The sweeping environmental change hypothesis: the case of obesity and diabetes among Mediterranean migrants in Belgium

Vandenheede H.[1], Deboosere P.[2]

'Do we not always find the diseases of the populace traceable to defects in society?'

Rudolf Virchow (1821-1902)

1. Introduction

Throughout most of human existence communicable diseases were the leading cause of death. During the last centuries and especially during the last decades, however, many demographic, social, economic and ecological changes gradually led to a decrease in the occurrence of infectious diseases. Non-communicable diseases (NCDs), such as obesity and type 2 diabetes, became a major health problem (Omran 1971; WHO 2002). Contrary to conventional wisdom, obesity and type 2 diabetes are not restricted to industrialized societies, but are global phenomena, especially affecting the developing countries (IDF 2009a; WHO 2002). Obesity and type 2 diabetes mellitus are also highly prevalent among migrants and indigenous people throughout the world (Carter et al. 1996; Greenhalgh 1997; Knowler et al. 1990; Tremblay et al. 2005; Uitewaal et al. 2004; Vandenheede & Deboosere 2009). To account for these differences, physiological, cultural as well as socio-economic explanations are put forward (Baschetti 1998; Cruickshank et al. 2001; Hales & Barker 1992; King & Roglic 1999). However, the most often cited explanations for the relatively high prevalence of obesity and diabetes among migrant groups are of a physiological nature, id est the thrifty genotype and the thrifty phenotype hypotheses.

The *thrifty genotype hypothesis* is based on the assumption that the human genotype hasn't changed substantially since the Stone Age. In this age – when men lived as 'hunter-gatherers' –, there were periods during which food was plentiful and periods when food was scarce. In order to survive, it was adaptive to have genes that enhanced the storage of excess energy in times of plenty to be used in times of want and that stimulated the use of fatty acids instead of glucose as a muscle fuel. Hence natural selection favoured such a thrifty genotype. However, in modern times, this thrifty genotype is in fact a disadvantage, manifesting itself among other things in the development of obesity and type 2 diabetes (Chakravarthy & Booth 2004; Neel 1999). In this hypothesis, population variability in the prevalence of obesity and type 2 diabetes is attributed to variations in local niches. Adaptations to different local stresses, like dietary ecology, agricultural patterns, climate ..., might be responsible for differences in obesity and type 2 diabetes mellitus between populations. To explain the relatively high prevalence of these conditions among migrants, attention is drawn to the intense selection process during migration. Large-scale migrations have often been undertaken during times of energy stress or famine. Consequently, the persons surviving these ordeals and reaching the new environments, are most likely the ones with the more thrifty genes (Wells 2006).

This highly controversial hypothesis received a lot of criticism (Baschetti 1998; Cruickshank et al. 2001; Hales & Barker 1992). An alternative explanation for population variability in non-communicable diseases

[1] Junior research fellow of the Research Foundation – Flanders; Interface Demography, Department of Social Research, Vrije Universiteit Brussel

[2] Interface Demography, Department of Social Research, Vrije Universiteit Brussel

has been put forward by Hales and Barker (1992) in the form of the *thrifty phenotype hypothesis*. According to this hypothesis, in utero and early post-natal malnutrition are detrimental to the development and function of the beta cells of the islets of Langerhans. Such structural and functional defects predispose people to the development of NCD risk factors. Whilst these early changes powerfully determine susceptibility, environmental risk factors also play a part in deciding the time of onset and severity of NCDs. In this hypothesis, variations in obesity and type 2 diabetes between populations are largely put down to differential nutrition conditions during pregnancy and early life and a differential food availability in later life (Middelkoop 2001).

Both hypotheses emphasize – although to a different extent – the role of physiological factors, while the environmental risk factors associated with obesity and type 2 diabetes are thought to play second fiddle. In this paper, we would like to bring the environment back in. With the *sweeping environmental change hypothesis*, we will formulate an alternative explanation for population variability in the prevalence of obesity and type 2 diabetes that puts the aetiological role of the environment in the development of these conditions to the fore. We will corroborate this hypothesis with migration data from Belgium.

2. Background

2.1. Obesity

Obesity is defined as excessive fat accumulation that may impair health. People with a body mass index[3] of equal to or more than 30 are generally considered obese (WHO 2006). The World Health Organization (WHO) (2000) describes obesity as one of the most blatantly visible – yet most neglected – public health problems. In 1948 obesity received its 'official' disease status with the 6th revision of the International Classification of Diseases (Wolfbane 2007). But it was not until the 1990s that the problem received global recognition (Haslam & James 2005, Swinburn et al. 1999). Moreover, obesity is not only a disease in itself, but it is also associated with an increased risk of hypertension, coronary heart disease, type 2 diabetes and several types of cancer (Haslam & James 2005).

In 2005 the global prevalence of overweight – BMI $\geq$ 25 – has been estimated at 1.6 billion adults. Of them, at least 400 million were obese (WHO 2006). Over the past decades a dramatic increase in the global prevalence of overweight and obesity has been observed (Deitel & Toronto 2002). E.g. in most European countries the prevalence of obesity in adults amounted to 5 to 10% in the early 1990s, while in recent years most countries have an adult obesity prevalence of more than 15% (IOTF 2009a). However, this upward trend is not limited to Europe, but represents a global tendency in both less and more developed countries (Deitel & Toronto 2002; IOTF 2009b). Profound societal changes and the worldwide nutrition transition are often seen as driving forces for this global increase in the prevalence of obesity. Economic growth, modernization, urbanization and the globalization of food markets are just some of the factors held responsible (WHO 2003). As societies urbanize and grow richer, food security generally improves and diets low in fat and high in starch give way to more varied diets with a higher proportion of fats, saturated fats and sugar. At the same time, large shifts towards less physical activity have been observed: less physically demanding work, increased use of automated transport, more technology in the home … (Nicolaou 2009; Popkin 1992; WHO 2003). These drastic changes in both diet and physical activity may result in a positive energy balance and hence a high rate of weight gain and obesity (Nicolaou 2009; Swinburn et al. 2009).

[3] Body mass index is obtained by dividing the weight in kilograms by the square of the height in meters.

Yet large differences in obesity prevalence are found *between* and *within* countries. The highest prevalence rates are found in the industrialized countries and in the urban areas in the developing countries (IOTF 2009b). *Within* countries striking differences between social groups are observed. In industrialized countries groups with a lower socio-economic status generally have a higher obesity prevalence (Mackenbach et al. 2008), whereas in developing nations obesity is more prevalent among the higher socio-economic strata and among urban versus rural dwellers (Aspray et al. 2000; IOTF 2009b, Subramanian et al. 2009).

The close association between urbanization, socio-economic position, lifestyle changes and obesity prevalence seems to suggest that obesity is pre-eminently a social and environmental disease.

2.2. Type 2 diabetes mellitus

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 common form is type 2 diabetes mellitus. It affects 90 to 95% of all individuals with diabetes. Type 2 diabetes occurs predominantly at an advanced age (over 35 years old) (Capet et al. 1999) and is accompanied by an increased death probability (Mackenbach et al. 1991). There is strong evidence that genetics play an important part in interaction with other risk factors. Important risk factors are: obesity (cf. supra), excessive abdominal fat, rapid weight gain, a lack of physical activity, diet and stress (McEwen 2008; Yki-Järvinen 1997).

The global prevalence of diabetes in adults has been estimated at 285 million patients in 2010. By 2030 this disease is expected to affect 438 million people, especially in developing countries (IDF 2009a). Recent research has shown a dramatic increase in the global prevalence of diabetes. As in the case of obesity, urbanization and the accompanying lifestyle change to an energy-dense, high-fat diet and to a more sedentary subsistence are often put forward as explanatory factors (Popkin 1992; Zimmet 2000).

Between countries large differences in diabetes prevalence are observed. In general diabetes is on the rise, but this tendency is more pronounced in developing countries. E.g. the diabetes prevalence in India is 7.8% versus 3.6% in the UK (IDF 2009b). *Within* countries some groups have a higher diabetes prevalence than others. In industrialized countries a higher prevalence is observed among groups with a lower socio-economic status (Espelt et al. 2008); whereas in developing nations diabetes is more prevalent among the higher socio-economic strata compared to the lower socio-economic strata and among urban versus rural dwellers (Aspray et al. 2000; Benjelloun 2002; Boddula et al. 2008). E.g. according to our own calculations based on data from the International Diabetes Federation (IDF 2009b), the prevalence of diabetes mellitus is about 10.9% in urban India, against 5.7% in rural India.

Based on these data, we may assume that type 2 diabetes is also closely associated with urbanization, socio-economic position and lifestyle changes, as in the case of obesity.

2.3. Body perception

As mentioned before, in industrialized countries a negative association between socio-economic status and obesity/diabetes prevalence is observed; whilst in developing countries a positive association is found. To gain a deeper insight into this differential relationship, it is important to take cultural values concerning food and body fatness into account (Nicolaou 2009).

Although body shape and size certainly have biological significance, they also have social meaning. The bodily experience is always modified by the social categories through which it is known and hence sustains a particular view of society (Cassidy 1991). In a society characterized by recurrent food shortages, corpulence is often admired, as it represents the fulfilment of the dream of plenty. A stout body conveys a message of food abundance, health, beauty, (male) strength and (female) fertility. In a context of food abundance on the other hand, thinness is highly valued.

In western societies there have been many changes in the body shape preferences, especially for women. Until the 1920s plumpness was positively valued. Voluptuous women were considered beautiful. E.g. the second wife of Peter Paul Rubens, Helen Fourment, was rotund – or may we say 'Rubenesque'? – and acclaimed a great beauty (cf. Figure 1). But in the twenties of the previous century thinness became the new beauty ideal. The – then – relatively new context of food abundance and the successful marketing by the fashion industry are often seen as important contributing factors (Cassidy 1991; Grogan 1999; van Otterloo 1995). On the other hand, big remains beautiful in contemporary non-western societies that are still characterized by recurrent food shortages. E.g. white Moors of Mauritania value a 'woman of substance' as both beautiful and healthy. They have a tradition of 'fattening up' girls before marriage to make them beautiful and fertile (cf. Figure 2) (Cassidy 1991; Pollock 1995a; Pollock 1995b; Nicolaou 2009).

Figure 1: The Little Fur (Peter Paul Rubens, 1638) (Harden 2009)

Figure 2: 'Fat' Mauritanian woman (BBC 2005)

In a context of food scarcity those of higher social rank can express their status through corpulence, while poorer people remain thin and undernourished. However, when food becomes plentiful, high-fat food and a large body size are no longer exclusive to higher socio-economic groups; but healthy food and a slender body become scarce commodities. If high status groups want to express their status in a context of food abundance, they have to become thin. The inverse association between socio-economic status and obesity in western societies may in part be explained by this human tendency to express status. To distinguish themselves, those of higher status tend to value slimness and to consume lower-fat foods, while people of lower status have a strong preference for 'filling' food and hence are more likely to become fat (Nicolaou 2009; van Otterloo 1995; Wells 2006).

3. The sweeping environmental change hypothesis

To explain the population variability in obesity and type 2 diabetes in general and the high prevalence of these diseases among migrants in particular, we will formulate the sweeping environmental change hypothesis.

This hypothesis is based on several assumptions.

Firstly, as we observe a particularly high obesity and diabetes prevalence among migrants in industrialized countries and among urban dwellers in developing countries, we may assume that urbanization and the accompanying lifestyle change are positively associated with obesity and diabetes. The *environmental change* – towards more urbanization – plays an *aetiological role*.

Secondly, we postulate that (migrant) populations that undergo the *largest environmental change*, have the *highest obesity* and *diabetes prevalence*. Migrants, especially those who originate from less and move to more developed countries, not only move through space but also through time. Migration not only provides them with a macro environment that is geographically different, but they are also confronted with a different 'time period', as the respective home and host countries are often in another phase of the economic, demographic, epidemiological and nutrition transition. Hence migrants may be seen as time travellers (Razum & Twardella 2002). They are as it were catapulted into another 'age'. Immigrants originating from less or non-industrialized countries and moving to more industrialized countries, are suddenly subject to a society in which food abundance predominates, considerably less physical force is needed to produce a living and the everyday diet is high in carbohydrates, sugars, meat and fat. Such environment differs largely from their 'original' environment in which relative food scarcity prevailed, physical activity was necessary for food procurement and the diet was high in fibre and starch (Nicolaou 2009, Popkin 1992). What applies to migrants, holds true to a certain degree for all populations who are subject to rapid economic growth, urbanization and demographic, epidemiological and nutrition changes. As migrants are often confronted with the most disruptive environmental changes, we may assume that they represent an extreme case of a more general evolution.

Thirdly, we hypothesize that a drastic shift in environment is associated with a *shift in lifestyle* that is not less drastic. In predominantly rural societies periods where food is plentiful are alternated with periods of relative food shortage. During the former periods people tend to stuff themselves in order to have a 'fat cushion' against forthcoming food shortages (Chakravarthy & Booth 2004). As economic growth and urbanization proceed, populations are (gradually) subject to a non-stop food abundance. There are indications that those (former) farmers, confronted with this new situation, transplant the lifestyle of the periods of food abundance to the new environment (Landman & Cruickshank 2001). As this lifestyle becomes permanent, this results in a continuously positive energy balance. Such a (sweeping) shift in lifestyle may lead to a high rate of weight gain and hence obesity and type 2 diabetes (Hanson et al. 1995).

Fourthly, we might assume that this holding on to the lifestyle of the periods of food abundance is in part associated with *cultural values* related to food and body fatness. Although the environmental conditions are different, love of 'filling' food, a deep-seated value of food as a means of communication and an admiration of a large body size may not have changed (Pollock 1995b). We may say that there is a cultural lag. The material surroundings have changed substantially, but cultural values haven't. As populations become more and more acquainted to their new environments, we might expect cultural values to change too. Hence food quality and thinness may be positively valued and eventually a 'new' lifestyle – with the consumption of low-fat, low-sugar foods and a lot of (leisure time) physical activity – might emerge.

4. Relation with thrifty genotype and thrifty phenotype hypotheses

The sweeping environmental change hypothesis is partially consistent with both the thrifty genotype and thrifty phenotype hypotheses, but bears closer resemblance to the thrifty phenotype hypothesis.

The thrifty genotype hypothesis mainly explains population variability in NCDs by variation in evolutionary history. Populations with an evolutionary history of vagaries and hardship have undergone a more intense selection for thrifty genes. Hence they are more likely to develop NCDs, such as type 2 diabetes. The thrifty phenotype hypothesis on the other hand, does not emphasize the evolutionary history of groups, but attaches great importance to their life history. Differences in foetal malnutrition are seen as important contributors to population variability in NCDs. These early life differences highly determine susceptibility to NCDs, especially when environmental risk factors are also at stake.

The sweeping environmental change hypothesis does not rule out these hypotheses. Harsh circumstances during the evolutionary and/or life history of certain populations may play a part in their higher prevalence of obesity and diabetes. However, the sweeping environmental change hypothesis does not consider differences in harsh circumstances – either in evolutionary or in life history – to be the main determinants of the population variability in NCDs. The environment is seen as the driving force behind differences in NCDs between populations. In other words, instead of 'thriftiness' of genes or phenes, the 'obesogenic' environment and particularly the (rapid) changeover to such an environment are considered the main aetiological factors.

5. Mediterranean migrants in Belgium

As noted above, we will corroborate this hypothesis with data concerning the four largest Mediterranean migrant groups in Belgium, id est the Spanish, Italian, Turkish and Moroccan communities. After all they constituted one of the most important influxes of immigrants in recent Belgian history.

As a small country and active trading centre with a geographically open and central location, Belgium has a long history of migration. But it was not until the interbellum period that today's migrant population started taking form. During the twenties labour demands of heavy industry and coal mines attracted migrants from Italy and Eastern Europe. At the end of the twenties the Italian community in Belgium approached 30,000 persons (Morelli 2004). Immediately after the Second World War labour migration rose sharply with tens of thousands of mainly Italian workers recruited for the mining industry. The Italian migration continued for a long period, even after the official migration stop of 1956, and was still important in the sixties and seventies. The next migration flux was chiefly formed by Spanish and Greek workers. After the labour migration agreement of 1956 between Belgium and Spain, the Spanish community rose quickly approaching 70,000 immigrants in 1970 (Sanchez 2004). Later on, as the post-war economic boom spread over Europe, new cheap labour force was recruited from Turkey and Morocco. This massive labour migration ended abruptly with the economic crisis of the early seventies. Migration since then has been restricted to family reunion and the import of brides and grooms by the populations of Turkish and Moroccan origin.

This brief overview of the recent migration history of Belgium illustrates the relative homogeneity of the Mediterranean migrant groups in Belgium. All groups have a history of labour migration. Yet there are group differences in the timing of onset of migration and in the environmental conditions of their countries of origin. Taking these differences into account, we formulated three hypotheses based on the theoretical framework of the sweeping environmental change hypothesis.

(1) Obesity and diabetes morbidity and mortality are more prevalent among the Mediterranean migrant groups than in the Belgian host population.

(2) The highest prevalence of obesity and the highest diabetes morbidity and mortality are found among the Turkish and Moroccan communities, as they experienced the most sweeping environmental and hence lifestyle change.

(3) The higher obesity and diabetes prevalence among the Mediterranean groups cannot entirely be explained by differences in lifestyle and socio-economic factors, since the sweepingness of the environmental and lifestyle change plays an important part.

6. Methods

6.1. Design and study population

To analyze *obesity* and *diabetes morbidity*, we used the Belgian Health Interview Surveys of 1997, 2001 and 2004. The main objective of these surveys is to give a description of the health status of the population residing in Belgium. The health surveys reached a total of 37,387 respondents. The non-response at household level amounted to 41.5%, 38.6% and 38.6% in 1997, 2001 and 2004 respectively (Demarest et al. 1998; Demarest et al. 2002; Bayingana et al. 2006). The morbidity analyses were restricted to the age group of 25- to 74-year-olds. The lower age limit was set at 25 years, as type 2 diabetes generally emerges later in life (over 35-years-old). The older ages were excluded from the analyses, because the number of Belgians of Mediterranean origin in the dataset is too small to get accurate estimates. The total population of age 25 to 74 included in the analyses accounts for 23,106 persons (Spanish origin N=213; Italian origin N=642; Moroccan origin N=612; Turkish origin N=247).

To gain insight in ethnic differences in *diabetes mortality*, we used the National Mortality Database 1991-1996. This database consists of a linkage between the 1991 Belgian census and the registration records of all deaths and emigrations between the census of 1991 and 1 January 1996. The cohort is semi-closed, as nobody could enter the population but people could leave the population by emigration or death (Deboosere & Gadeyne 1999).

6.2. Variables

To define *obesity*, we used the body mass index cut-off points of the WHO. A person is considered obese when his or her BMI is equal to or more than 30.

Diabetes morbidity is self-reported. In order to exclude type 1 diabetes at younger ages, we selected the age group of 25-year-olds and older. This is a relatively crude, but nonetheless effective way of focusing on type 2 diabetes, particularly because the proportion of type 2 diabetes in the total diabetes prevalence is estimated at 90%.

To determine *mortality from diabetes mellitus*, the 9th revision of the International Classification of Diseases (ICD) was employed. The relevant code was ICD-9: 250.

Ethnicity was based on a combination of nationality and country of birth. If a person had either the Spanish, Italian, Turkish or Moroccan nationality or was born in Spain, Italy, Turkey or Morocco, he or she was considered as being of Spanish, Italian, Turkish or Moroccan origin.

Lack of leisure time physical activity is a variable with two categories, namely weekly physically active and sedentary.

The variable *educational attainment* was constructed according to the International Standard Classification of Education (ISCED). This variable can acquire the following modalities: no diploma/primary education; lower secondary education/special secondary education; higher secondary education and higher education.

6.3. Data analysis

In order to gain a deeper insight in *obesity* and *diabetes morbidity*, we computed their respective prevalence in the age group of 25 to 74. Furthermore, we conducted stepwise logistic regression analyses with obesity/diabetes as the dependent variables.

To obtain an overview of ethnic differences in *diabetes mortality*, age-standardized mortality rates were computed for each ethnic group. These rates were attained by direct standardization using the total Belgian population as the standard population. As indirect standardization method age-adjusted Poisson regression was used. When hazard rates are approximately constant during the observation period and the risk of the event under study is small, Poisson regression provides a good alternative to Cox (Parodi & Bottarelli 2006). Given the relatively short study period (1991-1996) and the rareness of diabetes mortality, both conditions are met and Poisson regression is deemed a valuable alternative to Cox regression.

Only a small part of the analyses is presented. For a more detailed overview of the diabetes morbidity analyses, we refer to Vandenheede & Deboosere (2009). All the analyses were done for men and women separately. As regards the morbidity analyses, the study population was restricted to men and women aged 25 to 74 years. The study population of the mortality analyses on the other hand consisted of 25- to 54-year-olds. The upper age limit was set at 54 years, because of the small numbers of Turks and Moroccans above that age, especially in women.

7. Results

7.1. Morbidity: obesity and diabetes

Obesity

Table 1 presents the prevalence of overweight, obesity and diabetes by ethnic origin for the age group of 25- to 74-year-olds. In men ethnic differences in overweight and obesity are rather small and not univocal. E.g. Spanish men have a lower prevalence of overweight compared to Belgian men (34.1% versus 41.4%), but are slightly more obese (16.5% versus 13.6%). In women on the other hand, differences are more pronounced. As regards overweight, Spanish, Turkish and Moroccan women have a higher prevalence compared to Belgian women (30.6%, 30.8%, 35.2% versus 26.2%). However, ethnic differences in obesity are even more striking. No less than 20.9% of the Italian, 32.7% of the Turkish and 29.2% of the Moroccan women are obese. By comparison: 'only' 13% of the Belgian women are considered obese.

Table 1: Overweight, obesity and diabetes (in %; age group 25-74 years)

Ethnicity	**Overweight (%)**		**Obesity (%)**		**Diabetes (%)**	
	Men	Women	Men	Women	Men	Women
Belgian	41.4	26.2	13.6	13.0	4.1	3.6
Spanish	34.1	30.6	16.5	9.0	2.2	5.4
Italian	43.7	25.9	20.2	20.9	5.5	6.3
Turkish	41.7	30.8	11.0	32.7	4.7	12.6
Moroccan	33.8	35.2	12.2	29.2	4.1	9.7
Pearsons χ^2 *(Sign)*	10.1 *(*)*	13.0 *(**)*	14.4 *(*)*	102.6 *(***)*	5.7 *(ns)*	54.1*(***)*

** p < 0.05; ** p < 0.01; *** p < 0.001; ns: not significant*

In table 2 the results of the logistic regression analyses with obesity as the dependent variable are presented. As expected from the prevalence results, no ethnic differences are observed in men. Only Italian men have a higher odds ratio compared to Belgian men (OR=1.63; 95% CI 1.24 – 2.14); whereas in women Italian, Turkish and Moroccan women are more obese than Belgian women. In Italian women the higher obesity prevalence is entirely explained by their generally less physically active leisure activities and their generally lower educational attainment. In Turkish and Moroccan women on the other hand, the higher obesity risk remains, even when lack of leisure time physical activity and educational attainment are taken into account (Model 2).

Table 2: Odds ratios of obesity by ethnicity, age, physical activity and educational attainment (age group 25-74 years)

	Odds ratios (OR) of obesity					
	Men		**Women**			
	Model 1		*Model 1*		*Model 2*	
Independent variables	OR	95 % CI	OR	95 % CI	OR	95 % CI
Ethnicity						
Belgian	1.00 (ref.)		1.00 (ref.)		1.00 (ref.)	
Spanish	1.24	0.70 – 2.20	0.69	0.36 – 1.34	0.19	0.03 – 1.41
Italian	1.63	1.24 – 2.14	1.80	1.33 – 2.42	1.42	0.79 – 2.55
Turkish	0.96	0.55 – 1.69	4.36	2.87 – 6.62	2.52	1.50 – 4.25
Moroccan	1.02	0.72 – 1.44	3.58	2.71 – 4.74	1.92	1.33 – 2.77
Age	1.02	1.02 – 1.03	1.03	1.03 – 1.04	1.02	1.01 – 1.02
Physical activity						
Physically active					1.00 (ref.)	
Sedentary					1.85	1.62 – 2.10
Educational attainment						
No dipl/ primary educ					1.00 (ref.)	
Lower secondary educ					0.72	0.61 – 0.86
Higher secondary educ					0.59	0.49 – 0.71
Higher educ					0.34	0.28 – 0.43

CI = Confidence Interval

Diabetes

No ethnic differences in diabetes are observed in men, whereas in women all Mediterranean migrant groups have a higher prevalence of type 2 diabetes compared to Belgian women. In Turkish and Moroccan women this prevalence even amounts to 3 to 4 times the prevalence in Belgian women (cf. Table 1).

The results of the logistic regression analyses with diabetes are presented in Table 3. As expected, no statistically significant ethnic differences are observed in men. In women the odds ratios are higher in the Italian, Turkish and Moroccan communities. The highest odds ratios are observed in the Turkish and Moroccan communities: 7.36 (95% CI 4.00 – 13.58) and 5.00 (95% CI 3.23 – 7.74) respectively. As in the case of obesity, the excess diabetes prevalence in women of the Italian community can be explained, but the excess diabetes prevalence in women of Turkish and Moroccan origin persists, even when important contributing factors, like body mass index and educational level are taken into account (Model 2).

Table 3: Odds ratios of diabetes by ethnicity, age, BMI and educational attainment (age group 25-74 years)

	Odds ratios (ORs) of diabetes					
	Men		Women			
	Model 1		*Model 1*		*Model 2*	
Independent variables	OR	95 % CI	OR	95 % CI	OR	95 % CI
Ethnicity						
Belgian	1.00 (ref.)		1.00 (ref.)		1.00 (ref.)	
Spanish	0.62	0.15 – 2.56	1.84	0.79 – 4.31	1.28	0.17 – 9.75
Italian	1.43	0.88 – 2.33	1.92	1.16 – 3.17	1.36	0.47 – 3.96
Turkish	2.24	0.95 – 5.27	7.36	4.00 – 13.58	5.06	2.65 – 9.64
Moroccan	1.62	0.91 – 2.90	5.00	3.23 – 7.74	2.51	1.46 – 4.33
Age	1.07	1.07 – 1.08	1.07	1.06 – 1.08	1.06	1.05 – 1.07
Body Mass Index					1.13	1.11 – 1.15
Educational attainment						
No dipl/ primary educ					1.00 (ref.)	
Lower secondary educ					0.89	0.66 – 1.18
Higher secondary educ					0.82	0.60 – 1.12
Higher educ					0.48	0.32 – 0.73

CI = Confidence Interval

7.2. Diabetes mortality

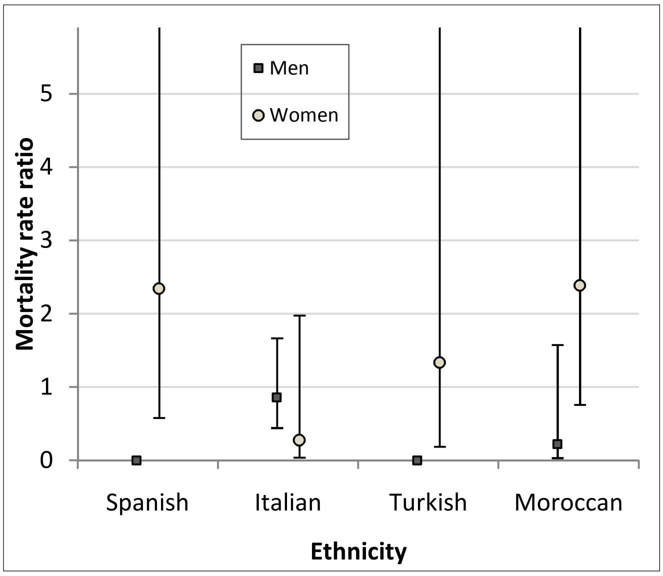
In Table 4 the age-standardized mortality rates by ethnicity are presented. Due to the small numbers of recorded diabetes deaths, it is difficult to draw conclusions from these results. No statistically significant ethnic differences in diabetes mortality are observed. In men the age-standardized mortality rates even amount to zero in the Spanish and Turkish communities, as no deaths from diabetes were recorded in 25- to 54-year-old men of Spanish and Turkish origin. In women higher diabetes mortality rates are observed in the Spanish and Moroccan communities, although they fail to reach statistical significance.

Table 4: Age-standardized mortality rates by ethnicity (age group 25-54 years)

	Age-standardized diabetes mortality rates (ASMRs) (per 100,000)			
	Men		Women	
Ethnicity	ASMR	95 % CI	ASMR	95 % CI
Belgian	2.7	2.4 – 3.0	1.1	0.9 – 1.3
Spanish	0.0	0.0 – 0.0	2.5	0.0 – 5.9
Italian	2.4	0.8 – 3.9	0.3	0.0 – 0.9
Turkish	0.0	0.0 – 0.0	1.5	0.0 – 4.6
Moroccan	0.7	0.0 – 2.2	3.0	0.0 – 6.4

The mortality rate ratios (cf. Figure 3) give us the same information as the ASMRs, but in a relative form. As we can see in Figure 3, no statistically significant differences in diabetes mortality are observed, but the rate ratios in women indicate a higher diabetes mortality in Spanish and Moroccan women.

Figure 3: Age-adjusted diabetes mortality rate ratios by ethnicity (age group 25-54 years)



Legend: Bars indicate the 95% confidence intervals.

8. Discussion

To summarize: we found no ethnic differences in obesity and diabetes morbidity nor in diabetes mortality in men. Yet women of Italian, Turkish and Moroccan origin were more likely to be obese and have a higher diabetes prevalence compared to Belgian women. These prevalence rates were highest among women of Turkish and Moroccan origin. Among these women the relatively high obesity and diabetes prevalence rates could not entirely be explained by the risk factors taken into account. With regard to mortality from diabetes, there were indications that women of Spanish and Moroccan origin have a higher diabetes mortality.

What strikes one immediately is the discrepancy between the results for men and women. But before putting this and other findings in a broader theoretical framework, we will discuss some methodological issues.

Methodological considerations

Obesity and diabetes morbidity – The Belgian Health Interview Surveys of 1997, 2001 and 2004 enabled us to study differences in obesity and diabetes prevalence between 'native' Belgians and Belgians of Mediterranean origin. An important advantage of these health surveys is that they give a sufficiently representative picture of the health condition of the population residing in Belgium. An important caveat on the other hand is that these data are cross-sectional. Hence it is sometimes difficult to conclude on any causality in the observed associations. Yet the time sequence of the relations may be logically inferable, as in the case of the relation between educational attainment and type 2 diabetes. As type 2 diabetes occurs predominantly at an advanced age, educational attainment precedes this type of diabetes and the relation thus goes from educational level to type 2 diabetes.

In the Belgian Health Interview Surveys data on height, weight and diabetes are based on self-reporting, not measurement. The use of self-reported height and weight may lead to an underestimation of body mass index, overweight and obesity (Roberts 1995). Moreover self-reported diabetes prevalence also represents an underestimation of the actual diabetes prevalence as one third to half of all diabetics are unaware of the fact that they suffer from diabetes (Capet et al. 1999; Mooy et al. 2000). To the extent that there are systematic differences in self-reported height, weight and diabetes between ethnic groups, the results of our study are biased.

During our analyses we were confronted with another data problem: some information, such as waist-to-hip ratio, total caloric intake or parity, was not available in the Belgian Health Interview Surveys.

Diabetes mortality – The mortality data were obtained from the National Mortality Database 1991-1996, a census-linked mortality study. The longitudinal design of this study provides a solution for the classic problem of numerator-denominator bias. However, for approximately 2% of the people who were registered at the time of the census and who died during the observation period, no linkage between the census of 1991 and the death records could be established. The main reason for non-matching is that a number of death certificates are simply missing. When the place of death is outside Belgium, no Belgian death certificate is established and the register of death certificates holds no trace of this death; whereas the registration of the decease in the population register still takes place. As immigrants have a higher probability of dying abroad, relying exclusively on death certificates would introduce the risk of underestimating migrant mortality. By establishing a linkage between the census and the death certificates, this problem is avoided. We therefore may conclude that the population register is fairly accurate in registering death, but that the non-establishment of death certificates for deaths outside Belgium will result in a large proportion of unknown deaths, particularly among migrant groups. However, as we limited our analyses to the age group of 25- to 54-year-olds, we may assume that this problem remains relatively small (Deboosere & Gadeyne 2005).

An additional data problem is related to the practice of classifying the 'underlying cause of death'. As diabetes mellitus is often part of a complex clinical picture, in which the disease is considered as of secondary importance, diabetes is not registered as the 'underlying cause of death'. This leads to an underestimation of deaths due to diabetes (Mackenbach et al. 1991). To the extent that this under-registration differs between the Mediterranean migrants in Belgium and the Belgian host population, the results of our study are biased. However we have no indications that such differential registration practices exist.

To conclude this methodological section we would like to refer to another data problem, namely the problem of *small numbers*. With regard to *diabetes morbidity*, the relatively small number of diabetes cases among Belgians of Mediterranean origin implied that some indicators that might play an important part, could not be taken into consideration. With respect to *diabetes mortality*, there are few diabetes deaths among Mediterranean migrant groups. This problem is an inherent part of the study of diabetes deaths in relatively small groups, as mortality from diabetes is fairly rare and it is underestimated. In our study this problem of small numbers is also associated with the relatively young age structure of the Mediterranean migrant groups in Belgium during our study period (1991-1996).

Theoretical considerations: sweeping environmental change?

Men of Mediterranean origin do not have a higher obesity and diabetes prevalence compared to Belgian men, whereas women of Mediterranean origin are more likely to be obese and have diabetes than their Belgian counterparts. The association between ethnicity and obesity/diabetes thus differs between the sexes. In this discussion we would like to interpret this striking observation in the light of the three hypotheses previously elaborated, namely the thrifty genotype, thrifty phenotype and the sweeping environmental change hypothesis. The *thrifty genotype hypothesis* assumes that persons selected for and surviving the migration experience are more likely to have 'thrifty' genes and hence are more susceptible to NCDs like obesity and diabetes. In this case we should assume that Mediterranean women represent a more intensely selected subpopulation than men of Mediterranean origin. However this is unlikely to be true since men of Mediterranean origin often came to Belgium as labour migrants; whereas Mediterranean women often joined them as part of family reunification. Therefore it is far more likely that Mediterranean men represent a more selective group with regard to health than their female counterparts. If the thrifty genotype hypothesis holds true, not the Mediterranean women, but the Mediterranean men should have the more thrifty genes and hence should be more vulnerable to both obesity and diabetes. According to the *thrifty phenotype hypothesis*, foetal and early life malnutrition are the main determinants of population variability in NCDs. Foetal conditions are unlikely to differ systematically between male and female foetuses as parents were generally not informed about the sex of the foetus. To the extent that early life conditions are more harsh for women than for men, this hypothesis might explain why Mediterranean women are more vulnerable to obesity and diabetes. However a more likely explanation for the relatively high obesity and diabetes rates among women of Mediterranean origin, especially among women of Turkish and Moroccan origin, and the relatively low rates among their male counterparts is provided by the *sweeping environmental change hypothesis*. We may assume that the environmental and hence the lifestyle change is more sweeping for Mediterranean women. E.g. women of Mediterranean origin often had a physically active job in the agriculture in their home countries, while their labour market participation in the host country is generally low and their domestic activities are of light intensity. Mediterranean men on the other hand generally remain physically active as they often have physically taxing jobs. When we adjusted our diabetes mortality analyses for confounding by labour market participation, we found that the slightly higher mortality from diabetes in Spanish and Moroccan women disappeared (results not shown). Whether the job was physically active or not, seemed to bear little significance. Furthermore we might hypothesize that this larger environmental and hence lifestyle change in Mediterranean women is not something isolated. Sex differences in cultural values related to food and body fatness may also play a role. In many cultures a positive value is attached to female plumpness and fertility, whereas male stoutness is less positively valued (Cassidy 1991; Pollock 1995b). This might partially explain why Mediterranean women – especially women of Turkish and Moroccan origin – are more vulnerable to obesity and diabetes than their male counterparts. When we took parity into account in our analyses, the somewhat higher diabetes mortality in women of Spanish and Moroccan origin disappeared (results not shown).

The prevalence of obesity and diabetes is highest in women of Turkish and Moroccan origin. In these women the higher obesity and diabetes rates could not be explained by the 'classical' risk factors, such as an unhealthy lifestyle and a lower socio-economic status. This finding is in line with the assumption that the relatively high rates of obesity and type 2 diabetes among recently westernized populations cannot entirely be explained by an 'obesogenic' environment and lifestyle but that the sweepingness of the change plays towards such an environment and lifestyle also plays an important role. This assumption was also corroborated by the fact that there exists an inverse relation between gross domestic product per capita of the country of origin and migrant diabetes mortality in Europe (Vandenheede et al. X).

As regards the diabetes mortality analyses, it is difficult to draw conclusions because the age structure of the Mediterranean migrant population was relatively young in the period 1991 to 1996. Yet, we might expect that a higher Mediterranean migrant diabetes mortality will emerge in the future as there is a large discrepancy between diabetes morbidity and mortality.

9. Conclusion

In this study we put forward an alternative hypothesis for population variability in obesity and diabetes, namely the sweeping environmental change hypothesis. Thereby, we went back to a common finding of migrant studies that as environments change, disease rates change too. We postulated that the (rapid) change to an 'obesogenic' environment and lifestyle is the key determinant of population variability in obesity and diabetes.

To further corroborate or falsify this hypothesis, more research is needed. If our hypothesis is correct, future generations of migrants (and urban populations) should have lower rates of obesity and diabetes than the 'first generation(s)', as they gradually adapt to their new environments. However it would still remain difficult to rule out the thrifty phenotype hypothesis, as these second and third generations will also be less exposed to foetal and early life malnutrition.

To conclude, our research clearly demonstrates the importance of the (social) environment. Hence, preventive strategies of obesity and type 2 diabetes should not only focus on lifestyle but also on the 'obesogenic' environment. The latter is likely to prove essential in reducing diabetes morbidity and mortality.

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