

THE ANALYSIS OF SCREENING COSTS FOR HYPERCHOLESTEROLEMIA AND HYPERGLYCEMIA AS PART OF OBLIGATORY EXAMINATIONS OF EMPLOYEES

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Abstract

Objectives: High prevalence of hyperlipidemia and hyperglycemia requires searching for efficient and cost-effective methods of an early detection of these disorders. In Poland, obligatory employee medical check-ups could be a solution. **Material and Methods:** The study included a group of university employees who underwent obligatory occupational examinations in 2018. Each employee had an additional lipid (unit cost: EUR 2.56) and blood glucose profile (EUR 0.93) done. The number of respondents involved in the study was 850 (340 males and 510 females), and their average age was 47 years (SD = 11 years). The education distribution was as follows: employees with secondary vocational and general education (physical, frontline and administrative workers): 176 (age: M±SD 50.3±10.3); employees with a university degree (academics with an M.Sc. or/and Ph.D. title and administrative staff): 535 (age: M±SD 43.6±9.8); and academics with a university title (Ass. Prof. and/or Prof.): 139 (age: M±SD 56.2±10.2). **Results:** Dyslipidemia (elevated total cholesterol ≥190 mg/dl and/or low-density lipoprotein cholesterol ≥115 mg/dl) was reported in 560 workers (65.9%). Hyperglycemia (fasting glucose ≥100 mg/dl) was observed in 256 workers (31%). The total cost of detecting a single case of dyslipidemia and hyperglycemia was EUR 3.88 and EUR 3.09, respectively. Divided by age groups, the costs were as follows: EUR 4.34 and EUR 4.53 in the age group <45 years; EUR 3.56 and EUR 2.42 in the age group ≥45 years. The costs of detecting a single case of dyslipidemia and hyperglycemia in employees aged ≥45 with regard to education were as follows: EUR 3.20 and EUR 2.07 in persons with secondary vocational and general education; EUR 3.40 and EUR 2.80 in persons with a university degree; and EUR 4.38 and EUR 2.28 in persons with a university title. **Conclusions:** Due to the fact that the reporting rate for screening tests in the framework of occupational medicine is high, the cost of occupational screening tests for dyslipidemia and hyperglycemia can be lower than the cost of screening tests in the general population. *Int J Occup Med Environ Health.* 2021;34(5)

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INTRODUCTION

High prevalence of hyperlipidemia and hyperglycemia indicates the necessity to use the already available systemic health care solutions to implement effective preventive measures aimed at an early detection of cardiovascular diseases and diabetes, and increasing general awareness of the risk related to these diseases. Special attention should be focused on the labor force, especially in the context of the aging of working populations and occupational risk factors for cardiovascular diseases and diabetes. Numerous examples presented in scientific literature show that occupational health programs can not only improve workers' health, but also bring significant savings in both short and long term [1]. A multicenter study in Europe, North America and Australia revealed that an investment of EUR 1 in occupational health can be recouped in the amount of EUR 2.2 as well as bring additional benefits including increased safety and a better health condition of workers [2]. The basic problem related to the publicly funded health prevention programs in Poland is the insufficient reporting rate, even though these programs are free of charge [3]. A solution could be an effective use of obligatory periodic occupational examinations, which are performed in 5 million workers annually in the 12-million population of the employed [4]. Administratively imposed occupational examinations require a worker to visit a health center, thus creating an opportunity to do a number of screening tests.

The current, legally regulated scope of mandatory occupational examinations does not cover the lipid and blood glucose profiles [5], and including these tests requires cooperation between an employer, an occupational health center and an employee. The employer has to finance these tests, the employee has to report to the health center on an empty stomach, and the medical facility has to adopt a proper procedure.

Health programs aimed at an early detection of diseases should be validated following 2 basic criteria: efficacy

expressed as the number of detected disease cases, and cost-effectiveness understood as the health program cost per 1 detected disease case.

The aim of the study was to evaluate the efficacy and cost-effectiveness of hypercholesterolemia and hyperglycemia detection in university employees by means of obligatory occupational screening tests.

MATERIAL AND METHODS

The authors analyzed the effects of a 1-year occupational screening program aimed at detecting hypercholesterolemia and hyperglycemia. The study included all employees of a university in Łódź, who obligatorily underwent occupational examinations in 2018.

The analysis was based on data obtained from 850 study participants (340 males and 510 females), their average age being 47 years (SD = 11 years). The following 3 subgroups were distinguished with regard to the educational status of those included in the study:

- employees with secondary vocational and general education (physical, frontline and administrative workers) – 176 persons (age: $M \pm SD$ 50.3 ± 10.3);
- employees with a university degree (academics with an M.Sc. or/and Ph.D. title and administrative staff) – 535 persons (age: $M \pm SD$ 43.6 ± 9.8);
- academics with a university title (Ass. Prof. and/or Prof.) – 39 persons (age: $M \pm SD$ 56.2 ± 10.2).

Every employee who reported to the health center with a referral issued by the university underwent an obligatory occupational examination whose scope was extended with the lipid profile and a fasting plasma glucose (FPG) test. Employees had been informed by the referring body about the necessity to appear for the examination on an empty stomach. This information was also written down on the referral. After the examination, each employee received the results, interpretation of the results and recommendations (e.g., follow-up examinations, lifestyle changes, treatment). Laboratory tests were performed

on a fasting blood sample in an accredited laboratory. The concentration of low-density lipoprotein (LDL) cholesterol was calculated with the Friedewald formula. Dyslipidemia was established based on the criteria indicated in the Sopot Declaration [6].

The χ^2 test was used to compare the proportions in the subgroups. The analysis was performed using TIBCO Software Inc. (2017) Statistica (data analysis software system) ver. 13.

The exchange rate of EUR 1 = PLN 4.3 was adopted in the cost calculation.

The study was approved by the Bioethics Committee of the Nofer Institute of Occupational Medicine in Łódź (Resolution No. 04/2015 of February 18, 2015).

RESULTS

Efficacy of dyslipidemia and hyperglycemia detection

The number of detected dyslipidemia cases, i.e., elevated total cholesterol ≥ 190 mg/dl (4.9 mmol/l) and/or LDL cholesterol ≥ 115 mg/dl (3 mmol/l), and also the number of detected hyperglycemia cases, i.e., fasting glucose

≥ 100 mg/dl (5.6 mmol/l), are presented in Table 1 by education and age.

In the calculation of the efficacy of hyperglycemia detection, only persons with no previous diagnosis of diabetes were included. A total of 23 employees (2.7%) had been previously diagnosed with diabetes, including 4 persons with secondary vocational or general education, 11 persons with higher education, and 8 senior academics. Apart from 5 persons with higher education, the diabetics were aged >45 years.

A statistically significant, higher incidence of dyslipidemia and hyperglycemia in employees aged ≥ 45 years was observed among employees with secondary vocational or general education, and among those with a university degree.

Cost-effectiveness of dyslipidemia and hyperglycemia detection

In the analyzed study, the unit cost of the lipid profile was PLN 11.00 (EUR 2.56), and the unit cost of blood glucose profile was PLN 4.00 (EUR 0.93).

Table 1. Dyslipidemia (total cholesterol ≥ 190 mg/dl and/or low-density lipoprotein cholesterol ≥ 115 mg/dl) and hyperglycemia cases (fasting glucose ≥ 100 mg/dl) in a group of university employees who underwent obligatory occupational examinations in 2018, Łódź, Poland

Variable	Participants (N = 850)						
	secondary vocational or general education (N = 176)		university degree (N = 535)		university title (N = 139)		total
	n (%)	p	n (%)	p	n (%)	p	
Dyslipidemia in the age group							
<45 years	36 (64.3)	0.02	186 (57.4)	<0.001	10 (71.4)	0.35	232 (58.9)
≥ 45 years	96 (80)	0.02	159 (75.4)	<0.001	73 (58.4)	0.35	328 (71.9)
total	132 (75)	–	345 (64.5)	–	83 (59.7)	–	560 (65.9)
Hyperglycemia in the age group							
<45 years	14 (25)	0.01	63 (19.7)	0.0003	4 (28.6)	0.37	81 (20.8)
≥ 45 years	54 (46.6)	0.01	70 (34.1)	0.0003	51 (43.6)	0.37	175 (40)
total	68 (39.5)	–	133 (25.4)	–	55 (42)	–	256 (31)

Table 2. The cost of detecting a single dyslipidemia case (total cholesterol ≥ 190 mg/dl and / or low-density lipoprotein cholesterol ≥ 115 mg/dl) and hyperglycemia case (glucose concentration ≥ 100 mg/dl) in a group of university employees (N = 850) who underwent obligatory occupational examinations in 2018, Łódź, Poland

Age group	Single case detection cost															
	participants with secondary vocational or general education		participants with university degree		participants with university title		all participants									
	dyslipidemia	hyperglycemia	dyslipidemia	hyperglycemia	dyslipidemia	hyperglycemia	dyslipidemia	hyperglycemia	dyslipidemia	hyperglycemia	dyslipidemia	hyperglycemia				
<45 years	PLN 17.11 EUR 3.98	PLN 16.00 EUR 3.72	PLN 19.16 EUR 4.46	PLN 20.57 EUR 4.78	PLN 15.40 EUR 3.58	PLN 14.00 EUR 3.26	PLN 18.68 EUR 4.34	PLN 19.46 EUR 4.53	PLN 17.11 EUR 3.98	PLN 16.00 EUR 3.72	PLN 19.16 EUR 4.46	PLN 20.57 EUR 4.78	PLN 15.40 EUR 3.58	PLN 14.00 EUR 3.26	PLN 18.68 EUR 4.34	PLN 19.46 EUR 4.53
≥ 45 years	PLN 13.75 EUR 3.20	PLN 8.89 EUR 2.07	PLN 14.60 EUR 3.40	PLN 12.06 EUR 2.80	PLN 18.84 EUR 4.38	PLN 9.80 EUR 2.28	PLN 15.29 EUR 3.56	PLN 10.42 EUR 2.42	PLN 13.75 EUR 3.20	PLN 8.89 EUR 2.07	PLN 14.60 EUR 3.40	PLN 12.06 EUR 2.80	PLN 18.84 EUR 4.38	PLN 9.80 EUR 2.28	PLN 15.29 EUR 3.56	PLN 10.42 EUR 2.42
Total	PLN 14.67 EUR 3.41	PLN 10.35 EUR 2.41	PLN 17.06 EUR 3.97	PLN 16.09 EUR 3.74	PLN 18.42 EUR 4.28	PLN 10.11 EUR 2.35	PLN 16.70 EUR 3.88	PLN 13.28 EUR 3.09	PLN 14.67 EUR 3.41	PLN 10.35 EUR 2.41	PLN 17.06 EUR 3.97	PLN 16.09 EUR 3.74	PLN 18.42 EUR 4.28	PLN 10.11 EUR 2.35	PLN 16.70 EUR 3.88	PLN 13.28 EUR 3.09

Exchange rate: EUR 1 = PLN 4,3 (June 13, 2020).

The costs of detecting one case of dyslipidemia or hyperglycemia are presented in Table 2 by education and age. All the study participants (also those previously diagnosed with diabetes) were included in the calculation of the cost-effectiveness of detecting a single case of hyperglycemia.

DISCUSSION

The occupational screening program presented in this paper was based on the obligatory performance of the occupational examination (pursuant to the Polish Labor Code [7]), and additional laboratory lipid profile and glucose tests done in all participants to the study. Considering the administratively imposed obligation to undergo occupational medical examinations, the efficacy of dyslipidemia and hyperglycemia detection in the presented study should be higher than that obtained in the population-based studies. A beneficial effect of occupational screening tests was also observed by Wilson [8] who indicated a positive influence of the high reporting rate of employee medical check-ups on the profitability analysis. However, the effectiveness of dyslipidemia and hyperglycemia detection depended largely on workers' compliance with the requirement of performing the tests on an empty stomach.

Efficacy of dyslipidemia and hypercholesterolemia detection

The percentage of dyslipidemia cases reported in the study (Table 1) corresponds both to the data on the population aged 20–74 years (65.9% vs. 70%) and to the data presented by age groups (in the WOBASZ II study, the percentage was <50% in males aged <34 years; it reached >70% in the older age groups; an increase in the incidence of hyperglycemia was also observed in women aged 55–64 years, which was followed by a decrease in older age groups) [9].

The percentage of the diagnosed hyperglycemia cases (Table 1) was significantly higher than in other studies, where the incidence of impaired glucose regulation in

Europe was at the level of approx. 15%; impaired fasting glucose (IFG) in adults reached only 10%, and the incidence by age groups was 10.6% in the group aged 30–65 years, and 8.9% in the group aged >66 years) [10]. However, the incidence of abnormal glycemia (25.3%) was similar to the results obtained in the corresponding screening tests on another group of workers in Poland [11]. Interpretation of the obtained results requires considering the risk of non-compliance with the requirement of undergoing the examination on an empty stomach, on the one hand, and the possible underestimation of the incidence of carbohydrate metabolism disorders in the general population, and high unawareness of diabetes (even up to 42%), on the other [12].

Scientific literature indicates a positive influence of education on better health indicators [13]. This regularity was also observed in the study presented in this paper with regard to hyperglycemia. An exception was the higher incidence of hyperglycemia in persons with a university title, i.e., in the group of participants to the study with the highest level of education. The reason behind this phenomenon could be risk factors for diabetes related to a long scientific career, such as long working hours and a sedentary lifestyle [14,15].

Cost-effectiveness of dyslipidemia and hyperglycemia detection

Health and economic benefits of screening tests for hyperlipidemia and hyperglycemia are undeniable. However, there is a discussion about selecting the right target group (the entire population with no preselection or a part of the population that meets additional criteria, such as age or comorbidity criteria), the scope of screening and diagnostic tests, and the frequency of tests. Numerous occupational screening strategies have been presented in the literature on the cost-benefit analysis [8,16,17]. Participation in the occupational medical examination program for senior construction workers showed beneficial results

in a 3-year period with regard to workers' levels of lipids, glycated hemoglobin HbA_{1c}, blood pressure, nicotine, and an assessment of the 10-year risk for cardiovascular diseases. In the same study, Welch [16] also observed that physical workers were motivated to improve their health condition when they were given a tailored health program. In turn, Weinhold [18] revealed a positive impact of the health program on university employees.

Age group selection

A systematic review of 56 studies on the cost-effectiveness of interventions aimed at preventing and controlling diabetes showed the uncertainty of data on cost-benefit in relation to the age of those screened for undiagnosed type 2 diabetes. One study found that cost-effectiveness ratios increased, while another study reported that they decreased with age [19]. In the dyslipidemia management guidelines, the lipid profile screening is recommended in men aged >40 years, and in women aged >50 years or after the menopause [20]. However, the diabetes management guidelines recommend screening for diabetes every 3 years in patients without risk factors aged >45 years, and with selected risk factors every year regardless of age [21]. The studies by Hoerger et al. [22] and Waugh et al. [23] indicate the profitability of targeting diabetes screening tests at specific age groups, as they obtained the highest cost-benefit ratios in the 55–75 and 40–70 age groups, respectively.

Target group selection

In American studies on the detection of diabetes in the population of all ages who were under the care of a primary care physician, profitability rates were more favorable for screening tests in the group of persons with arterial hypertension than for universal screening (without additional criteria) [22]. Apart from hypertension, Waugh et al. [23] noted the greater cost-effectiveness of screening tests aimed at obese persons. Considering the Polish

screening tests for familial hypercholesterolemia, which also included first job takers, the most cost-effective strategy was the selection of patients after an acute coronary syndrome below 55–65 years of age [17].

Type of screening tests

The choice of the scope of screening tests aimed at detecting diabetes is also interesting. In a German study conducted by Icks et al. [24], the most effective screening strategy (54% of detected cases), but also the most expensive one (EUR 21.44 and EUR 31.77 per patient), was the HbA_{1c} test in combination with the oral glucose tolerance test (OGTT). Lower costs were generated by the OGTT alone (EUR 4.90 per patient) and the FPG test in combination with OGTT (EUR 10.85) [24]. In England, based on the multiethnic LEADER population aged 40–74 years, Gillet et al. [25] indicated that it is more cost-effective to perform screening tests for diabetes with the HbA_{1c} test than with the FPG test. However, they observed that in other populations characterized by a higher incidence of diabetes and a higher risk of diabetes, FPG may be more profitable than HbA_{1c}. In the case of lipid profile screening tests, Berg [36] noted an increased benefit-cost ratio of the complex cardiovascular risk indicators (total cholesterol, high-density lipoprotein [HDL] cholesterol, apolipoprotein A) compared to the total cholesterol alone [26].

Screening frequency

In a study conducted in Canada, changing the frequency of screening tests for diabetes had little effect on the cost-effectiveness rates. However, it was observed that the lack of screening tests with regard to the quality-adjusted life years (QALY) cost the health care system USD 4812 more than the performance of screening tests every 5 years, and the greatest health and financial benefits were achieved when IFG tests were done every 3 years or every year in persons with no prediabetes or with prediabetes, respectively [27]. Brateanu et al. [28] also indicated the benefits

of adjusting the screening frequency to the previous test results, and they showed that patients with the high risk of diabetes might be re-tested after 8 months, while patients with relative and low risk might be re-tested after 3 and 5 years, respectively.

Scope of screening tests

It is worth noting that additional health interventions, besides screening tests, can be beneficial. One-time screening for undiagnosed diabetes and pre-diabetes in young adults in China showed greater cost savings when it was accompanied by appropriate lifestyle interventions among patients with impaired glucose tolerance [29]. A study in America showed that lifestyle interventions in university workers are highly effective in lowering fasting glucose levels [18]. Wilson et al. [8] proved the cost-effectiveness of behavioral interventions aimed at reducing high serum cholesterol in the production population, and they obtained the lowest costs for 1- and 3-month educational interventions.

Implications of screening tests of employees

Screening tests that go beyond the scope of standard periodic occupational examinations [5], e.g., tests for hypercholesterolemia and hyperglycemia, can be financed by employers using 2 mechanisms. The first one is the subscription fee (flat rate), which gives an employee access to an agreed test package at any time. There is no time limit imposed, and it is voluntary to do the tests. The other mechanism is the one presented in this study and based on the employee's obligation to undergo a periodic occupational examination, during which lipid and fasting glucose profiles are additionally done at the employer's expense. This mechanism translates into a very high reporting rate (100% in this study). The precondition for performing additional screening tests is an appropriate preparation of the employees concerned, which involves effective notification of the purpose of the examination and the necessity

to report to the health center on an empty stomach. A solution to this problem could be another more convenient test that does not require fasting, i.e., HBA1c, as suggested by Waugh et al. [23]; however, according to the current guidelines, this test is not recommended for the diagnosis of diabetes in Poland [21].

Considering the frequency of occupational examinations, on the one hand, which is determined, e.g., by high fluctuation [4], and cost-effectiveness, on the other hand, which results from the frequency of screening tests [21,27,28], it seems to be an optimal solution to include screening tests for hyperglycemia and dyslipidemia in occupational medical examinations at specific time intervals, e.g., every 3–5 years. However, the condition should be the continuation of preventive care in the same occupational health center or easy access to previous test results, e.g., by means of electronic records.

Based on the results obtained in this study (lower costs of detecting hypercholesterolemia and hyperglycemia) and other studies [20–23], it seems to be justified to preselect the target group with the criterion of age being >40 or >45 years. It is worth considering additional screening tests for younger persons based on the results of their medical examination (previous test results, identified increased cardiovascular or diabetes risk). Preselection with regard to the job position does not determine better cost-benefit effects, as shown in the case of the costs of hyperglycemia detection in persons with a university title. However, the occupational risk factors for cardiovascular diseases and diabetes, such as occupational stress or shift work, cannot be forgotten [30]. Moreover, it should be noted that the medical screening tests without further intervention are not legitimized. Therefore, after detecting abnormality during periodic examinations, employees should receive further instructions on lifestyle, continuation of diagnosis and possible therapy in primary or specialist health care. This study is not a prospective study, and the analysis was based on one-time screening tests, which constitutes one

of the study limitations, apart from the lack of an in-depth cost-benefit analysis and QALY. However, it is still the first survey in Poland to show the costs incurred by the employer financing additional screening tests within the framework of periodic occupational examinations. It is worth noting that other related costs (e.g., the cost of the employee's absence during the occupational examination or medical consultations) should not be treated as a separate cost of screening tests, as they have already been included in the costs of obligatory periodic examinations. This seems to be an advantage of doing screening tests as a part of other examinations, such as periodic occupational examinations.

CONCLUSIONS

Due to the fact that the reporting rate for screening tests in the framework of occupational medicine is high, the cost of occupational screening tests for dyslipidemia and hyperglycemia can be lower than the cost of screening tests in the general population.

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