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PSYCHOSOCIAL AND DEMOGRAPHIC DETERMINANTS OF REGIONAL DIFFERENCES IN THE PREVALENCE OF OBESITY

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Summary. Differences in the prevalence of obesity between adjacent regions are quite common, but usually unexplained. This study examined whether birth place, selective migration, intelligence or education – which are both inversely and possibly causally related to obesity – are determinants of such differences. This population-based case-control study (case-cohort design) took place in the greater Copenhagen area (region 1) and surrounding provincial areas of Zealand (region 2), Denmark. A total of 2948 men with a median age of 19 years from two draft board regions during 1966–1977 were examined. The odds ratio (OR) for being obese (defined as body mass index $\geq$31 kg/m^2) was investigated using multiple logistic regression analyses. The OR for being obese in region 2 compared with region 1 was 1·74 (1·50–2·03). Adjustment for birth place, intelligence test score and educational level reduced the OR to 1·42 (1·10–1·82). The OR for being obese for those born in region 2 compared with region 1 was 1·71 (1·46–2·01). Adjustments for intelligence test score, educational level and examination region reduced this OR to 1·13 (0·87–1·46). Irrespective of birth place, men examined in region 2 had a higher OR for being obese than those examined in region 1; this effect was most pronounced for those born in region 2 and examined in either region 1 or 2, with an OR of 1·06 (0·71–1·57) and 1·87 (1·58–2·22) respectively. In conclusion, the regional differences in the prevalence of obesity could not be explained by birth place or later selective migration, but educational level and intelligence test score did explain some of the difference.

Introduction

During the last few decades the prevalence of obesity has increased in both developed and developing countries (World Health Organization, 2000). Differences in the prevalence of obesity as well as different rates in secular trends are seen between countries, as well as within countries, frequently as urban–rural differences (Hejda & Osancova, 1989; Kuskowska-Wolk & Bergstrom, 1993; Pietinen *et al*., 1996; Reeder *et al.*, 1997; Cairney & Wade, 1998; Rasmussen *et al*., 1999; Mokdad *et al.*, 1999). In most surveys where regional differences are observed no further investigations of reasons for these differences have been employed, but they may give clues to the causes of obesity.

The role of diet and physical activity in regional differences in the prevalence of obesity is not convincing (Reeder *et al*., 1997; Gutíerrez-Fisac *et al.*, 1999). Comstock and co-workers found that obese subjects were less likely to move away from a defined area than lean subjects (Comstock *et al*., 1966), which may contribute to such regional differences. Several studies have found negative associations between educational level as well as intelligence test score and the prevalence of obesity (Sørensen & Sonne-Holm, 1985; Teasdale *et al.*, 1992; Gutíerrez-Fisac *et al.*, 1996, 1999). A prospective study by Lissau and Sørensen suggested that weak school performance was associated with a greater risk of obesity in young adulthood (Lissau & Sørensen, 1993). Teasdale and co-workers found a strong association between educational level, intelligence test score and population density in a Danish survey (Teasdale *et al.*, 1988). So, lower educational levels and lower intelligence test scores in rural areas may contribute to regional differences in the prevalence of obesity. On the other hand, obesity in childhood or adolescence has been found to influence later social class status, e.g. as defined by fewer completed years of school (Sonne-Holm & Sørensen, 1986; Gortmaker *et al.*, 1993), suggesting that bi-directional associations between education or cognitive ability and obesity might be present.

The purpose of this study was to search for possible determinants of differences in the prevalence of obesity between adjacent regions in a developed society with equal social welfare and health systems, free exchange and mobility, and virtually the same distribution of dietary and physical activity habits (Haraldsdóttir *et al.*, 1987; Groth, 1988). Whether place of birth, selective migration, intelligence test score or educational level could explain the considerable difference in prevalence of obesity between two such adjacent regions – a metropolitan and surrounding provincial area – was assessed (Sonne-Holm & Sørensen, 1977).

Methods

Study population

All young Danish men are registered as liable for military service when attaining the age of 18 years. They have to appear before the Danish draft boards for examination within the next few years. Reasons for delayed appearance are mainly ongoing education, diseases, travelling abroad etc. Reasons for exemption from service without appearing before the board include chronic diseases and disease sequelae, handicaps and mental retardation requiring institutionalization, but not obesity.

The population of this study comprises those men registered during the period 1964–1977 in the metropolitan areas of Copenhagen and north-eastern part of Zealand (region 1), and in the remaining part of Zealand and adjoining islands (region 2).

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Information about birth place was provided by the Danish Central Office of Civil Registration and divided into three groups: born in examination region 1, in examination region 2, or outside regions 1 and 2. Almost all men had undergone systematic health examination, including measurement of weight in underwear, height without shoes, intelligence testing and rating of educational level (Sonne-Holm & Sørensen, 1977; Sørensen & Sonne-Holm, 1985).

For testing intelligence the (Børge Priens Prøve 1953) BPP-53 test was applied. The BPP-53 test is a 45-minute test designed for testing groups. It has remained unchanged since its incorporation into the draft board pre-induction procedure in 1957. The test is still in use and is therefore not open to the public. The BPP-53 test comprises four subtests – letter matrices, verbal analogies, number series and geometric figures – with a total of 78 items (Rash, 1960; Teasdale *et al.*, 1988). Intelligence measured by the BPP-53 group test has been evaluated against the Wechsler Adult Intelligence Scale (WAIS), which is an individual intelligence test widely used and approved in psychological research, in a study by Mortensen and co-workers (Mortensen *et al.*, 1990). A high correlation was found indicating that the group-based BPP-53 test measured the same general intelligence as the WAIS test and therefore is suitably for epidemiological and demographic studies of intelligence. For data analysis the intelligence test scores going from 0 to 78 were divided into eight levels (0–15, 16–21, 22–27, 28–34, 35–40, 41–46, 47–53, 54–78) (Sørensen & Sonne-Holm, 1985).

Educational level at the time of examination was recorded in nine categories starting with primary school and ending with an academic university degree (Sørensen & Sonne-Holm, 1985). In the data analysis levels 7–9 were merged into one group.

Study design

The study is a population-based case-control study, where a group of extremely overweight men are compared with a randomly selected control group of young men from two draft board regions in Zealand and adjoining islands in the period 1964–1977 (case-cohort design). The obese group was identified as all men in the study population who were extremely overweight, originally defined as 35% overweight (according to a national standard of that time), which corresponds to a BMI $\geq$ 31 kg/m^2, and they were found by a manual, systematic search through the files (Sonne-Holm & Sørenson, 1977). In the time period 1964–1977, 1525 obese men were identified, 901 from region 1 and 624 from region 2. As control group, a random 1% sample was drawn as every hundredth in the files screened for obese draftees ($n = 2014$). From this control group, ten draftees with BMI $\geq$ 31 kg/m^2 were removed from the sample when analysing the determinants of the regional differences. Another 96 draftees were excluded from the control group owing to missing values on weight or height at the examination. The final non-obese control group for the time period 1964–1977 consisted of 1908 men: 1341 from region 1 and 567 from region 2.

Statistical analyses

Data were analysed in three logistic regression models where the odds for being obese relative to controls were addressed by examination region (Model 1),

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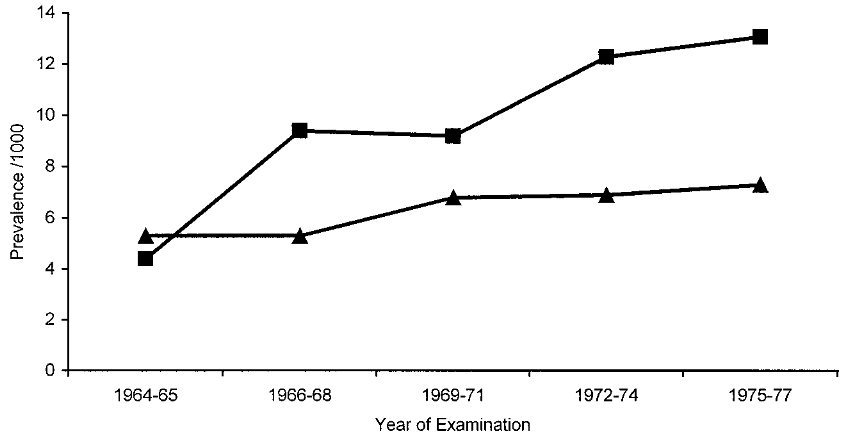

Fig. 1. Prevalence of obesity in regions 1 and 2 during the time period 1964–1977. Triangles, region 1; squares, region 2.

birth place region (Model 2) and a combination of examination and birth place region (Model 3). Explanatory class variables were: calendar year of examination, educational level, intelligence test score level and birth place.

The results are presented as odds ratios (OR) with 95% confidence intervals (CI 95%). All statistical analyses were performed using the SPSS 10·0 software programme.

Results

Regional differences and secular trends in the prevalence of obesity

The prevalence of obesity in regions 1 and 2 was estimated from the number of obese men divided by the number in the complete control sample × 100, for the time period 1964–1977. In 1964–65 the prevalence of obesity was almost the same in the two regions whereafter it increased over time in both regions, although not at the same rate (Fig. 1). From 1964–65 to 1966–68 the prevalence more than doubled, from 4·4 per 1000 to 9·4 per 1000 in region 2, while there were no changes in region 1 (logistic regression analysis showed a significant interaction between region and examination year, $p = 0{\cdot}03$). However, in the time period 1966–1977 the rate of increase in the two regions was almost parallel, and there was no significant interaction ($p = 0{\cdot}53$). The subsequent analyses therefore only include data for the time period 1966–1977.

Descriptive statistics

The obese group had a significantly higher BMI ($p < 0{,}001$), lower educational level and lower intelligence test score ($p < 0{\cdot}001$) (Table 1). There was a significantly higher BMI ($p < 0{\cdot}001$) and lower educational level and intelligence test score in region 2 than in region 1 ($p < 0{\cdot}001$).

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Table 1. Characteristics of the study population 1966–1977: median (range)

	Obese group*		Control group	
	Region 1	Region 2	Region 1	Region 2
Total no. men examined	802	587	1163	488
No. born in region 1†	656 (91%)‡	68 (9%)	955 (93%)	75 (7%)
No. born in region 2	45 (9%)	458 (91%)	62 (15%)	356 (85%)
No. born outside regions 1 & 2	89 (70%)	39 (30%)	126 (78%)	36 (22%)
BMI	32·8 (31·0–51·8)	32·7 (31·0–43·2)	21·1 (15·9–30·9)	22·0 (16·0–30·9)
Educational level§	4 (1–9)	4 (1–9)	5 (1–9)	4 (1–9)
IQ test score	34 (5–66)	33 (2–68)	42 (4–69)	39 (10–66)

* BMI $\geq$ 31 kg/m^2.
†Due to missing values for birth place, the three birth place groups do not sum up to the total number of men examined in regions 1 and 2.
‡Percentage of draftees from a certain birth place region, which had their draft board examination in either region 1 or 2.
§Educational levels are divided into nine groups.

Ninety per cent of the draftees were born within either region 1 or 2 while the remaining 10% were born outside the two regions or outside Denmark. Most men born in regions 1 and 2 were also examined in the region where they were born. Among those born outside regions 1 and 2 the majority, both obese and controls, were examined in region 1 (Table 1).

Model-based analyses

Analyses with examination region as the main variable of interest (Model 1) showed that the crude OR for being obese in region 2 compared with region 1, adjusted only for year of examination, was 1·74 (Table 2). Intelligence test score and educational level were both highly significantly and inversely associated with the OR for obesity. After adjusting for these factors, the OR for region 2 was reduced to 1·51. Adjustment for birth place reduced the OR to 1·48. Combining the adjustments reduced the OR to 1·42.

The crude OR, for being obese if born in region 2 compared with being born in region 1 (model 2), adjusted only for year of examination, was 1·72 (Table 3). Adjustments for intelligence test score and educational level reduced the OR to 1·48. Adjustment for examination region reduced the OR to 1·25, and thereby removed the significant differences between the birth places. Combined adjustments reduced the OR further to 1·13.

The difference in the OR of being obese among those who did compared with those who did not migrate was addressed in Model 3 (Table 4). The OR for being obese for the three groups examined in region 2 was generally higher than among the draftees examined in region 1. The highest OR, adjusted only for year of examination,

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Table 2. Odds ratios (OR) for being obese at draft board examination in region 2 compared with region 1

Variables included in Model 1*	*n*	OR (95% CI)
Region†	3040	1·74 (1·50–2·03)
Region, year of examination	3040	1·74 (1·50–2·02)
Region, year of examination, IQ test score	3022	1·62 (1·39–1·90)
Region, year of examination, education	3023	1·48 (1·27–1·74)
Region, year of examination, IQ test score, education	3022	1·51 (1·29–1·78)
Region, year of examination, place of birth	2965	1·48 (1·17–1·88)
Region, year of examination, place of birth, IQ test score	2948	1·50 (1·18–1·92)
Region, year of examination, place of birth, education,	2949	1·37 (1·07–1·76)
Region, year of examination, place of birth, IQ test score, education	2948	1·42 (1·10–1·82)

*Logistic regression with stepwise inclusion of the explanatory variables: year of examination, intelligence test score, educational level and birth place.
†Region 1 is reference group.

was found for the group of draftees both born and examined in region 2 (OR = 1·88) compared with the draftees both born and examined in region 1 (reference). Also, the draftees born in region 1 or outside regions 1 and 2 and examined in region 2 showed a clear tendency towards a higher OR for being obese compared with the reference group. Adjustments for intelligence test score and educational level increased the OR of being obese for the draftees born outside regions 1 and 2 and examined in region 2 to 1·78, while the OR for the draftees born and examined in region 2 was slightly reduced (OR = 1·59). For the draftees born in region 1 and examined in region 2 additional adjustments did not change the OR noticeably. The OR of being obese for the draftees born in region 2 or outside regions 1 and 2 and examined in region 1 was not significantly different from the reference group and further adjustments did not change the OR.

Discussion

The basis for this study was that despite a high degree of socioeconomic and cultural homogeneity and close geographical proximity, draftees examined in the provincial areas (region 2) had a higher risk of being obese compared with those examined in the adjacent metropolitan areas (region 1). These differences persisted even after adjusting for educational level and intelligence test score, both well known factors that are inversely and possibly causally related to obesity (Sørensen & Sonne-Holm, 1985; Teasdale *et al.*, 1992), and for place of birth.

The higher risk of being obese among the men born in region 2 compared with those born in region 1 disappeared when examination region, intelligence test score and educational level were adjusted for. Finally, these analyses suggested that no matter where the men were born, the risk of being obese was considerably higher if they subsequently were examined in region 2. The results suggest that place of birth

Table 3. Odds ratios (OR) for being obese if born in region 2 compared with if born in region 1

Variables included in Model 2*	*n*	OR (95% CI)	
		Born in region 2	Born outside regions 1 & 2
Place of birth†	2965	1·71 (1·46–2·01)	1·12 (0·88–1·44)
Place of birth, year of examination	2965	1·72 (1·46–2·02)	1·13 (0·88–1·45)
Place of birth, year of examination, IQ test score	2948	1·57 (1·33–1·86)	1·24 (0·95–1·61)
Place of birth, year of examination, education	2949	1·47 (1·24–1·74)	1·28 (0·98–1·68)
Place of birth, year of examination, IQ test score, education	2948	1·48 (1·25–1·76)	1·30 (1·00–1·70)
Place of birth, year of examination, region	2965	1·25 (0·98–1·61)	1·05 (0·82–1,36)
Place of birth, year of examination, region, IQ test score	2948	1·14 (0·88–1·47)	1·15 (0·88–1·51)
Place of birth, year of examination, region, education	2949	1·14 (0·88–1·48)	1·21 (0·92–1·59)
Place of birth, year of examination, region, IQ test score, education	2948	1·13 (0·87–1·46)	1·22 (0·93–1·60)

*Logistic regression with stepwise inclusion of the explanatory variables: year of examination, intelligence test score, educational level and examination region.

†Born in region 1 is reference group.

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Table 4. Odds ratios (OR) for being obese if born in a certain region and examined in either regions 1 or 2 compared with if born and examined in region 1

Place of examination:	Region 1			Region 2		
Place of birth:	Region 1	Region 2	Outside regions 1 & 2	Region 1	Region 2	Outside regions 1 & 2
n	1611	107	215	143	814	75
Variables in Model 3*	OR	OR (CI 95%)	OR (CI 95%)	OR (CI 95%)	OR (CI 95%)	OR (CI 95%)
(Birth × region)	1	1·06 (0·71–1·57)	1·03 (0·77–1·37)	1·32 (0·94–1·86)	1·87 (1·58–2·22)	1·58 (0·99–2·51)
(Birth × region), year of examination	1	1·05 (0·71–1·57)	1·04 (0·79–1·39)	1·29 (0·92–1·82)	1·88 (1·58–2·23)	1·56 (0·98–2·49)
(Birth × region), year of examination, IQ test score	1	1·06 (0·70–1·60)	1·14 (0·84–1·54)	1·41 (0·99–2·01)	1·71 (1·43–2·04)	1·76 (1·09–2·85)
(Birth × region), year of examination, education	1	1·09 (0·71–1·66)	1·19 (0·88–1·62)	1·31 (0·91–1·88)	1·57 (1·31–1·88)	1·70 (1·04–2·77)
(Birth × region), year of examination, IQ test score, education	1	1·09 (0·72–1·66)	1·20 (0·88–1·64)	1·36 (0·95–1·95)	1·59 (1·33–1·91)	1·78 (1·09–2·90)

*Logistic regression with stepwise inclusion of the explanatory variables: year of examination, intelligence test score and educational level.

does not influence the risk of being obese as much as place of living at the time of examination.

The number of men who had moved away from the region where they were born was small. A hypothetical calculation, under the assumption of equal prevalence by region of birth, and that none of the obese and none from the control group in region 1 moved out of the region, showed that 20,800 controls out of 42,300 men from region 2 should have moved to region 1 in the time period 1966–1977 to produce the observed differences in the prevalence of obesity. However, the migration rate was generally low in all groups, and both controls and obese were moving in both directions with no preponderance of the control group in region 2. Selective migration can therefore not be the main determinant of regional differences in the prevalence of obesity in these regions.

Educational level has been found to be inversely related to the prevalence of obesity (Østbye *et al.*, 1995; Gutíerrez-Fisac *et al.*, 1996; Cairney & Wade, 1998; Rasmussen & Johansson, 1998; Mokdad *et al.*, 1999), and that was also the case in this study population (Sørensen & Sonne-Holm, 1985; Teasdale *et al.*, 1992). Moreover, educational level was an important determinant of regional differences in the prevalence of obesity, which was also seen in an ecological study in Spain in 1999, where they observed that illiteracy, among several lifestyle and socioeconomic factors, was the only significant determinant to explain the geographical variation in the prevalence of obesity. However, the illiteracy variable only explained 12% of the total variation (Gutíerrez-Fisac *et al.*, 1999). In a Canadian study, Reeder *et al.* (1997) found a higher OR of being obese in the rural areas compared with the urban areas in one of the regions in the country. In this study educational level and age reduced the OR for being obese, but the urban–rural differences persisted after the adjustments. In most other studies region or place of residence are used, together with other socioeconomic and lifestyle factors, as potential confounders in multiple regression models (Kuskowska-Wolk & Rössner, 1990; Gutíerrez-Fisac *et al.*, 1996; Rasmussen & Johansson, 1998; Cairney & Wade, 1998). In a Dutch study where only weak regional differences were seen for men, and no differences for women, the authors suggested that the lack of difference seen in other studies might be due to the adjustments for educational level in the analyses (Baecke *et al.*, 1983), which is to some extent supported by the present results.

The other presumed determinant associated with regional differences in obesity in this study was the intelligence test score. Despite its high correlation with education (Spearman's rho $=0{\cdot}73$, $p<0{\cdot}01$), as also found in another Danish study (Teasdale *et al.*, 1988), there was an independent inverse association with obesity (Sørensen *et al.*, 1982), and it reduced the OR for being obese in region 2 compared with region 1. Inclusion of both intelligence test score and educational level gave a better model than when only one of them was included, but it did not reduce the regional differences in regard to obesity further.

It is conceivable that being obese leads to a lower educational and intelligence level, and not the other way round. Several studies have investigated both hypotheses; some have found associations supporting low education being a predictor of development of later overweight and obesity, while in other studies obesity in youth seemed to inversely influence later achieved social status (Sonne-Holm & Sørensen, 1986; Lissau & Sørensen, 1993; Gortmaker *et al.*, 1993). The two associations, however, do not necessarily exclude each other. The inverse relation between these social factors and obesity is probably due to bi-directional effects (Stunkard & Sørensen, 1993).

Both educational level and intelligence test scores, on a national level, increased throughout the time period 1964–1977 (Teasdale & Owen, 1987), but the mean levels for the full period were lower in region 2 and other regions with lower population density, which simultaneously also had a higher rise in the prevalence of obesity than region 1 (Teasdale *et al.*, 1988; Sørensen & Price, 1990). These cross-country variations in educational level and intelligence test scores and prevalence of obesity make it reasonable to consider educational level and intelligence test score as possible determinants of regional differences.

Two evident factors that presumably could contribute to regional differences in the prevalence of obesity are differences in diet patterns and physical activity levels. Data from the first national Danish diet survey in 1985 showed some regional differences in food patterns, but these hardly affected nutrient composition (Haraldsdóttir *et al.*, 1987). Total energy intake was higher among men living in rural areas compared with more densely populated areas, probably due to a higher level of occupational physical activity. A national survey on leisure time physical activity and sports habits among the Danish adult population in 1987 found no major regional differences in activity level (Groth, 1988). Based on these data and other studies, which did not find strong regional correlations in physical activity, energy intake and obesity (Reeder *et al.*, 1997; Gutíerrez-Fisac *et al.*, 1999), it is suggested that other determinants should be searched for.

In conclusion, regional differences in the prevalence of obesity are quite common, and this study found that the differences could be attributed to differences in intelligence test score and educational level, whereas birth place and migration did not contribute much. More studies are needed to identify other determinants of regional differences and trends in the prevalence of obesity, which may reveal hitherto unknown causes of obesity and facilitate the understanding of the global obesity epidemic.

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