Type 2 Diabetes in Belgians of Turkish and Moroccan Origin

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Abstract

The objectives of this paper are twofold: *(1)* to compare the prevalence of type 2 diabetes in adults – aged 35 to 74 years – of the Turkish and Moroccan communities in Belgium with the prevalence in native Belgians; and *(2)* to examine the determinants and specific mechanisms responsible for differences in diabetes between these communities. Both aims were examined by means of the Health Interview Surveys of 1997, 2001 and 2004. Stepwise logistic regression analyses were performed with diabetes as outcome variable; lifestyle and socio-economic factors as independent variables. In 35- to 74-year-olds, the prevalence of type 2 diabetes is higher in Belgians of Turkish and Moroccan origin than in native Belgians. The differences are larger in women than in men. In men, the differences are strongly reduced after controlling for physical activity and educational attainment. In women, ethnic differences become smaller after accounting for body mass index and educational level.

1. Introduction

1.1. Type 2 diabetes mellitus

This paper addresses one of the major health problems of this moment, namely type 2 diabetes. The estimated number of 150 million diabetic patients worldwide is expected to double within the next 20 years. Prevalence estimates of both type 1 and type 2 diabetes in Belgium vary between 2 % and 5 %. This figure presents an underestimation of the actual prevalence of diabetes mellitus. It is estimated that one third to half of all diabetics are unaware of their situation. Based on the Belgian Health Interview Surveys of 1997, 2001 and 2004 (HIS 97-01-04), we found a self-reported diabetes prevalence of 3.7 %. In the near future, the prevalence of diabetes is expected to rise, especially in developing countries. Worldwide ageing and increased corpulence are held responsible for this increase (1-3).

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Diabetes mellitus is an umbrella term for different metabolic disorders, all associated with glucose intolerance, a relative or absolute insulin deficiency and an increased blood sugar level (hyperglycaemia). The most commonly discerned types are type 1 diabetes mellitus (T1DM), type 2 diabetes mellitus (T2DM) and gestational diabetes mellitus (GDM) (4).

T2DM is characterized by a relative lack of insulin. The peripheral tissues in individuals with T2DM are resistant to the action of insulin. This form of diabetes affects 90 % to 95 % of all individuals with diabetes. T2DM occurs predominantly at an advanced age (over 40 years old) and is accompanied by an increased death probability. However, it can be curable, when patients lose a large amount of weight, as has been shown in studies of obesity surgery (1-6).

There is strong evidence that genetics play an important part in interaction with environmental factors. A hereditary susceptibility can develop into T2DM, if there are also environmental and/or lifestyle factors present, such as excess weight/obesity, excessive abdominal fat, rapid weight gain, a lack of physical activity, diet and stress (1, 7-12). Some authors also emphasize the link with the metabolic syndrome (13-15).

1.2. Ethnic differences in the prevalence of T2DM

Ethnic differences in the prevalence of T2DM are found in many countries (16-20). Clinical practice and research both strongly indicate a higher prevalence of T2DM in Belgians of Turkish and Moroccan origin (21-22). Moreover, Deboosere and Gadeyne (23) found an excess mortality rate from diabetes mellitus amongst Moroccan women living in Belgium (25 to 54 years old). Dutch research (17-18) also shows a higher prevalence of T2DM in persons of Turkish, Moroccan and Surinam origin than in native Dutchmen.

Only a few Belgian studies have been published on the determinants and specific mechanisms responsible for the higher prevalence of T2DM amongst Belgians of Turkish and Moroccan origin (21-22). To our knowledge, these studies are based on clinical data. The results have not yet been quantified in a sample, representative for the population of Turkish and Moroccan origin in Belgium. In the Netherlands, some authors (17-18, 24) did examine risk factors responsible for the higher prevalence of T2DM amongst persons of Turkish, Moroccan and Surinam origin. They give diverging explanations: biological, cultural as well as socio-economic differences are hypothesized to account for the higher prevalence of T2DM in these communities. With regard to the *biological factors*, three hypotheses are distinguished: the 'thrifty genotype', the 'genetically unknown food' and the 'thrifty phenotype' hypothesis (16, 24, 25). Next to the biological explanations put forward by some authors, others mainly attribute the higher prevalence of T2DM amongst migrant communities to lifestyle patterns and socio-economic factors (17-18, 24, 26). The most commonly cited associated *lifestyle patterns* are diet – the composition of the diet as well as an excessively high total caloric intake –, excess weight/obesity and physical activity. All of these lifestyle patterns are not only strongly culturally related; they also have a strong socio-economic component (27). Thus, next to the biological and lifestyle factors, *socio-economic determinants* also play an important part in differences in the prevalence of T2DM (2, 26). T2DM – and health and

illness in a broader sense – is a social phenomenon. T2DM contributes to the process of surviving and dying and is an outcome of a large and diverse set of risk factors during lifetime. Research by Kriegsman et al. (17) showed that a higher socio-economic position is associated with a lower risk of T2DM, regardless of ethnic origin.

To assess the relative value of these explanations, it is important to compare the prevalence of T2DM in the immigrant-receiving countries, such as the Netherlands or Belgium, to the prevalence in the countries of origin. However, the comparability is generally poor, as reliable epidemiological data on the prevalence of T2DM in Turkey and Morocco are sparse. Moreover, in countries experiencing economic transition (like Turkey and Morocco), there are usually huge regional differences in the prevalence rates of T2DM with higher rates in urban compared to rural regions. Based on the Turkish Diabetes Epidemiology Study (conducted in 1997-1998), Satman et al. (28) found a prevalence of T2DM of 7.2 % amongst adults of 20-year-old or older. Prevalence rates were considerably higher in women. In Morocco, during the year 2000 a study was conducted on a Moroccan representative sample aged 20 years or more. The prevalence of T2DM amounted to 6.6 % and was similar for men and women (29). Some studies (17-18) report a higher prevalence of T2DM among migrants in western, industrialized countries than in their countries of origin.

2. Objectives

The first aim of this study was to report the prevalence of T2DM amongst a representative sample of Belgian adults of Turkish and Moroccan origin and to compare these prevalence rates to that of native Belgians of the same age (35- to 74-year-olds). The second objective was to examine several of the explanations cited above. In this study, we focus on lifestyle factors and socio-economic determinants associated with observed ethnic differences in T2DM. However, the influence of socio-economic factors on the prevalence is not direct, but it is mediated by other factors. Socio-economic factors can be considered as 'causes of causes'. Socio-economic determinants influence the distribution of risk factors of diseases and the vulnerability to these risk factors (30). In this paper, we examine if the influence of socio-economic factors on the prevalence of T2DM is mediated by lifestyle factors.

3. Methods

3.1. Data

Both objectives were examined using the Belgian Health Interview Surveys of 1997, 2001 and 2004 (HIS 97-01-04). These Health Interview Surveys were carried out by the Epidemiology Unit of the Scientific Institute of Public Health. The main objective of these surveys is to give a description of the health status of the population residing in Belgium. For that purpose, a wide range of health related issues has been considered,

covering five main domains: health status, health determinants, medical prevention, health consumption and health and society (31-33).

The target population of the health surveys consists of all inhabitants of Belgium, regardless of their place of birth, nationality or any other characteristic. To cover this target population as completely as possible, a random sample was drawn out of the National Register. However, the population studied does not cover the target population completely. Certain categories of persons, such as illegal refugees, homeless people, diplomats … are not listed in the National Register. Thus, only officially registered inhabitants of Belgium were eventually included. In HIS 97-01-04, a total of 37,387 respondents was reached. The non-response at household level amounted to 41.5 %, 38.6 % and 38.6 % in 1997, 2001 and 2004 respectively. With regard to the non-response in people of Turkish and Moroccan origin, no information is available. It is however assumed that the Health Interview Surveys sketch a representative image of the health condition of the population residing in Belgium[3] (31-33).

The research group Interface Demography pooled the Surveys in order to obtain sufficient high numbers of Belgians of Turkish and Moroccan origin. The total population of age 35 to 74 included in the analysis accounts for 17,947 persons (Turkish origin N=169; Moroccan origin N=495) (31-33).

3.2. Method

In order to better understand the prevalence of T2DM in the age group of 35- to 74-year-olds, we conducted logistic regression analyses with prevalence of T2DM as the dependent variable. Initially, we included each covariate one by one. Separate regression analyses were done with age, sex and ethnic origin as independent variables. Then, the independent variables were included two by two. In a final model, age, sex and ethnic origin were all included at the same time.

To estimate the impact of socio-economic determinants and lifestyle factors upon the prevalence of T2DM, we used stepwise logistic regression with prevalence of T2DM as the outcome variable. First, we introduced indicators of socio-economic position and lifestyle factors separately. In subsequent models, all combinations of the different indicators were examined to estimate their net effects on the prevalence of T2DM. Statistical analyses were executed by means of the SPSS 17.0 software.

3.3. Operational definition of the variables[4]

- *Type 2 diabetes mellitus (T2DM)*

  The variable 'T2DM' is a dummy variable with the categories no diabetes (0) and diabetes (1). An important remark is that it concerns self-reported diabetes. This self-reportage leads to an underestimation of the actual diabetes prevalence, since one third to half of all diabetics are unaware of the fact that they suffer from

[3] For more information about the sample design and methodology of HIS 97-01-04, we refer to the reports of the Epidemiology Unit of the Scientific Institute of Public Health (31-33).
[4] An important remark is that the variables in HIS 97-01-04 are based on self-reportage.

diabetes. In order to exclude T1DM at younger ages, we selected the age group of 35-year-olds and older. This is a relatively crude, but nonetheless effective way of focussing on T2DM, particularly because the proportion of T2DM in the total diabetes prevalence is estimated to be at least 90 % (1). T2DM occurs predominantly at an advanced age (over 40 years old). However, it is assumed that this disease will manifest itself in middle-aged adults because of the increased prevalence of excess weight (1). Some authors also report an earlier onset in 'newly westernized populations' (17, 25, 34). Therefore, the lower limit is set at 35 years. The upper limit is 74 years, because the number of Belgians of Turkish and Moroccan origin of 74-year-old or older in our sample is too small.

- *Ethnic origin*

  To get the largest possible number of Belgians of Turkish and Moroccan origin in the sample, we used a criterion that maximizes their proportion. Each member of a household, where one person had the Turkish (Moroccan) nationality or was born in Turkey (Morocco), was considered as being of Turkish (Moroccan) origin. The variable 'ethnic origin' is a categorical variable with four categories: Belgian origin (1); Turkish origin (2); Moroccan origin (3); residual category (4). 'Belgian origin' was taken as the reference modality. The residual category was excluded from our analyses.

- *Age*

  We used the variable 'age in years'. We didn't subdivide age into categories, since the prevalence of T2DM changes continuously with age in the group studied (35- to 74-year-olds). We also 'centred' age, by extracting 35, so that the intercept would have a more meaningful interpretation. An important remark is that, by pooling the three Belgian Health Interview Surveys, we bring different birth cohorts together.

- *Sex*

  'Sex' is a dummy variable with the modalities man (0) and woman (1). 'Man' was chosen as the reference category.

- *Socio-economic determinants*

  We used the variables 'educational attainment' and 'income' as socio-economic determinants. These variables are correlated[5], but measure different aspects of socio-economic position.

  - *Educational attainment*

    For the variable 'educational attainment', we used the ISCED-classification. With regard to T2DM in the age group of 35- to 74-year-olds, there is an 'educational gradient'. Persons with a lower educational level have a greater risk

[5] In the age group of 35- to 74-year-olds, Kendall's τ is 0.326 and Spearman's ϱ amounts to 0.387.

of T2DM than persons with a higher educational attainment (results not shown). The group with the highest prevalence of T2DM – no diploma / primary education – was chosen as the reference modality.

- *Income*

  The variable '(equivalent) income' consists of the following categories: less than 750 Euros (1); 750 to 1,000 Euros (2); 1,000 to 1,500 Euros (3); 1,500 to 2,500 Euros (4); more than 2,500 Euros (5). To calculate this variable the modified OECD-scale was used (35). Here again, socio-economic differences in the prevalence of T2DM were found (results not shown). The group with the highest prevalence of T2DM – 750 to 1,000 Euros – was taken as the reference category.

- *Lifestyle factors*

  In this paper, we focused on two of the most important risk factors of T2DM, namely excess weight/obesity and lack of physical activity. We took diet, albeit an important lifestyle factor with relation to differences in the prevalence of T2DM, only indirectly into account by excess weight/obesity, as the indicators constructed using HIS 97-01-04 appeared inadequate.

  - *Excess weight/obesity*

    We used the variable 'body mass index' (BMI) as an operational definition of the concept 'excess weight/obesity[6]'. In order for the intercept to have a more meaningful interpretation, this variable was centred ('BMI – 25.77').

    A limitation of the variable 'body mass index' is that it is based on reported height and weight and therefore less reliable compared to measured data (36-37). A second limitation of our data is the use of BMI as the sole criterion of excess weight. According to a number of studies (1, 7, 38), abdominal obesity is, apart from overall excess weight, an independent risk factor of T2DM.

  - *Physical activity*

    We measured the concept of 'physical activity' by the variable 'lack of (leisure time) physical activity'. This is a dummy variable with the categories: weekly physically active (0) and sedentary (1). The category 'weekly physically active' was taken as the reference modality.

    A restriction of this indicator is that it does not take physical exercise during professional activity into account. As a consequence, it is strongly socio-economically related. Persons with a lower education more often have sedentary leisure activities[7]. A second limitation of the variable 'lack of (leisure time) physical activity' is that it is culturally related. In the Turkish and Moroccan

[6] We considered a person with a body mass index equal to or more than 25 as overweight. A person with a BMI of 30 or more is considered obese.

[7] To tackle the socio-economic component of 'lack of (leisure time) physical activity', we constructed several indicators, but there were not enough Belgians of Turkish and Moroccan origin to keep these variables in the analyses.

culture, there is no tradition of leisure time physical activity, especially not for women (28).

4. Results

4.1. Prevalence of T2DM

As expected, the prevalence of T2DM in our sample increases with age (figure 1) (1, 7). Moreover, the prevalence of T2DM is higher at all ages in Belgians of Turkish and Moroccan origin than in native Belgians (21-22). Finally, figure 1 reveals that T2DM has an earlier onset in the Turkish and Moroccan communities in Belgium.

Figure 1: Prevalence of T2DM as a function of age and ethnic origin

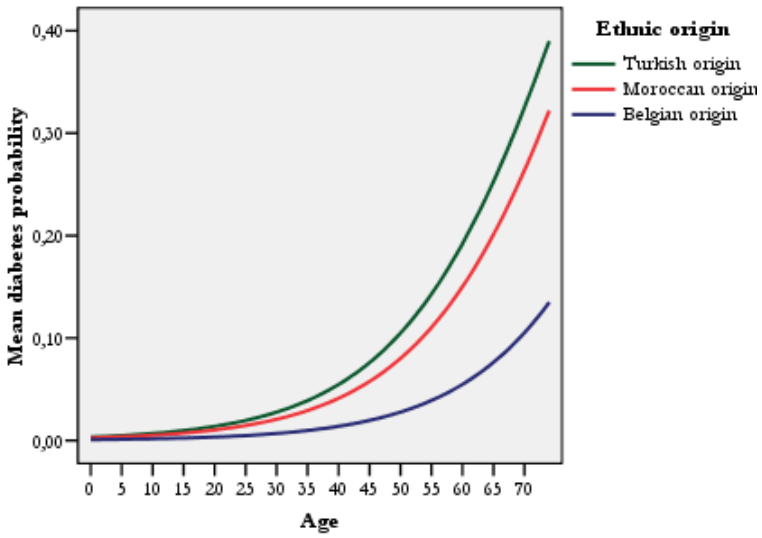

Table 1 gives an overview of the results of the logistic regression analyses of the prevalence of T2DM by age, sex and ethnic origin (age group of 35- to 74-year-olds).

As stated above, Belgians of Turkish and Moroccan origin have a higher risk of T2DM (model 2). The odds ratio for Turkish versus Belgian subjects amounts to 4.6. For Moroccan subjects, the odds ratio is 3.1. However, as appears from the parameter estimates of model 3, the ethnic differences in the prevalence of T2DM are more pronounced in women. There is effect modification between ethnic origin, sex and T2DM. The mean T2DM probability in native Belgians is lower in women than in men. In the Turkish and Moroccan communities on the other hand, women are at a higher risk.

In the age group of 35- to 74-year-olds, the prevalence of T2DM amounts to 5.0 %, 5.8 % and 6.5 % in men of Belgian, Turkish and Moroccan origin respectively. In the same age group, the prevalence of T2DM in women of Belgian origin is 4.3 %. In the Turkish and Moroccan communities in Belgium, women are at a higher risk (18.7 % and 11.9 % respectively) (results not shown).

Table 1: Model estimates of the prevalence of T2DM by age, sex, ethnic origin and the interaction effect 'ethnic origin*sex' (men and women jointly)

		Model					
		Model 1		*Model 2*		*Model 3*	
Variables	Categories	e^b	95% CI$^\Delta$	e^b	95% CI	e^b	95% CI
Intercept		0.013	-0.178 – 0.204	0.012	-0.197 – 0.221	0.012	-0.197 – 0.221
Age - 35		1.065	1.058 – 1.073	1.069	1.061 – 1.076	1.069	1.061 – 1.076
Sex	Man (ref.)						
	Woman			0.881	0.758 – 1.023	0.818	0.700 – 0.955
Ethnic origin	Belgian (ref.)						
	Turkish			4.573	2.720 – 7.690	1.702	0.607 – 4.773
	Moroccan			3.106	2.189 – 4.408	1.978	1.146 – 3.413
Ethnic origin*sex	Turkish*woman					5.102	1.529 – 17.022
	Moroccan*woman					2.393	1.178 – 4.861
	Deviance	5,640.207		5,583.089		5,569.258	
	$\Delta\chi^2$	350.488	***	57.118	***	13.831	***
	Df	1		3		2	
	AIC	5,642.207		5,593.089		5,583.258	
	BIC	5,659.516		5,631.360		5,636.838	
	N	15,588		15,588		15,588	

$^\Delta$CI = confidence interval — Significance level: *** p < 0.001

4.2. Socio-economic determinants and risk factors

In this section, we examine the contribution of educational attainment, income, excess weight/obesity and lack of physical activity to the observed differences in the prevalence of T2DM amongst adults of Turkish, Moroccan and Belgian origin, but first we present the distribution of these factors in the age group 35- to 74-year-olds (table 2).

Table 2: The distribution of socio-economic determinants and lifestyle factors (in %; age group of 35- to 74-year-olds)

		Distribution (in %)									
		Men					*Women*				
Variables	Categories	Belgian	Turkish	Moroccan	χ^2	Df	Belgian	Turkish	Moroccan	χ^2	Df
Socio-economic factors											
Educational level	No diploma/prim. ed.	18.4	65.1	46.9	228.907	6	22.3	82.2	65.9	354.869	6
	Lower sec. ed.	22.9	10.8	16.3	***		24.4	8.2	15.2	***	
	Higher sec. ed.	29.4	14.5	22.2			27.3	5.5	10.4		
	Higher ed.	29.2	9.6	14.6			26.0	4.1	8.5		
Income	Less than 750 euros	5.3	11.5	9.8	70.325	8	7.5	12.3	10.8	37.370	8
	750 to 1,000 euros	8.2	16.7	15.4	***		11.1	13.7	18.8	***	
	1,000 to 1,500 euros	23.9	29.5	27.4			24.9	26.0	23.9		
	1,500 to 2,500 euros	36.8	30.8	39.3			34.0	35.6	37.6		
	More than 2,500 euros	25.8	11.5	8.1			22.5	12.4	8.9		
Lifestyle factors											
Excess weight		59.7	58.6	56.2	1.194 n.s.	2	43.2	72.2	68.8	76.731 ***	2
Obesity		15.5	17.2	15.7	0.194 n.s.	2	14.7	37.5	33.2	80.922 ***	2
Lack of physical activity		28.2	65.5	47.9	70.295 ***	2	35.9	72.0	63.6	76.978 ***	2

Significance levels: *** p < 0.001; n.s.: not significant

Socio-economic determinants

Educational attainment

Accounting for educational attainment, the ethnic differences in the prevalence of T2DM become smaller in both men and women. The higher prevalence of T2DM in Belgians of Turkisch and Moroccan origin is thus partly associated with their lower educational level (table 3 and 4, model 2). People with a lower educational level have a greater risk of T2DM. This socio-economic gradient in the prevalence of T2DM is stronger in women than in men. This finding is in keeping with our expectations as Beck, Vanroelen and Louckx (27) also show a steeper socio-economic gradient in chronic morbidity in women, compared to men.

Income

Accounting for income, in men as well as in women, the ethnic differences in the prevalence of T2DM remain almost unaltered (table 3 and 4, model 3). Moreover, in men, the income gradient – the decreased risk of T2DM as income increases – is rather small (controlling for age). In women, the gradient is a bit steeper (controlling for age), but the risk of T2DM differs only substantially from the reference category in people with an income of more than 2,500 Euros. Yet, this does not necessarily mean that income isn't an important socio-economic determinant in the prevalence of T2DM. It simply implies that the relation between income and T2DM is probably more complex and differs according to ethnic origin. However, we didn't have enough statistical power to further explore the relationship between income and T2DM. We therefore excluded the variable 'income' from further analyses.

Lifestyle factors

First, we conducted analyses with BMI and lack of physical activity separately (results not shown). In *men*, the ethnic differences in T2DM remain, accounting for BMI. However, when the variable 'lack of (leisure time) physical activity' is included in the analyses, the ethnic differences in the prevalence of T2DM in men are strongly reduced. In *women*, the differences in T2DM prevalence between the ethnic communities in Belgium persist, after controlling for 'lack of physical activity'. The more sedentary leisure lifestyle of Turkish and Moroccan women does not explain their higher risk of T2DM compared to Belgian women. In women, differences in the prevalence of T2DM between the different communities get particularly smaller, accounting for BMI. The higher prevalence of T2DM in 35- to 74-year-old women of Turkish and Moroccan origin is thus associated with their higher mean BMI (Turkish origin: BMI = 28.7, Moroccan origin: BMI = 27.5; Belgian origin: BMI = 25.1).

Then, we inserted both lifestyle factors in the analyses. In men, the ethnic differences in the prevalence of T2DM are (strongly) reduced, especially in the Turkish community (table 3, model 4). In women on the other hand, the community differences in the prevalence of T2DM remain high, accounting for both lifestyle factors (table 4, model 4).

Table 3: Model estimates of prevalence of T2DM by age, ethnic origin, lifestyle factors and socio-economic determinants (men)

		Model									
		Model 1		*Model 2*		*Model 3*		*Model 4*		*Model 5*	
Variables	Categories	e^b	95% CI	e^b	95% CI	e^b	95% CI	e^b	95% CI	e^b	95% CI
Intercept		0.012	- 0.262 – 0.286	0.015	- 0.346 – 0.375	0.015	- 0.432 – 0.463	0.009	- 0.310 – 0.328	0.010	- 0.406 – 0.427
Age - 35		1.070	1.059 – 1.080	1.067	1.056 – 1.078	1.068	1.056 – 1.079	1.070	1.058 – 1.082	1.069	1.056 – 1.081
Ethnic origin	Belgian (ref.)										
	Turkish	1.714	0.610 – 4.819	1.536	0.542 – 4.354	1.788	0.629 – 5.079	1.121	0.256 – 4.906	1.061	0.241 – 4.671
	Moroccan	1.990	1.151 – 3.442	1.840	1.054 – 3.212	1.808	1.002 – 3.264	1.868	0.953 – 3.662	1.805	0.915 – 3.558
Lifestyle factors											
BMI - 25,77								1.095	1.071 – 1.120	1.094	1.069 – 1.119
Lack of physical activity	Weekly physically active (ref.)										
	Sedentary							1.423	1.121 – 1.805	1.395	1.098 – 1.772
Socio-economic factors											
Educational attainment	No diploma/prim. ed. (ref.)										
	Lower sec. ed.			1.061	0.797 – 1.413					1.020	0.743 – 1.401
	Higher sec. ed.			0.778	0.577 – 1.049					0.878	0.635 – 1.213
	Higher ed.			0.716	0.524 – 0.977					0.807	0.574 – 1.135
Income	Less than 750 euros					1.068	0.655 – 1.741				
	750 to 1,000 euros (ref.)										
	1,000 to 1,500 euros					0.861	0.596 – 1.244				
	1,500 to 2,500 euros					0.774	0.536 – 1.116				
	More than 2,500 euros					0.733	0.480 – 1.121				
	Deviance	2,820.730		2,811.812		2,531.701		2,341.165		2,338.702	
	$\Delta\chi^2$ [a]	199.773	***	208.691	***	189.429	***	244.291	***	246.753	***
	Df	3		6		7		5		8	
	AIC	2,828.730		2,825.812		2,547.701		2,353.165		2,356.702	
	BIC	2,856.489		2,874.391		2,602.274		2,393.938		2,417.862	
	N	7,630		7,630		6,779		6,605		6,605	

[a] Deviances are always compared to the respective intercept model

Significance level: *** $p < 0.001$

Educational attainment and lifestyle factors

The effect of educational level on the risk of T2DM in *men* becomes smaller and is no longer statistically significant, when the variables BMI and lack of physical activity are inserted in the analyses (table 3, model 2 and 5). Therefore, we may suppose that the influence of educational attainment on the prevalence of T2DM is partially mediated by these lifestyle factors.

After controlling for educational attainment, the ethnic differences in the prevalence of T2DM in men become even smaller. This implies that, next to lifestyle effects, there is an additional effect of educational level on the ethnic differences in the prevalence of T2DM. On the other hand, accounting for educational attainment, the influences of BMI and lack of leisure time physical activity on T2DM persist (table 3, model 4 and 5).

In *women*, the effect of educational level on the risk of T2DM becomes smaller, but remains significant; when BMI and lack of physical activity are included in the analyses (table 4, model 2 and 5). In women too, the influence of educational level on the risk of T2DM is likely to run partially through the lifestyle factors BMI and lack of (leisure time) physical activity, although other factors – not inserted in these analyses – mediate

the relationship between educational level and the prevalence of T2DM. Moreover, after controlling for educational level, the ethnic differences in the prevalence of T2DM become smaller. Yet, the odds ratios for Turkish versus Belgian and for Moroccan versus Belgian women are still rather high (6.9 and 2.2 respectively). Thus, in women, other determinants play an important part in the ethnic differences in the prevalence of T2DM (cf. discussion).

Table 4: Model estimates of prevalence of T2DM by age, ethnic origin, lifestyle factors and socio-economic determinants (women)

		Model									
		Model 1		*Model 2*		*Model 3*		*Model 4*		*Model 5*	
Variables	Categories	e^b	95% CI	e^b	95% CI	e^b	95% CI	e^b	95% CI	e^b	95% CI
Intercept		0.010	- 0.276 – 0.296	0.018	- 0.343 – 0.380	0.014	- 0.419 – 0.448	0.007	- 0.343 – 0.357	0.010	- 0.430 – 0.450
Age - 35		1.068	1.057 – 1.079	1.058	1.046 – 1.069	1.061	1.049 – 1.073	1.060	1.048 – 1.073	1.055	1.042 – 1.068
Ethnic origin	Belgian (ref.)										
	Turkish	8.608	4.583 – 16.166	6.007	3.161 – 11.414	7.826	4.065 – 15.064	8.243	3.855 – 17.622	6.872	3.163 – 14.930
	Moroccan	4.696	2.960 – 7.450	3.497	2.172 – 5.632	4.687	2.931 – 7.495	2.554	1.328 – 4.913	2.215	1.140 – 4.302
Lifestyle factors											
BMI - 25,77								1.128	1.106 – 1.151	1.123	1.100 – 1.146
Lack of physical activity	Weekly physically active (ref.)										
	Sedentary							2.019	1.564 – 2.606	1.930	1.493 – 2.495
Socio-economic factors											
Educational attainment	No diploma/prim. ed. (ref.)										
	Lower sec. ed.			0.761	0.579 – 1.001					0.863	0.634 – 1.175
	Higher sec. ed.			0.657	0.487 – 0.887					0.828	0.588 – 1.165
	Higher ed.			0.321	0.213 – 0.482					0.486	0.307 – 0.768
Income	Less than 750 euros					0.895	0.578 – 1.385				
	750 to 1,000 euros (ref.)										
	1,000 to 1,500 euros					0.982	0.700 – 1.377				
	1,500 to 2,500 euros					0.885	0.626 – 1.249				
	More than 2,500 euros					0.517	0.321 – 0.832				
	Deviance	2,748.458		2,712.155		2,471.748		2,072.725		2,062.089	
	$\Delta\chi^2$ [a]	220.493	***	256.795	***	209.292	***	374.465	***	385.101	***
	Df	3		6		7		5		8	
	AIC	2,756.458		2,726.155		2,487.748		2,084.725		2,080.089	
	BIC	2,784.386		2,775.029		2,542.610		2,125.738		2,141.609	
	N	7,958		7,958		7,029		6,874		6,874	

[a] Deviances are always compared to the respective intercept model

Significance level: *** $p < 0.001$

5. Discussion

5.1. Prevalence of T2DM

Based on HIS 97-01-04, in native Belgian men a prevalence of T2DM of 5.0 % was found. In 35- to 74-year-old men of Turkish and Moroccan origin, the prevalence amounts to 5.8 % and 6.5 % respectively. In the same age group, the prevalence of T2DM in women of Belgian origin is 4.3 %. In the Turkish and Moroccan communities in Belgium, the prevalence rates are strikingly higher. 18.7 % and 11.9 % of the women of Turkish and Moroccan origin respectively suffer from T2DM. Comparing this prevalence rates with those in Turkey and Morocco (7.2 % and 6.6 % respectively in the age group of

20-year-olds or older), we may assume that the prevalence of T2DM in Belgians of Turkish and Moroccan origin is considerably higher, at least in women. This assumption is reinforced by the fact that the Turkish and Moroccan surveys are based on measured data, while the Belgian HIS rely on self-reported information.

5.2. Socio-economic determinants and risk factors

In this study, we found evidence that in both men and women BMI, lack of leisure time physical activity and educational attainment play an important part in the higher prevalence of T2DM in the Turkish and Moroccan communities in Belgium. In women however, other determinants – other than BMI, lack of physical activity, educational attainment and income – play an important part in the ethnic differences in the prevalence of T2DM, as the odds ratios for Turkish versus Belgian and Moroccan versus Belgian women remain high.

Thus, for women, possible explanations have to be sought elsewhere. The migration experience, foetal conditions, dietary habits, psychosocial stress, parity (and gestational diabetes mellitus (GDM)) and a higher lead exposure are presented as possible explanations for this ethnic gap in T2DM. These explanations are neither exhaustive nor mutually exclusive.

As we may assume that the prevalence of T2DM is higher in Belgian women of Turkish and Moroccan origin than in Turkish and Moroccan women living in Turkey and Morocco respectively, it might be hypothesized that the *migration experience* and the associated *rapid changeover to a western lifestyle* (low level of physical activity, calorie rich diet ...; often accompanied by a high rate of weight gain) contribute to the excess prevalence of T2DM in Belgian women of Turkish and Moroccan origin. A high rate of weight gain is assumed to be an independent risk factor of T2DM, irrespective of obesity (12, 34). Turkish and Moroccan migrants are generally originating from specific rural regions in Turkey and Morocco respectively (39). Both men and women were used to perform physically taxing labour, especially in agriculture. It might be hypothesized that women, coming from these rural areas in Turkey or Morocco, experience the most sweeping lifestyle change, as the men generally exert physically taxing jobs in Belgium while the women become housewives and switch to a predominantly sedentary existence (28). This hypothesis is further supported by the fact that there are regional differences in the prevalence of T2DM in Turkey and Morocco. In these countries, the T2DM rate is substantially higher in urban areas than in rural areas. This urban-rural differential in the prevalence of T2DM is likely to be associated with different lifestyles. Among urban populations, a sedentary lifestyle and obesity are more prevalent (28-29).

The *'foetal origins hypothesis*' might provide additional insight in the relatively high prevalence of T2DM in Belgian women of Turkish and Moroccan origin. This hypothesis is based on the observation that a low birth weight is associated with a higher risk of T2DM. In the last two decades, two (partially) competing 'foetal origins hypotheses' have been formulated to account for this association, namely the 'thrifty phenotype hypothesis' and the 'foetal insulin hypothesis' (40). According to the 'thrifty phenotype hypothesis', in utero and early post-natal malnutrition are detrimental to the

development and function of the ß-cells of the islets of Langerhans. Such structural and functional defects predispose to the later development of T2DM. Whilst these early changes powerfully determine susceptibility, additional factors, such as obesity and physical inactivity, also play a part in the development of T2DM (41). The essence of the 'foetal insulin hypothesis' is that the association between low birth weight and T2DM is at least partially caused by an insulin resistant-prone genotype. Genetic factors increase insulin resistance in utero and may produce two phenotypes: a growth-restricted infant and an adult with insulin resistance and increased risk of T2DM (42). The 'thrifty phenotype hypothesis' might at least partly explain why Belgian women of Turkish and Moroccan origin are at a higher risk of T2DM. As almost 90 % of the 35- to 74-year-old women of the Turkish and Moroccan communities in our sample are born and have spent a part of their childhood in their respective home countries where the risk of poor nutrition in childhood was higher, the 'thrifty phenotype' hypothesis might provide a partial explanation for their relatively high prevalence of T2DM, especially when they also experience a rapid changeover to a western lifestyle.

Dietary habits may play an important part in the ethnic differences in the prevalence of T2DM in women. With regard to nutritional behaviour, the habits of Turkish and Moroccan migrants seem to be healthier at some points and less healthy in other aspects (43-46). In general, their diet consists of more fruit and vegetables and less saturated fat, but their eating pattern is very irregular. In Ghent, a study about dietary habits in Turkish T2DM patients was conducted. Not only the irregular eating pattern is remarkable, but Belgians of Turkish origin also have a hot meal twice a day, often having white bread with it. That results in the consumption of a large amount of carbohydrates (22). Malki and Waterval (44) descry the same pattern in Dutch Moroccans. Moreover, they state that the irregular eating pattern – eating when hungry – makes Dutch people of Moroccan origin eat bigger helpings. Another often cited dietary explanation for the relatively high prevalence of T2DM in women of Turkish and Moroccan origin is unbalanced eating habits (23). According to Darmon and Khlat (46), the 'nutrition transition' – the large shift in the structure of diet associated with the economic transition – might be more rapid in migrants due to the large differences between their 'imported' traditional way of living and the predominant western lifestyle in the immigrant-receiving countries. Changes in the traditional culinary culture have been observed, especially among the second generation of migrants. Furthermore, this rapid changeover to a western lifestyle might be associated with rapid weight gain (cf. supra).

Additionally to the explanations above, *psychosocial stress* may also be an important factor in the high prevalence of T2DM in women of both Turkish and Moroccan origin. The relationship between blood glucose level and acute stress situations is demonstrated in a number of studies (8). Less is known about the influence of chronic stress on T2DM (10). Björntorp (9) hypothesized that psychosocial stress with a defeatist or helpless reaction leads to 'hypothalamic arousal', which is expressed as a high rate of secretion of cortisol and a low rate of secretion of sex steroids. This hormonal imbalance directs storage fat to visceral adipose tissue (47). Furthermore, an increase in serum cortisol and a decrease in sex steroids affect the insulin activity and may cause hyperglycaemia (9). Another hypothesis concerning the relationship between (chronic) stress and T2DM

was put forward by McEwen in 1998. According to McEwen, 'stress' responses – responses to a sudden, unexpected event – are twofold: on the one hand, the body responds by releasing chemical mediators; on the other hand, chronic elevation of these same mediators produces a chronic wear and tear on the bodily systems. In order to avoid the ambiguous term 'stress', McEwen uses the term 'allostasis' (i.e. the process of achieving stability (homeostasis) through change). Although allostasis is essential for maintaining a 'healthy' body, chronically increased or deregulated allostasis – 'allostatic overload' – can lead to disease, such as T2DM. According to McEwen, allostatic overload may be associated with reduced hippocampal volume. Furthermore, reduced hippocampal volume for his part might be associated with poor glucose control and outright T2DM (11, 48). To conclude, psychosocial stress is repeatedly cited as an important risk factor in the higher prevalence of T2DM amongst 'recently westernized populations' (16-17, 24). 'Recently westernized populations', like Belgians of Turkish and Moroccan origin, often live in a country that still is foreign to them. Moreover, their generally lower socio-economic position, discrimination experiences, and perceived lack of social support may cause stress. Finally, migration and the consequences of migration are often very stressing (13, 49).

Next to the migration experience, foetal conditions, dietary habits and psychosocial stress, *pregnancy – and in particular GDM* – may play an important part in the higher prevalence of T2DM in women of Turkish and Moroccan origin. According to Satman et al. (28), obesity and glucose intolerance become common in women beyond childbearing age in Turkey. It might be hypothesized that Turkish and Moroccan women are already overweight/obese before they get pregnant. Consequently, during the pregnancy period, they are at a higher risk of GDM (50). Moreover, after giving birth to one or more children, they never lose their excess weight. Both excess weight and GDM are independent risk factors of T2DM (1, 7). Additionally, parity is higher in the Turkish and Moroccan communities than in the Belgian community (51). A cycle, in which excess weight/obesity, pregnancy and GDM reinforce one another and cause T2DM, could appear. Nevertheless, we were not able to test this hypothesis as 'parity' was not questioned in HIS 97-01-04. Therefore, we suggest the inclusion of this variable in future health surveys.

Next to the above explanations, it might be hypothesized that a *higher lead exposure* could be (partially) responsible for the relatively high prevalence of T2DM in Belgian women of Turkish and Moroccan origin. Standard lead sources are tap water, paint chips and dust; sources of lead, which are mostly found in old, ramshackle houses (52). Due to their generally lower socio-economic position, Belgians of Turkish and Moroccan origin are more likely to live in such dwellings. Other – less standard – sources of lead intoxication are traditional medicines (especially some herbs) (53) and metallic teapots, traditionally used by North African populations (54). In the Turkish and Moroccan communities, traditional healers are more often consulted than among the native Belgian population. Moreover, they have a 'culture' of tea sipping (54-55). Many negative health consequences ensue from (high) lead exposure. In adults, a positive association of lead exposure with blood pressure – an independent risk factor of T2DM – has been identified in a number of studies in different settings. Schwartz (56) and Navas-Acien et al. (57) conclude that the evidence is sufficient to infer a causal relationship of lead

exposure with hypertension. Moreover, Bener et al. (58) found a positive correlation between blood lead levels and fasting serum glucose, indicating that lead exposure may be associated with T2DM. Other studies (59-60) showed that diabetics are more vulnerable to the damaging effects of long-term exposure to lead, such as renal dysfunction and inflammation.

5.3. Limitations and strenghts

The Health Interview Surveys of 1997, 2001 and 2004 enabled us to examine the prevalence of T2DM in adults of Turkish, Moroccan and Belgian origin in Belgium and to study the risk factors responsible for the differences in the prevalence of T2DM between these communities. To our knowledge, this study is the first Belgian study on this subject with data that can be considered as sufficiently representative for the health condition of the population residing in Belgium. Although there is no information available with regard to the non-response in the Turkish and Moroccan communities in Belgium, there are no indications that Belgians of Turkish and Moroccan origin are underrepresented. Comparing the percentage of 35- to 74-years-old Belgians of Turkish and Moroccan origin in our sample with the percentage in the census population of 2001, aged 35- to 74-years-old, we find an accurate representation of Turks and Moroccans in HIS 97-01-04.

Next to these strengths, some caveats should also be mentioned. The cross sectional character of the Health Interview Surveys makes it difficult to conclude on any causality in the observed associations, although the (causal) direction of associations may sometimes be logically inferable. A second limitation is that our data are self-reported, not measured. As stated before, the use of self-reported diabetes probably leads to an underestimation of the actual diabetes prevalence as one third to half of all diabetic people are unaware of the fact that they have diabetes (1-2). In the Netherlands, the Hoorn study indicated that the number of unknown (newly detected) diabetics equals the number of known diabetics (61). An additional limitation is the fact that we have no information about this 'unknown versus known diabetes' ratio in Belgians of Turkish and Moroccan origin. However, there are indications that known diabetes might be lower in these communities (55). In any case, we might state that the total prevalence of known and unknown diabetes in these communities will probably be higher than the prevalence found in this study. A third limitation is that some information, such as waist-to-hip ratio, total caloric intake or parity, was not available in HIS 97-01-04. Moreover, the number of Belgians of Turkish and Moroccan origin in the sample was relatively small. Consequently, some indicators of physical activity and diet could not be included in the analyses.

6. Conclusions

This study provides evidence for a high prevalence and early onset of T2DM in Belgians of Turkish and Moroccan origin. We identified some mechanisms involved. The most important socio-economic factor associated with the relatively high prevalence of T2DM in both men and women of Turkish and Moroccan origin is educational attainment. The influence of lifestyle factors on community differences in T2DM is more complex. In men, a lack of physical activity plays an important part. In women, the higher mean T2DM probability in the Turkish and Moroccan communities is particularly associated with their higher mean BMI. However, some of the ethnic differences in the prevalence of T2DM in women could not be explained; the odds ratios for Turkish versus Belgian and Moroccan versus Belgian women remain high. In the discussion, we hypothesized that cultural and environmental factors in particular, such as the migration experience, dietary habits and a combination of excess weight and GDM, may play an important part.

In the light of worldwide ageing and increased corpulence, the prevalence of T2DM is expected to rise in the future. The costs for the individual and the society will be tremendous. Consequently, prevention of T2DM is extremely important. Moreover, prevention of T2DM also gains importance as the same risk factors underlie other disorders, such as cardiovascular and cerebrovascular diseases, and as T2DM is accompanied by an increased death probability. Identification of (causes of) risk factors and risk groups of T2DM is a conditio sine qua non for an efficient preventive policy. In this study, we already identified one high risk group, namely women of Turkish and Moroccan origin. An active screening of these women – if possible in collaboration with existing initiatives – should be be considered as one of the most important tracks for preventive policy. However, costs and benefits of this 'high-risk' strategy should be weighed up against each other. In this study, we also identified some risk factors: excess weight/obesity and a sedentary leisure lifestyle. Preventive policy of T2DM should focus on these determinants, not only in the communities at stake but also in the general population. A wide range of interventions is possible: alerting to the risks of being overweight/obese, promoting knowledge and skills in the field of healthy eating, encouraging adults to participate in sports and other types of physical activity ... Finally, the results of this study are indicative for a protective effect of educational attainment. A higher educational level is associated with a lower risk of excess weight/obesity, a higher level of leisure time physical activity and a lower risk of T2DM. Therefore, enduring efforts should be made to improve the educational level of the general population in Belgium, but especially of persons from the Turkish and Moroccan communities in Belgium. To conclude, further – mainly qualitative – research into the relatively high prevalence of T2DM in women of the Turkish and Moroccan communities is necessary in order to unravel the specific mechanisms at stake and to fine-tune preventive policy.

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