Screening for pre-diabetes and diabetes in the workplace

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Background Diabetes is an increasingly prevalent and burdensome disease in working populations. In settings with established occupational medical programmes, there may be opportunities to intervene in a positive way to reduce the burden of this disease.

Aim To integrate diabetes screening and prevention into an existing occupational medical programme.

Methods Screening to detect potential cases of pre-diabetes and diabetes was conducted in a large working population using differing criteria to define risk groups over a 2-year period. Classification of new cases was based on fasting plasma glucose, random plasma glucose or oral glucose tolerance test (OGTT).

Results Among 13 086 employees screened via fasting or random glucose, there were 96 diabetes and 650 pre-diabetes cases detected. Among high-risk employees, 20 new cases of pre-diabetes and 8 cases of diabetes were detected in 84 employees assessed by OGTT. The percentage of employees with new findings increased with increasing age (2.3%, under age 40 compared to 11.4% for age 50 years and above) and body mass index (2.6, 6.1 and 11.4% among normal weight, overweight and obese employees, respectively).

Conclusions Given the likely magnitude of unrecognized diabetes and pre-diabetes cases, further interventions are being implemented targeting all employees and not just those who require routine occupational medical examinations.

Key words Aging workforce; diabetes; pre-diabetes; workplace health promotion.

Introduction Projected increases in the global prevalence of Type 2 diabetes suggest that its treatment and prevention could become one of the major health challenges of the 21st century [1]. Within Germany, diabetes is among the most common and expensive of chronic diseases [2] and yet large numbers of cases remain undiagnosed [3]. It has been estimated that as many as 14 million Germans will be diagnosed with Type 2 diabetes by 2010 [4].

Pre-diabetes, characterized as impaired glucose tolerance (IGT) or impaired fasting glucose (IFG), is recognized as a key step in the progression from normoglycemia to Type 2 diabetes [5]. Several recent studies have shown that early detection of pre-diabetes and intervention with lifestyle changes can prevent or delay the onset of diabetes among high-risk adults [6–8]. In the Finnish diabetes prevention study, the subsequent development of diabetes was reduced by 58% >3 years in the intervention arm of the study.

There is also considerable impetus to detect and treat pre-diabetes as early as possible, given the implications with respect to risk of cardiovascular disease [9].

Corporate medical departments are frequently required to perform routine health examinations for occupational health and safety reasons. Meeting these obligations can provide opportunities to contribute more broadly to disease prevention. As part of its employee health commitments, the BASF Occupational Medical and Health Protection Department (Medical Department) in Ludwigshafen, Germany, performs such medical examinations and maintains an occupational medical information system. We undertook an assessment of the overall health status of our workforce with respect to age, obesity levels and the prevalence of known cases of diabetes and initiated screening studies to gauge the potential scope of diabetes risks within the workforce and
estimate the prevalence of undetected pre-diabetes and diabetes in defined risk groups. The findings of these investigations and their implications to the design of disease prevention programmes in occupational settings are described and discussed in the present article.

Methods

Through an electronic search of occupational medical records, we retrospectively examined the results of diabetes screening undertaken during 2004–05 in conjunction with routine occupational medical examinations. Initially, a subset of active employees was identified, who had participated in prior occupational medical examinations in recent years and for whom a diagnostic history, as well as data on age and body mass index (BMI), was available. Additional searches were then performed to retrieve results on different screening approaches utilized during 2004–05 within the identified target population.

One screening approach was specifically aimed at identifying employees at high risk for diabetes. High-risk employees were identified in two different ways. First, for a period of 4 months in 2004 and for the full year of 2005, employees seen by two physicians for scheduled occupational health examinations at the BASF on-site clinic were offered voluntary participation in a diabetes screening programme. Each participant was interviewed and measurement of height, weight and blood pressure taken. Laboratory analyses consisted of a complete blood count, triglycerides, total cholesterol, low-density and high-density lipoprotein, random glucose, hepatic transaminases and creatinine. Employees at risk for pre-diabetes or diabetes were identified as candidates for further evaluation based on physician review of laboratory data, physical measurements and family history of diabetes according to the recommendations for screening for Type 2 diabetes from the American Diabetes Association (ADA) in 2004 [10].

A second high-risk group consisted of 35 obese (BMI >30 kg/m²) employees identified from among participants in a voluntary weight reduction programme conducted by the medical department in 2005. Eligible employees in both groups were then offered an oral glucose tolerance test (OGTT) if they were not currently under treatment for diabetes. The standard OGTT was performed with 75 g of glucose followed by estimation of intravenous blood glucose concentrations at 60 and 120 min. The findings for each participant were classified according to the World Health Organization criteria as having normal glucose tolerance, IGT or overt diabetes mellitus. Individuals with positive findings were referred to their personal physicians for follow-up.

An additional screening approach was to identify all members of the active workforce who had fasting or random plasma glucose tests performed during 2004 or 2005. Fasting glucose tests are not routinely performed and may have been requested by physicians as part of medical follow-up examinations. Random plasma glucose tests are performed much more frequently, generally in conjunction with routine occupational medical examinations and as part of a standard laboratory test battery.

Data analysis was carried out using SAS version 8 software (SAS Institute, Cary, NC, USA). The first analysis step was to merge data from the various screening tests to the master file of active employees with prior occupational medical examinations. Employees were subdivided into four groups: those with (i) OGTT in the high-risk group, (ii) fasting glucose testing, (iii) random glucose testing only and (iv) no glucose testing. Employees in each subgroup were characterized with respect to age, BMI and prior history of diabetes. All subjects without a prior history of diabetes were then categorized as having findings consistent with pre-diabetes or diabetes based on the glucose test results. For pre-diabetes, the following criteria were used: (i) 2-h OGTT values of 7.8 to <11.1 mmol/l, fasting glucose values of 6.1–6.9 mmol/l or random glucose between 7.2 and <11.1 mmol/l. The corresponding limits for diabetes were as follows: 2-h OGTT ≥11.1 mmol/l, fasting glucose ≥7.0 mmol/l or random glucose ≥11.1 mmol/l. Classification and diagnoses entered by physicians were also examined as additional laboratory tests such as HbA1c were often obtained, particularly among the individuals who underwent OGTT.

Results

Of an active workforce of 33 800 employees including those in office and administrative positions, 24 749 had participated in prior medical examinations and had available height and weight data. Selected characteristics of this population are summarized in Table 1. The population includes a large percentage of men because men are more likely than women to be assigned to jobs requiring clinic visits for work-related examinations such as respiratory fitness testing or shift-work examinations. Table 1 summarizes the distribution of employees by age group, gender, BMI category and prior diabetes status. Approximately 42% of the employees were under age 40 at the start of 2004. In general, the percentage of normal weight individuals declined with increasing age group and the percentages of overweight and obese individuals increased with increasing age. About 1% of all employees were classified as severely obese across all age groups.

Of these employees, 743 (3.0%) had a history of diabetes recorded in the occupational medical record based on clinic visits occurring before 2004. This number does not include ~250 individuals for whom the examining physician had indicated only a suspicion of diabetes. The prevalence of diabetes by age group and BMI...
for diabetes. Among those tested, we identified eight new cases of screen-detected diabetes and 20 new cases of screen-detected pre-diabetes via 2-h OGTT results. Based on physician evaluations and additional follow-up, there were 11 new cases of diabetes and 34 cases of pre-diabetes diagnosed in individuals at high risk and without a prior diagnosis.

Based on evaluation of fasting glucose levels in 2255 employees, we detected via laboratory results 65 new diabetes cases and 266 cases of pre-diabetes. Thus, 15% of all tested employees had findings consistent with diabetes or pre-diabetes. Using the new ADA (2006) recommendation for categorizing all individuals with a fasting glucose $\geq 5.55 \text{ mmol/l}$ [11] as having IFG, an additional 718 pre-diabetes cases (32%) would be recognized. Among the 10831 employees who only participated in random glucose testing, 4% had findings consistent with diabetes or pre-diabetes.

All three screening methods combined led to the detection of 104 new diabetes cases and between 670 and 1388 cases of pre-diabetes, depending on the range of fasting glucose values used to define pre-diabetes cases. With each screening method, detection rates increased with increasing age and BMI. For example, new findings were detected in 11.4% of employees over age 50 compared with 2.3% in employees under age 40. Among obese individuals (BMI $\geq 30 \text{ kg/m}^2$), new findings were detected in 11.3% compared with 2.6 and 6.1% among normal weight and overweight individuals, respectively. However, because of the larger number of overweight compared to obese employees, in absolute terms there were more total new case findings among overweight employees (322 pre-diabetes and 40 diabetes cases) than among obese employees (241 pre-diabetes and 50 diabetes cases). Pre-screening for high risk did result in a higher prevalence of new positive findings among those tested (34%) compared with the other screening methods that did not involve formal pre-screening (15% for fasting glucose and 4% for random glucose testing).

**Discussion**

Our diabetes prevalence findings are consistent with other surveys from this region of Germany. In comparison with 1998 results for West Germany [12], we found similar, but somewhat higher, age-specific prevalence rate in men. For example, among men, aged 18–39, our diabetes prevalence rate was 1.2 versus 0.5% for West Germany. The corresponding prevalence rate among men, aged 40–49 and 50–59, were 3.5 versus 1.4% and 7.8 versus 7.4%, respectively. The higher prevalence in younger men could be due to enhanced prior screening in our population compared to that seen in the general population. A recent survey conducted in this region of Germany reported that many cases of pre-diabetes go
undetected and that diabetes is diagnosed later in the course of the disease than desirable [13]. This appears to be the situation even though screening tools, such as the fasting glucose test, are readily available for detecting progression to pre-diabetes. Even within the normoglycemic range (<5.55 mmol/l), relatively higher fasting plasma glucose levels among men under age 45 constitute an independent risk factor for Type 2 diabetes [14].

The screening efforts undertaken during 2004–05 resulted in the detection of 104 new diabetes and 670 new pre-diabetes cases based on the algorithms used in defining cases. Although these numbers are substantial, there are several limitations to the approach used in deriving these estimates. First, while pre-screening to identify candidates for OGTT resulted in higher percentage yields of new cases among those tested, details regarding the size of the pre-screen population are not available. The fasting glucose testing could also involve a sequential element, in that the physician may have requested a fasting blood specimen due to a perceived risk of diabetes. The random glucose testing is limited by uncertainties in test interpretation as reflected in the higher values required by the algorithm for defining cases. In our population, there were 742 employees who had both random and fasting glucose tests during 2004–05. While for classification purposes, the fasting blood sample was preferred over the random blood sample, we compared the results in the same individuals based on the type of blood sample and found that 4.1 and 13.6% would be classified as new diabetes and pre-diabetes cases based on the fasting sample, whereas only 0.5 and 6.5% would be classified as new diabetes and pre-diabetes cases based on the random sample. Thus, the more stringent cutoff points for the random sample test probably resulted in an underestimate of the number of new cases which would have been identified had fasting samples been available for all individuals who were screened. Among employees who were tested first by random glucose and then had a fasting glucose test, the percent of positive findings was 22.9% suggesting that fasting glucose tests may have been requested in some instances because of a higher perceived risk. It is also recognized that our screening was not equally available to all employees, being mostly predicated on attendance at our medical clinic for required occupational examinations.

During 2006 the Medical Department initiated further pre-diabetes and diabetes screening and is developing an expanded intervention programme. The 2006 screening initiative was offered on a voluntary basis to all employees and not just those assigned to jobs requiring routine examinations. Brochures explaining the initiative were distributed to employees and notification of the enrolment procedure was provided through the BASF intranet and newsletters. Over 1500 employees elected to participate in the new initiative. The Department is developing further programmes to make available primary and secondary prevention measures to individuals at risk for diabetes and other chronic diseases. To this end, we are working cooperatively with the company’s health insurance providers and family physicians in the region and through the BASF Health Promotion Centre to implement programmes combining early detection of diabetes with lifestyle intervention and modification. The recent successes of intervention trials demonstrate that individuals at high risk can be identified and diabetes onset delayed, if not prevented [15, 16].

There are cost and efficiency advantages in undertaking chronic disease interventions within the existing occupational health programmes, particularly where an electronic medical information system is in place and there are large numbers of employees being served by the occupational medical programme. Existing data can be helpful in identifying high-risk individuals for special testing as in the case of the oral glucose tests performed in this study. The workplace also appears to be a promising focal point for conducting disease screening and prevention programmes based on the proximity of medical services to the employee and the requirements for conducting routine occupational health examinations. Previously, we have shown that offering participation in preventive health programmes during attendance at routine examinations was an effective way to reach employees who

<table>
<thead>
<tr>
<th>Screening method</th>
<th>No screening</th>
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<tbody>
<tr>
<td></td>
<td>OGGT (high-risk group)</td>
</tr>
<tr>
<td>Number of employees</td>
<td>84</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>34.3 ± 6.7</td>
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<tr>
<td>Age (years)</td>
<td>41.9 ± 8.6</td>
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<tr>
<td>Gender (% men)</td>
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<tr>
<td>Screen detected</td>
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<tr>
<td>Diabetes, n (%)</td>
<td>8 (10)</td>
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<tr>
<td>Pre-diabetes, n (%)</td>
<td>20 (24)</td>
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could benefit from such programmes [17]. Health interventions can be of value to the employee and employer alike with employers potentially benefiting from a reduction in direct medical and indirect or lost productivity costs as indicated by diabetes cost estimates developed by the ADA [18].

The timeliness of these diabetes detection and prevention initiatives is all the more important considering the expected aging of the workforce projected for Germany in the coming years. While 19% of our workforce is currently aged 50 or older that percentage is predicted to rise to 33% by the year 2015 [19]. In anticipation of the expected aging of the workforce over the next decade, additional plans are being developed to address other chronic diseases in a similar manner.

Key points
- The workplace is a promising setting for initiating health screening and disease prevention programmes, particularly where on-site medical services are in place and there are requirements for performing routine occupational health examinations.
- Integrating a diabetes screening strategy into an existing occupational medical programme can lead to detection of substantial numbers of previously unrecognized diabetes and pre-diabetes cases.
- Given the anticipated aging of the workforce over the next decade, there could be additional cost and efficiency advantages in broadening the scope of occupational medical programmes to include wellness and health screening activities of proven merit.

Conflicts of interest
C.O., S.M.N. and A.Z. are employees of BASF Aktiengesellschaft and M.G.O. is an employee of BASF Corporation and all authors hold stock in BASF.

References