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COMPARATIVE ANALYSIS OF SOCIOECONOMIC, BEHAVIOURAL AND BIOLOGICAL FACTORS BETWEEN HEALTHY INDIVIDUALS AND PATIENTS WITH NEWLY DIAGNOSED DIABETES IN THE LUBUSKIE VOIVODESHIP

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A – study design, **B** – data collection, **C** – statistical analysis, **D** – interpretation of data, **E** – manuscript preparation, **F** – literature review, **G** – sourcing of funding

ABSTRACT

Background: The most effective way to prevent an increasing diabetic population lies in early detection of risk factors and diagnosis of carbohydrate metabolism disorders.

Aim of the study: The study aimed at determining socio-economic variables, lifestyle behaviours and biological factors differentiating patients with newly diagnosed diabetes from diabetes-free individuals.

Material and methods: Assessment of diabetic vs. non-diabetic individuals was performed according to the American criteria issued by the Commission on Social Determinants of Health as well as the FINDRISC form, which helps identify patients who are at risk of developing type 2 diabetes on the basis of multi-factorial determinants of its development. The research was conducted in 2018 among 1167 primary health care patients from Lubuskie Voivodeship using a diagnostic survey method which interviewed the respondents according to the FINDRISC standard questionnaire.

Results: The group of healthy patients was similar to the group of patients with newly diagnosed diabetes with respect to variables such as age (p=0.713), sex (p=1), place of residence (p=1), level of education (p=0.076), professional activity (p=0.758), BMI (p=0.133), waist measurement (p=0.665), frequency of fruit and vegetables intake (p=0.572), frequency of taking hypotensive medications (p=0.176), frequency of diabetes occurrence in the family history (p=0.227) and physical activity (p=0.321).

Conclusions: Early detection of carbohydrate metabolism disorders, with the use of standardised tools that assess diabetes development, appears to be essential in the prevention of this disorder. Therefore, there is a strong need to create a tool adjusted to socio-demographic factors such as geographical location, economic conditions and lifestyle. Additionally, active and massive screening for carbohydrate metabolism disorders in patients with a low risk of diabetes seems to be crucial in its prevention.

KEYWORDS: patients, type 2 diabetes mellitus, prediabetic state

Background

Biopsychosocial determinants of diet-dependent disorders, including diabetes, generate a number of individual differences in predispositions, burdens and the course of the disease. Being aware of the variables, especially in the area of economic status, life and work conditions, socio-cultural context, individual lifestyles or biological determinants, has huge preventive value. Recent decades have resulted in significant scientific progress in primary prophylaxis for type 2 diabetes, its treatment as well as presentation with coexisting diseases and associated complications. Although measures to circumvent the growing diabetes pandemic are being introduced and implemented worldwide, scientific

progress in the area of diabetes does not align with real world public health improvements to address the disease. Over the past 30 years, the number of adults with diabetes has quadrupled globally, increasing from 108 million in 1980 to 463 million in 2020, while the age-standardised global prevalence has doubled from 4.7% to 8.5%. In the USA alone, one in 11 people was diagnosed as a diabetic [1], and expenditure on diabetes is among the highest of all spending for public health and in the health care sector. In Europe, 59 million people are affected by the disorder and it is estimated that by 2045, the number will have increased to approximately 70 million. In Poland, the overall adult population of the country is 28,891,100, of which 8.1% suffer from diabetes, making up 2,344,600 individual cases of the disorder [2].

World economic analysis points out the high costs associated with the treatment of diabetes. Research from the US shows that it remains the most expensive chronic condition. A diabetic patient spends 2.3 times higher in treatment costs than their age and sex-related non-diabetic counterparts. It was reported that in 2017, one in four American dollars spent on medical care was spent on diabetes treatment [3]. Therefore, we can observe a real precipice between the development of effective measures to prevent and treat diabetes, and existing health care systems that have high treatment costs for the disease.

Raising awareness about diabetes, particularly its prevention, has become a social challenge in the European region. Diverse initiatives including the mobilisation of patients, health care workers, partners and decision-makers have not brought radical changes thus far. Therefore, supporting physical and social lifestyle changes has becoming increasingly important. Assessing the plethora of factors that influence the development of diabetes requires a holistic approach. On the other hand, the impact of environmental and personal factors, which need to be addressed through coordinated and multi-sector approaches, is only possible when they are well-known and well-defined. The recognition of these factors will allow for the support of patients who are at high risk of diabetes at the national, regional and most importantly, local level. Urbanisation and socioeconomic status are primary factors that influence disease indicators in research on diabetes prevalence, introducing interesting differences between population groups. After a diabetes diagnosis, there is an urgent need for the effective implementation of interventions.

A complex approach to the development, management and assessment of interventions promoting equity in the prevention and treatment of diabetes is necessary. In the US, social determinants of health (SDOH) have a huge impact on health inequities in health care [4]. The basic components of SDOH based on the conceptual framework of the CSDH (Commission on Social Determinants of Health) include: (a) the socioeconomic and political context (e.g. the labour market, the educational system and political institutions including the welfare state), (b) structural determinants and socioeconomic position (e.g. income, education, occupation, social class, gender, race) and (c) intermediary determinants (e.g. material circumstances, social-environmental or psychosocial circumstances, behavioural and biological factors, the health system as a social determinant of health). Behavioural and biological factors include nutrition, physical activity, tobacco consumption, alcohol consumption and genetic factors [5]. (Fig. 1)

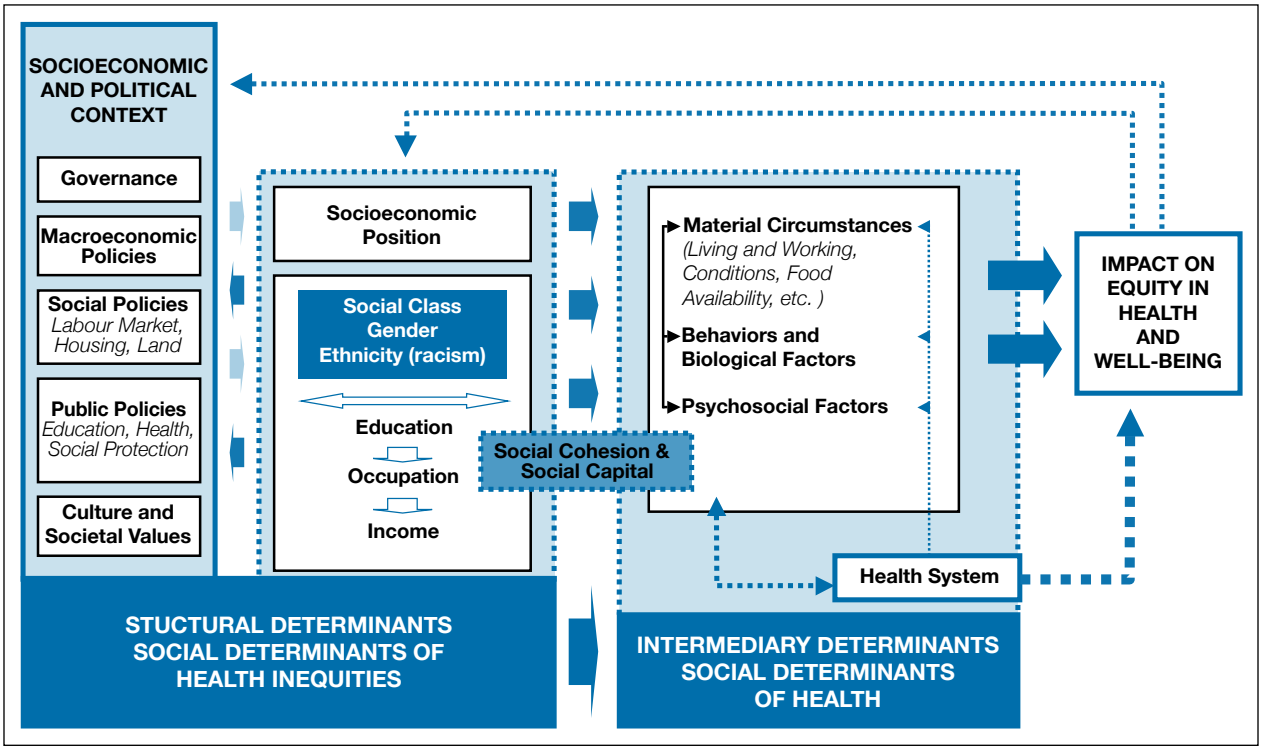

Figure 1. The CSDH conceptual framework [5].

The areas of influence are co-dependent rather than independent, which appears to be a significant differentiating factor when considering interventions. SDOH has a significant influence on health and diabetes development. Consideration of the influence of these factors on medical interventions for diabetes appears to be a priority as they might result in the improvement of prophylactic actions [6]. Diabetes is the fourth most prevalent health issue in Lubuskie Voivodeship, right after diseases of the circulatory, musculoskeletal, connective tissue and digestive systems [7]. Diabetes incidence in Lubuskie Voivodeship is shown in Tab. 1.

Despite advances in treatment and care for the disease, diabetes is still diagnosed too late. Early identification of risk factors and carbohydrate metabolism disorders can be key in preventing the alarming increases in diabetic patients in Poland and worldwide.

Aim of the study

The study aimed at determining socio-economic variables, lifestyle behaviours and biological factors differentiating patients with newly diagnosed diabetes from diabetes-free individuals according to the American criteria issued by the Commission on Social Determinants of Health as well as the FINDRISC form, which helps identify patients who are at risk of developing type 2 diabetes on the basis of multi-factorial determinants of its development.

Material and methods

Study design

A fundamental aspect of the program was conducting screening tests for diabetes in a population of working individuals with the highest risk of developing diabetes. The program received a positive review from the Agency for Health Technology Assessment and Tariff Systems (no. 8/2017 from January 16th, 2017).

Setting

The study was carried out from January to December 2018 in Polish primary health care patients in Zielona Góra (Lubuskie Voivodeship) as part of the "Health policy program of early detection and prevention of diabetes and its complications in professionally active people in Lubuskie Voivodeship". The program consisted of 5 stages, with results analysed from the first stage which included familiarisation with the program inclusion criteria, identification of people with carbohydrate metabolism disorders and preliminary qualification for the program. The research was conducted in the Primary Health Care Clinic 'Medkol' in Zielona Góra. The opportunity to participate in the program was announced and advertised in local media and across health care institutions. All adults were permitted to take part in the research study by coming to the clinic and filling out the FINDRISC, RODO and the research consent forms in the diabetes educational office in the presence of a nurse. If patients achieved ≥ 15 points, they were qualified for a OGTT (Oral Glucose Tolerance Test) in a certified analytical laboratory with the use of fluorine plasma.

Participants

The inclusive criteria consisted of professional activity age ≥15, not being diagnosed with diabetes (at time of study), not having been subjected to diabetes screening tests in the last 12 months, consent for the research study, achieving ≥15 points in the FINDRISC test (high and very high risk of developing diabetes) and performing the OGTT.

The research was carried out in compliance with the Declaration of Helsinki. Before the examination, each participant was informed about the aim, the method and the possibility of withdrawal at any stage of the study. The patients were assured full anonymity and freedom of participation. The research was conducted after receiving participants' consents in writing.

Table 1. The number of patients by age group diagnosed with ICD-10 related to diabetes treated in the province Lubuskie in 2017 [7].

Diagnosis of a disease entity ICD-10	Total number of people	Patient age ranges							
		0-18	19-29	30-39	40-49	50-59	60-69	70-79	≥80
E10-E10.9 Diabetes mellitus type 1	10,880	378	422	595	714	1 475	3,432	2,321	1,543
E11-E11.9 Diabetes mellitus type 2	51,698	109	300	1,055	2,665	7,556	19,653	12,739	7,621
E12-E12.9 Diabetes associated with malnutrition	28	0	0	1	2	3	11	6	5
E13-E13.9 Other specific forms of diabetes	812	9	74	173	111	141	191	85	28
E14-E14.9 Diabetes mellitus not specified	1,250	24	46	84	89	190	432	262	123
TOTAL	56,821	451	713	1,626	3,089	8,205	20,982	13,553	8,202

Variables

Variables were divided into two groups according to the CSDH criteria:

a. Structural determinants and socioeconomic position – age, sex, level of education, professional activity and the place of residence
b. Intermediary determinants (behavioural and biological factors) – physical activity, frequency of fruit and vegetables intake, regularity of taking hypotensive medications, diagnosis of diabetes in the family history, BMI, waist measurement, OGTT results, increased glycaemia in the past.

Study size

A total of 1167 non-diabetics were included in the study. 124 of them achieved below 15 points in the FINDRISC questionnaire (healthy patients) and 1043 scored 15 or more points, which meant they were at risk or high risk of diabetes development. In the latter group, 621 of the respondents were tested with the OGTT and 309 of them had a proper result while 254 were found to have pre-diabetes syndrome and 58 achieved results that were above normal, which indicated diabetes (unhealthy patients).

The study compared a group of 58 diabetics to a group of 58 healthy patients who were randomly chosen for the study (out of 124 individuals who achieved a result below 15 points in the FINDRISC questionnaire). The schematic for the group selection is shown in the Fig. 2.

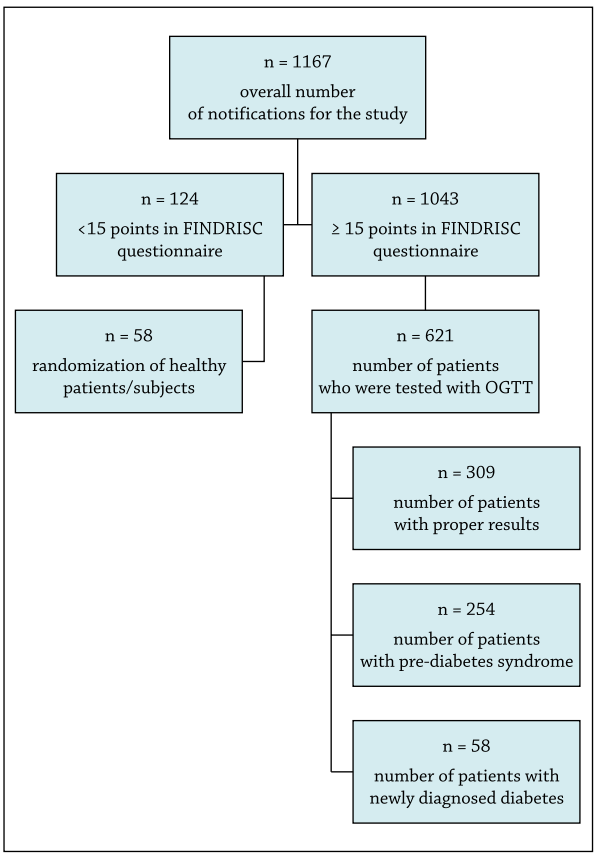

Figure 2 Schematic of the sample selection of the study.

The study was carried out using a diagnostic survey method and an interviewing technique with the use of a standardised FINDRISC questionnaire and a proprietary questionnaire for collecting socio-demographic data. To calculate BMI, a medical scale and a centimetre tape were used. The FINDRISC questionnaire was created by Finnish scientists, who were the authors of a first in Europe and the world National Program of Diabetes Prevention designed on the basis of the Data sources/measurement results of a randomised research study called the Finnish Diabetes Prevention Study. It was a tool to estimate the risk of diabetes occurrence in the next 10 years. The FINDRISC questionnaire consists of 8 questions concerning age, BMI, waist measurement, physical activity, fruit and vegetables intake, taking hypotensive medications and improper level of glucose detected on an empty stomach (i.e. fasting). If the result is below 7 points, it is estimated that the risk of diabetes is low (1 in 100 patients may develop diabetes). If the score is 7-11 points, the risk is slightly elevated and 1 in 25 patients will develop diabetes. If the score is in the range of 12-14 points, the risk is moderate which means that 1 in 5 patients will develop the disorder. If the score is between 15-20 points, the risk is high and 1 in 3 patients will suffer from diabetes while a score above 20 means very high risk and every second patient is likely to develop the disorder [8].

The questionnaire is very specific and responsive, and is recommended by the International Diabetic Federation to be used in population programs. It is available as an electronic form on the IDF website in various language options. What is more, patients who had a score of 15 points or higher on the FINDRISC questionnaire were tested with OGTT in a certified analytical laboratory with the use of fluoride plasma. Currently, the Polish Diabetes Association (PTD) does not recommend testing glycated haemoglobin (HbA1c) as a diagnostic measure for diabetes because it is not standardised in Polish laboratories. The OGTT was carried out, without the earlier limitation of carbohydrate intake, in the morning, on an empty stomach, in rested patients and after a night's sleep. The two-hour interval between intake of 75 g of glucose liquid and blood sample collection was spent with patients resting. Glucose concentration marking was done on venous blood plasma [9]. Results of the OGTT were assessed by the nursing coordinator of a program who specialises in diabetology. Patients at risk of diabetes were referred to a diabetes clinic in primary health care institutions. Patients with a pre-diabetes syndrome were qualified to a second stage of the program while healthy individuals were advised on healthy lifestyle approaches and modification of diabetes risk factors.

Statistical analysis

Correlation of qualitative variables in groups was calculated with the use of the Chi-squared test (with Yates' correction for tables 2x2) or Fisher's test if the

expected multiplicity values were low. The correlation of quantitative variables in both groups was obtained by Student's t-test (if the variable displayed a normal standard distribution) or Mann-Whitney's test (if not normally distributed). The correlation of qualitative variables in three or more groups was assessed by ANOVA variance analysis (if the variable displayed standard distribution in these groups) and Kruskal-Wallis test (if not a standard distribution). The normality of the variables' distribution was calculated with the Shapiro-Wilk test. The analysis assumed statistical significance at the level of 0.05. Therefore, values below 0.05 were interpreted as significant correlations. Analysis was performed in the R program, version 3.5.3. [10].

Results

Participants

The group of healthy respondents consisted mostly of people over 64 (37; 63.79%) and those between 55-64 (12; 20.69%) and who were residents of cities (49; 84.48%). The group of patients with newly diagnosed diabetes showed similar statistics – these can be viewed in Tab. 2.

Analysis of structural determinants and socioeconomic position

It was found that age, sex, place of residence, education and professional activity did not differentiate patients who had or did not have diabetes (Tab. 2).

Intermediary determinants – analysis of behavioural and biological factors

The group of healthy individuals was similar to the group of those with newly diagnosed diabetes with respect to variables including BMI (p=0.133), waist measurement (p=0.665), frequency of fruit and vegetables intake (p=0.572), regularity of taking hypotensive medications (p=0.176) and cases of diabetes in the family (p=0.227). For BMI, obese individuals constituted the largest group among both healthy respondents (79.31%; 46) and diabetics (91.38%; 53). For waist measurement in both groups, measurements of over 102 cm for men and over 88 cm for women were the most common (84.48%; 49 of the healthy group and 89.66%; 52 of diabetics). Respondents in both groups did not perform any physical activity for at least 30 minutes a day (94.83%; 55 of the healthy group and 87.93%; 51 of diabetics). Most respondents consumed fruit and vegetables daily (62.07%; 36 in the healthy group, 55.17%; 32 in diabetics) and took hypotensive medications (56.90%; 33 of the healthy group and 70.69%; 41 of diabetics) (Tab. 3).

Non-diabetic individuals (healthy) differed significantly from diabetics only with regard to OGTT results (p<0.001) and level of glycaemia (p=0.001). Diabetic patients displayed higher OGTT results at the '0' and '120' minute periods, and also more frequently showed higher results of glycaemia in the past compared to the healthy group (Tab. 3). The median OGTT level at the '0' minute time in diabetics was 127 mg/dL (min-max; 83-229) compared to 93 mg/dL (min-max; 33-99) in non-diabetics. The median OGTT at 120 minutes was 225 mg/dL (min-max; 83-351) in diabetics and 94 mg/

Table 2. Analysis of determinants between healthy and diabetic respondents in reference to socioeconomic variables.

Variables		Healthy patients n=58	Patients with newly diagnosed diabetes n=58	Total	p*
Age	< 45 years	5.17% (3)	8.62% (5)	6.9% (8)	0.713 F
	45-54 years	10.34% (6)	4 (6.90%)	8.62% (10)	
	55-64 years	20.69% (12)	15 (25.86%)	23.28% (27)	
	> 64 years	63.79% (37)	34 (58.62%)	61.21% (71)	
Sex	Women	43.10% (25)	25 (43.10%)	43.10% (50)	1 chi^2
	Men	56.90% (33)	33 (56.90%)	56.90% (66)	
Place of residence	City	84.48% (49)	50 (86.21%)	85.34% (99)	1 chi^2
	Village	15.52% (9)	8 (13.79%)	14.66% (17)	
Education	Basic	3.45% (2)	17.24% (10)	10.34% (12)	0.076 chi^2
	Vocational	24.14% (14)	18.97% (11)	21.55% (25)	
	Secondary	50% (29)	50% (29)	50.00% (58)	
	Higher	22.41% (13)	13.79% (8)	18.10% (21)	
Professional activity	Working	27.59% (16)	29.31% (17)	28.45% (33)	0.758 F
	Pensioner	67.24% (39)	62.07% (36)	64.66% (75)	
	Disability Pensioner	5.17% (3)	8.62% (5)	6.9% (8)	

Legend: chi^2 – Chi-squared test, F – Fisher's test (low expected values in the table).

Table 3. Analysis of determinants between healthy and diabetic respondents in reference to selected variables of the FINDRISC questionnaire.

Variables		Healthy patients n=58	Patients with newly diagnosed diabetes n=58	Total	p*
BMI	Normal weight	3.45% (2)	0% (0)	1.72% (2)	0.133 F
	Overweight	17.24% (10)	8.62% (5)	12.93% (15)	
	Obesity	79.31% (46)	91.38% (53)	85.34% (99)	
Waist circumference	M < 94 cm W < 80 cm	3.45% (2)	1.72% (1)	2.59% (3)	0.665 F
	M 94-102 cm W 80-88 cm	12.07% (7)	8.62% (5)	10.34% (12)	
	M > 102 cm W > 88 cm	84.48% (49)	89.66% (52)	87.07% (101)	
Physical activity at least 30 minutes a day	Yes	5.17% (3)	12.07% (7)	8.62% (10)	0.321 chi^2
	No	94.83% (55)	87.93% (51)	91.38% (106)	
Eating fruit and vegetables	Daily	62.07% (36)	55.17% (32)	58.62% (68)	0.572 chi^2
	Irregularly	37.93% (22)	44.83% (26)	41.38% (48)	
Antihypertensive drugs	No	43.10% (25)	29.31% (17)	36.21% (42)	0.176 chi^2
	Yes	56.90% (33)	70.69% (41)	63.79% (74)	
Diabetes in the family	No	25.86% (15)	36.21% (21)	31.03% (36)	0.227 chi^2
	Yes: at grandfather's or cousin's	36.21% (21)	22.41% (13)	29.31% (34)	
	Yes: at the parent, siblings or child	37.93% (22)	41.38% (24)	39.66% (46)	

Legend: BMI – body mass index, chi^2 – Chi-squared test, F – Fisher's test, M – man, W – woman.

Table 4 Analysis of determinants between healthy patients and diabetic patients with respect to OGTT results and glycaemia level

Variables		Healthy patients n=58	Patients with newly diagnosed diabetes n=58	Total	p*
OGTT 0 min [mg/dl]	M±SD	91.09±9.43	126.22±23.55	108.66±25.1	<0.001 NP
	Median	93	127	98.5	
	Quartiles (Q1-Q3)	89-96	109.75-137.5	92.75-127	
OGTT 120 min [mg/dl]	M±SD	96.78±23.75	228.58±44.08	159.08±74.66	<0.001 P
	Median	94	225	135.5	
	Quartiles (Q1-Q3)	78.25-114.75	204.75-259.25	93-221.75	
Elevated glycaemia in previous examinations	No	63.79% (37)	31.03% (18)	47.41% (55)	0.001 chi^2
	Yes	36.21% (21)	68.97% (40)	52.59% (61)	

Legend: p = normality of variance, parametric analysis, Student t-test, NP – no normality of variance, non-parametric analysis, Mann-Whitney's test, M – mean, SD – standard deviation.

dL (max-min; 53-139) in the healthy examinees. The latter had glucose levels on an empty stomach at levels below 70 mg/dL, which does not meet the criterion for pre-diabetes or diabetes conditions, but requires further observation for carbohydrate metabolism disorders (Tab. 4).

Discussion

Many aspects of medical care lack regular and systematic assessments of social and economic situations of patients including education levels, professional status or household income. This is a concern as social and economic factors may have a significant impact on determining an individual's health condition and their health care experience in terms of accessibility and overall results [11]. With respect to this, based on the CSDH model, it was found that it is essential to examine the socioeconomic, behavioural and biological variables that differentiate diabetes from non-diabetes patients.

Key results

The comparative analysis of socioeconomic, behavioural and biological variables showed no significant differences between the two participant groups (diabetic

and non-diabetic). The only difference was detected in OGGT and glycaemia results. The levels of both of these indicators was higher in diabetes patients compared to healthy participants.

Interpretation

Structural determinants and socioeconomic position

A Healthy People 2020 goal for the diabetes health indicator is to "reduce the disease and economic burden of diabetes mellitus, and improve the quality of life for all persons who have, or are at risk for diabetes" [12]. In the US, social determinants of health are being increasingly recognised for their relationship to the soaring incidence of type 2 diabetes [13]. Clark et al. suggested that social determinants of health and diabetes need to be considered when focusing on improving diabetes outcomes [12].

There is a plethora of research showing a relationship between social determinants of health and health condition among diabetes patients. Kollannoor-Samuel et al. found that those with lower socioeconomic status were more likely to have higher HbA1c [14]. Osborn et al. showed that higher HbA1c is associated with low health literacy [15]. In a study by Pirdehghan et al., problematic health literacy could increase the chance of uncontrolled diabetes by more than three times [16]. Socioeconomic status was a statistically significant independent predictor of mortality and morbidity for adults with type 1 diabetes in a study by Scott et al. [17]. Other researchers have reported that lower levels of education and income were found to be associated with higher mortality among diabetic individuals [18,19]. Moreover, there are studies which indicate particular socio-demographic factors as predisposing for diabetes occurrence. For example, Suwannaphant et al. showed that individuals who were of the female gender, of old age and low educational attainment were vulnerable to diabetes mellitus [20].

This self-reported study differs, however, from the research cited above, as it focused on comparing socioeconomic variables between healthy and diabetic patients *de novo*. The results displayed no significant correlations between age, sex, place of residence, level of education and professional activity. It might be slightly surprising, but suggests that the risk of diabetes might be the same regardless of socio-demographic determinants or professional activity. However, proving this hypothesis requires further studies. The presence of no socioeconomic differences may also be explained by the screening method used in the research (only non-diagnosed patients volunteered). It is highly probable that if we had compared a group of diagnosed diabetics affected by the disorder for many years with healthy individuals, the socio-demographic differences would have been detectable. However, the aim of the research was different. The results suggest that a deeper consideration is needed for the relevance and necessity of regular mass screening examinations to detect carbohydrate tolerance disorders in adult patients at a primary health care level irrespective of age, sex, place of residence or professional activity. We suggest the FINDRISC questionnaire and the OGTT, which are also recommended by the Polish Diabetes Association as successful diagnostic tools in detecting carbohydrate intolerance disorders [9] and may be prescribed by nurses and doctors as a self-examination. It is also advised to educate patients how to use the tools and how to evaluate their own risk of diabetes development.

Behavioural and biological factors

The data collected showed that both study groups were dominated by obese respondents whose waist measurement exceeded 102 cm in men and 88 cm in women, who do not participate in any physical activities at least 30 min a day, take hypotensive medicines and who are genetically predisposed to diabetes due to a family history of the disease. Inadequate physical activity accompanied with poor dietary habits are associated with the development of obesity and type 2 diabetes mellitus [21]. Many current type 2 diabetes interventions focus on biologic and behavioural factors, such as symptoms, diet and physical activity [13] because lifestyle and health behaviours determine human health to the highest degree [22]. A lot of studies have shown that patients with chronic diseases including diabetes mellitus are characterised by a higher level of pro-health behaviours when compared to healthy individuals. The fact of being chronically ill motivates patients to adjust their behaviours. For example, Juczyński showed that the average rate of pro-health behaviours was higher in a group of diabetics than in healthy adults [23]. Another example is a study by Kurpas et al. which demonstrated that diabetes patients had the highest rates of pro-health behaviours when compared to patients suffering from circulatory and nervous system diseases. Moreover, the results achieved were related to the external health locus of control (i.e. a patient's belief that their health is dependent on other peoples' actions, particularly those of medical staff) [24]. By analysing BMI, waist measurement and physical activity, it might be concluded that the level of pro-health activities was not high in both groups examined in the self-study, although most patients were already on hypotensive medicines (suffering from one chronic disease) and were aware of genetic predispositions towards diabetes. It is quite likely that newly diagnosed diabetes patients, while being supported by proper education from health care professionals, will be motivated to change their lifestyle behaviours in the future and change their biological parameters. However, validating the hypothesis would require further analysis.

Limitations of the study

The study was limited by the fact that the number of study groups was low and that it was only carried out in one voivodeship.

Conclusions

1. Early detection of carbohydrate metabolism disorders with the use of standardised tools, which assess the development of diabetes in patients, seems to be an essential factor in diabetes prevention.
2. There is a strong need for the development of a tool tailored to modifiable socio-demographic factors such as geographical location, economic status and lifestyle.
3. Screening for carbohydrate metabolism disorders in people with a low risk of diabetes development might constitute a key preventive measure.

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