuracy.

Because the study population is primarily employed, relatively young, educated white women, it did not include those who are unemployed, uninsured, or enrolled in public assistance plans such as Medicaid or Medicare. These higher-risk individuals may not have access to or wish to complete such questionnaires, which may limit the usefulness of

this approach in the wider population. Furthermore, it is likely that a more senior population more representative of these higher-risk groups would result in a higher incidence of DM in the high-risk group. These assumptions suggest that the 5-fold greater risk of developing type 2 DM in this evaluation is a conservative finding. Also, this evaluation was based on mean follow-up of 2.55 years. As follow-up lengthens, it would stand to reason that the incidence of DM would continue to rise, assuming that the modifiable risk factors remained the same over time.

The data available for this analysis also limited our ability to determine the proportion in each group that had received a DM screening test during the course of the study. However, based on previous studies conducted among members of this MCO, we know that screening for DM among high-risk patients is already high.⁴⁰

We were also limited in our ability to validate the actual status of the 102 patients without a diagnosis of DM owing to the absence of clinical detail. Many are likely to have diet-controlled DM, and the lack of clinical data leaves the question open. In addition, there were 45 diagnosed cases that did not self-report DM. These could have been individuals who were told that they have a "touch of sugar" or that they have "high blood glucose" without being told that they actually have DM. Clearly, access to the clinical data could have had an impact on the results. However, the dependence on administrative claims data without clinical data is the case for most MCOs, thus making this model a feasible, reasonably effective method of assessing an MCO population. This lack of clinical data also meant that we could not differentiate between type 1 and type 2 DM. The assumption was made that most (possibly as much as 95%) would have type 2 DM but that there were likely some with type 1 DM. The number of new cases is likely slightly less if we take this into consideration. Furthermore, there was likely some undiagnosed DM in the sample, which could also have an impact on the results. The assumption is that this information may have increased the number of new cases, but to what degree is uncertain and would require further study.

In 1997, there were changes in the diagnostic criteria for DM that required a fasting glucose level of 126 mg/dL.⁴¹ This may have impacted the efforts toward DM case finding in the MCO. If this new criteria increased the efforts to identify individuals with undiagnosed DM, it is possible that the number of new cases was higher owing to the increased attention that diagnosis of DM was receiving. The

available data did not allow for us to determine the exact impact of this change.

Another possible confounder is the existence of an intervention after identification of individuals at risk. Intervention was not withheld throughout the course of the study, and, consequently, interventions that did occur may have had an impact on the results. The assumption is that without any intervention, the actual new cases of DM could potentially have been even higher.

Conclusions

The focus of screening, as supported by the ADA, is on asymptomatic individuals of specific high-risk populations.²⁸ This view is shared by the Guide to Clinical Preventive Services²² and by experts at the National Institutes of Health.³⁰ A challenge remains, however, to identify individuals from the general, apparently healthy, population who are at a level of risk appropriate for screening. It has been unclear how to assess risk in individuals across large populations in a manner that has the potential to reach all individuals in a given population and that is sustainable within the constraints of dedicated, but limited, resources. Strategies to do so need to be simple and low cost and must allow for follow-up at the individual level. The use of self-report data as outlined in this report, in combination with diagnostic screening of only those identified as being at high risk, is a potentially efficient and effective strategy for appropriate resource allocation and population health improvement. To ensure proper follow-up, a recommendation to individuals who score ≥ 5 points on the DM assessment to visit their medical care provider may be warranted. The integration of this assessment tool into a more comprehensive HRA shows promise in effectively reaching out to a large population and seems to be effective. What remains to be determined is the long-term sustainability and scalability of such an approach.

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