Explanations of Socioeconomic Differences in Excess Risk of Type 2 Diabetes in Swedish Men and Women

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OBJECTIVE — We investigated to what extent socioeconomic differences in type 2 diabetes risk could be explained by established risk factors (obesity, physical inactivity, smoking, and heredity) and psychosocial factors (low decision latitude at work and low sense of coherence).

RESEARCH DESIGN AND METHODS — This cross-sectional study comprised 3,128 healthy Swedish men and 4,821 women, aged 35–56 years, living in the Stockholm area. An oral glucose tolerance test identified 55 men and 52 women with type 2 diabetes. The relative contribution of established and psychosocial factors to socioeconomic differences in diabetes risk was assessed by comparing analyses with adjustment for different sets of these factors.

RESULTS — The relative risks (RRs) for type 2 diabetes in middle and low socioeconomic groups in men were 2.4 (95% CI 1.0–5.3) and 2.9 (1.5–5.7), respectively, and in women 3.2 (1.5–6.6) and 2.7 (1.3–5.9), respectively. In men, the RRs decreased to 1.9 (0.8–4.4) and 2.1 (1.0–4.2) after adjustment for established risk factors; no further change was found when psychosocial factors were included. In women, the RRs changed to 2.4 (1.1–5.2) and 1.6 (0.7–3.8) by including established risk factors and to 2.3 (1.0–5.1) and 1.9 (0.8–4.3) by inclusion of psychosocial factors. After adjustment for both established and psychosocial factors, the RRs were 1.4 (0.6–3.6) and 1.0 (0.4–2.5), respectively.

CONCLUSIONS — In men, the excess risk of type 2 diabetes was partly explained by established risk factors (36–42%), whereas psychosocial factors had no effect. In women, most of the socioeconomic differences in type 2 diabetes were explained by simultaneous adjustment for established risk factors and psychosocial factors (81–100%).

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Type 2 diabetes is more prevalent in lower socioeconomic groups in Western societies (1–6). Obesity, physical inactivity, and smoking are implicated in the development of type 2 diabetes (7,8) and are also associated with low socioeconomic position (9–11). In addition, a range of psychosocial factors is involved in socioeconomic inequalities in health (12,13). However, the research explaining socioeconomic differences in type 2 diabetes risk has mainly focused on established risk factors such as obesity, physical inactivity, and smoking (1,2,5). In a recent study (14), we found that psychosocial factors, such as low decision latitude at work and low sense of coherence (SOC) (a factor in successful coping with stressors), seemed to be associated with type 2 diabetes in women. Decision latitude at work derives from the demand-decision latitude model introduced by Karasek and colleagues (15,16). The model proposes that the combination of high demands and low decision latitude increases the risk of coronary heart disease. However, publications show that the decision latitude dimension is consistently related to coronary heart disease, whereas the demand dimension is not (17). In addition to established risk factors, we suggest that psychosocial factors may be of importance for socioeconomic differences in type 2 diabetes risk. We investigated to what extent the excess risk of type 2 diabetes in lower socioeconomic groups can be explained by established risk factors (obesity, physical inactivity, smoking, and diabetes heredity) and psychosocial factors (low decision latitude at work and low SOC).

RESEARCH DESIGN AND METHODS

The design of the baseline study of the Stockholm Diabetes Prevention Program has been described previously (14,18). In brief, this cross-sectional study comprises 3,129 men and 4,821 women between the ages of 35 and 56 years at the time of examination (1992–1994 and 1996–1998, respectively). The male study sample was selected from four municipalities: Sigtuna, Värmdö, Upplands Bro, and Tiresö in Stockholm. The female study sample was selected from the same municipalities and one other: Upplands Väsby. All study individuals were identified by the Stockholm County Council register.

The selection of the study sample was obtained in two steps. First, a questionnaire containing questions on country of birth, diabetes diagnosis, and family history of diabetes (FHD) was sent to all men and women in the appropriate age-groups living within the study areas (n = 32,368). Completed questionnaires were

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Abbreviations: FHD, family history of diabetes; IGT, impaired glucose tolerance; OGTT, oral glucose tolerance test; SOC, sense of coherence.

received from 26,717 people (83%). At this stage, 12,979 (49%) were excluded due to already known diabetes (2%), insufficient knowledge of FHD (12%), incomplete responses (28%), and foreign origin (6%). In addition, 1% of the females were excluded due to death, mental retardation, and moving from the municipality.

In the second step, the study sample was divided into two groups: those with FHD, defined as having at least one first- (parent or sibling) or two second-degree relatives (grandparents, uncles, or aunts) (n = 5,689) with diabetes, and those without FHD (n = 7,625). All those with FHD, along with a random sample of those without FHD (n = 5,921), were invited to undergo a physical health examination. In addition, 424 women reporting previous gestational diabetes were invited.

In total, 8,108 (67% of those invited) individuals agreed to participate in the health examination. During the visit at the primary health care center, an oral glucose tolerance test (OGTT) was administered and the participants answered a detailed questionnaire about lifestyle factors. In addition, weight, height, and blood pressure were measured. The information on FHD was also verified. At this stage, 33 (1%) men were excluded due to insufficient FHD and 129 (2%) women were excluded due to breast-feeding, pregnancy, certain medications, or insufficient FHD. The final study sample consisted of 3,129 men and 4,821 women.

Classification of disease

The 75-g OGTT and classification of type 2 diabetes and impaired glucose tolerance (IGT) followed the World Health Organization criteria (19). A person was diagnosed as having type 2 diabetes when the 2-h serum glucose level was ≥11.1 mmol/l and as having IGT when 2-h serum glucose levels were between 7.8 and 11.0 mmol/l. The OGTT test identified 55 men and 52 women with type 2 diabetes and 172 men and 167 women with IGT according to this definition. Men and women with normal glucose tolerance were used as control subjects in all analyses.

Measurement of socioeconomic position

Socioeconomic position was based on self-reported occupational titles and classified according to the standard system elaborated by Statistics Sweden (20). We divided socioeconomic position into three groups, i.e., high (high- and medium-level nonmanual employees), middle (low-level nonmanual employees), and low (unskilled and skilled manual workers). A total of 2,864 (92%) men (49 with type 2 diabetes) and 4,509 (94%) women (48 with type 2 diabetes) were included in the analysis of socioeconomic position. Altogether, 265 men and 312 women were excluded from further analysis for the following reasons: 170 men (5 with type 2 diabetes) and 173 women (3 with type 2 diabetes) were classified as self-employed. Moreover, 15 men (none with type 2 diabetes) and 89 women (none with type 2 diabetes) were farmers. Among women, two were students, four were housewives, and two had retired (none of them had type 2 diabetes). In addition, missing information regarding socioeconomic position was found in 80 men (1 with type 2 diabetes) and 125 women (1 with type 2 diabetes).

Measurement of established risk factors

BMI was calculated as weight in kilograms divided by the square of height in meters and then categorized into three groups (≤25, 25–30 and ≥30 kg/m^2). Physical activity was measured from a question of how physically active the subjects had been during the latest year. The question contained a 4-scale responding alternative such as "sedentary," "moderately active," "regular exercise," and "regular exercise and training." The level of activity was classified into three groups: low (sedentary), middle (moderately active), and high physical activity (regular exercise and regular exercise plus training). Smoking habits were based on the question, "Have you ever smoked on a daily basis?" and those who stated that they had were asked if they still smoked. We divided the answers into current smokers or nonsmokers (nonsmokers included former smokers). Additionally, we categorized the subjects in the following categories: nonsmokers, 1–15, and ≥16 cigarettes/day. FHD was categorized as positive when at least one first- (parent or sibling) or two second-degree relatives (grandparents, uncles, or aunts) were reported as having had diabetes and as negative otherwise.

Measurement of psychosocial factors

Low decision latitude at work and low SOC has been described and analyzed previously in association with type 2 diabetes in women (14). Briefly, decision latitude at work describes a person's skills and ability to master work activities (21). It was analyzed by five of six questions from the demand-decision latitude questionnaire (15). Thus, our questionnaire lacked one of the questions, i.e., "Do you have the freedom to decide how your work should be performed?" The possible bias of lacking this question has been described previously (14). Cronbach's α for the internal consistency reliability for the decision latitude dimension has been measured to 0.76 in men and 0.77 in women (22). For each question, subjects were provided with four responding options, such as "almost always," "often," "seldom," and "never," and these were given points ranging from 1 to 4. We then calculated a summed score from the five questions. From the distribution of scores among all respondents, three groups were created from the upper, median, and lower quartiles (median represents those between the upper and lower quartile). These categories represent high, middle, and low decision latitude.

SOC is a paradigm developed by Antonovsky (23) and is based on three dimensions: comprehensibility, meaningfulness, and manageability. The original questionnaire contains 29 items. In our study, we analyzed SOC from three questions, one on each dimension (comprehensibility, meaningfulness, and manageability). The three-dimensional SOC has been tested for reliability and been previously recommended. The weighted κ for each item ranged from 0.5 to 0.6, indicating a satisfactory reliability (24). In addition, it has been discussed to be valid in relation to the original questionnaire. Each question contained three response alternatives: "yes, most often," "yes, sometimes," and "no." A summed index was created from the distribution of scores among all respondents and then divided into four groups: high, upper middle, lower middle, and low.

Data analysis

Prevalence odds ratios with 95% CIs were estimated in a multiple logistic regression model with dummy variables representing the various risk factors. The odds ratios were interpreted as incidence rate

Table 1—*Baseline characteristics of the study population (1992–1994 in men and 1996–1998 in women) by socioeconomic groups*

	High (High- and medium-level nonmanual employees)	Middle (Low-level nonmanual employees)	Low (Unskilled and skilled manual workers)
Men	1,383 (48.3)	492 (17.2)	989 (34.5)
Mean BMI (kg/m^2)	25.8	26.2	26.3
Low physical activity	119 (8.6)	54 (11.0)	112 (11.4)
Smokers	273 (19.7)	143 (29.1)	324 (32.8)
FHD	676 (48.9)	263 (53.5)	545 (55.1)
Low decision latitude	330 (24.3)	222 (46.4)	552 (58.4)
Low SOC	155 (11.4)	70 (14.4)	241 (24.6)
Women	2,040 (45.2)	1,222 (27.1)	1,247 (27.7)
Mean BMI (kg/m^2)	24.9	25.5	26.2
Low physical activity	190 (9.3)	154 (12.6)	153 (12.3)
Smokers	359 (17.6)	382 (31.3)	459 (36.8)
FHD	1,043 (51.1)	651 (53.3)	722 (57.9)
Low decision latitude	340 (17.3)	560 (50.1)	547 (48.7)
Low SOC	300 (14.7)	293 (24.0)	359 (28.8)

Data are *n* (%) unless noted otherwise.

ratios and are referred to as relative risks (RRs) (25). We performed analyses on men and women separately. First, we calculated age-adjusted RRs for occupational status and type 2 diabetes. Second, to explain socioeconomic differences in disease risk, we included each factor (BMI, physical activity, smoking, FHD, decision latitude, and SOC) one by one in the model. We then looked at the set of established risk factors and psychosocial factors, respectively, and finally we included all factors (both established risk factors and psychosocial factors) in the same model. The proportion of excess risks in type 2 diabetes (in lower socioeconomic groups) explained by different factors were calculated as {RR [age-adjusted (−1)] − RR [age-adjusted + risk factor(s) (−1)]/RR [age-adjusted (−1)]} (26,27). The SAS statistical package version 8.2 was used for calculations (28).

RESULTS — The proportion of smokers and FHD were higher among men and women with low and middle socioeconomic positions compared with those with high position (Table 1). In addition, low physical activity was slightly more prevalent and mean BMI somewhat higher among individuals with low and middle socioeconomic positions. With regard to psychosocial factors, low decision latitude at work and low SOC were more common in the middle and low socioeconomic groups. As compared with high socioeconomic position, middle and low socioeconomic positions were associated with higher type 2 diabetes prevalence in both men and women (Table 2).

In men, BMI, physical inactivity, smoking, and FHD explained a similar percentage of the excess risk of type 2 diabetes in middle and low socioeconomic groups (Table 3). The established risk factors together explained 36% of the excess risk in the middle group and 42% in the low group. When we adjusted for psychosocial factors, low decision latitude at work explained a minor part of the excess risk. Low SOC did not change the RR, and we could not identify any change in either socioeconomic group when adjusting for both psychosocial factors. Hence, when combining established risk factors and psychosocial factors, the RR was virtually the same as when adjusting for the established risk factors alone.

In women, smoking and BMI seemed to be important in middle and low groups (Table 4). Physical inactivity and FHD did not explain the excess risks to any important extent. When clustering the established risk factors, 36% of the excess risk was explained in the middle group and 65% in the low group. In women, on the other hand, low decision latitude at work together with low SOC explained a considerable part of the excess risk in the middle (38%) and low socioeconomic groups (53%). When we adjusted for both established risk factors and psychosocial factors, 81% of the excess risk of type 2 diabetes was explained in the middle group and 100% in the low socioeconomic group.

We performed additional analyses with regard to IGT with the same procedure as that for type 2 diabetes. In women, the RRs for IGT in association with middle and low socioeconomic groups compared with that of high socioeconomic groups were 1.5 (95% CI 1.0–2.2) and 1.9 (1.3–2.8), respectively. These excess risks were partly explained by established risk factors (40% in the

Table 2—*RRs with 95% CIs for type 2 diabetes in association with socioeconomic groups in men and women*

Socioeconomic groups	Normal glucose tolerance (*n*)	Type 2 diabetes *n*	RR	95% CI
Men				
High (High- and medium-level nonmanual employees)	1,299	13	1	—
Middle (Low-level nonmanual employees)	454	11	2.4	1.0–5.3
Low (Unskilled and skilled manual workers)	908	25	2.9	1.5–5.7
Women				
High (High- and medium-level nonmanual employees)	1,978	11	1	—
Middle (Low-level nonmanual employees)	1,158	20	3.2	1.5–6.6
Low (Unskilled and skilled manual workers)	1,173	17	2.7	1.3–5.9

All analyses are controlled for age (35–42, 43–50, and 51–56 years).

Table 3—*RRs with 95% CIs in type 2 diabetes by socioeconomic group after adjustment for various of factors in men*

	High (High- and medium-level nonmanual employees)	Middle (Low-level nonmanual employees)		Low (Unskilled and skilled manual workers)	
			%*		%*
Crude estimate	1	2.4 (1.0–5.3)		2.9 (1.5–5.7)	
Adjusted for					
BMI	1	2.2 (1.0–4.9)	14	2.5 (1.2–4.9)	21
Physical activity	1	2.2 (1.0–4.9)	14	2.6 (1.3–5.1)	16
Smoking	1	2.2 (1.0–5.0)	14	2.5 (1.3–5.1)	21
FHD	1	2.2 (1.0–5.0)	14	2.7 (1.3–5.2)	11
BMI + physical activity + smoking + FHD	1	1.9 (0.8–4.4)	36	2.1 (1.0–4.2)	42
Decision latitude	1	2.3 (1.0–5.3)	7	2.7 (1.3–5.6)	11
SOC	1	2.4 (1.0–5.5)	—	3.0 (1.5–6.0)	—
Decision latitude + SOC	1	2.5 (1.1–5.7)	—	2.9 (1.4–6.1)	—
BMI + physical activity + smoking + FHD + decision latitude + SOC	1	2.0 (0.8–4.7)	29	2.1 (1.0–4.4)	42

Data are RR (95% CI) unless noted otherwise. All analyses are controlled for age (35–42, 43–50, and 51–56 years). *Percentage of the excess risk in type 2 diabetes explained by various factors. Categorization of factors: BMI (≤25, 25–30, and ≥30 kg/m^2); physical activity (high, middle, and low); smoking (never, 1–15, and ≥16 cigarettes per day); FHD (no/yes); decision latitude (high, middle, and low); SOC (high, upper middle, lower middle, and low).

middle socioeconomic group and 44% in the low socioeconomic group) but not by psychosocial factors. In men, on the contrary, no obvious association was found between IGT and the lower socioeconomic groups: 1.1 (0.7–1.7) and 1.2 (0.8–1.7), respectively (data not shown).

CONCLUSIONS— In our study, established risk factors could not fully explain the association between socioeconomic differences and the risk of type 2 diabetes in either men or women. This is in line with previous results. One study (2) examined the association of poverty-to-income ratio, education, and occupational status in African American and non-Hispanic white women and men and found an association between lower socioeconomic position (in all three measures) and type 2 diabetes in non-Hispanic women, but not consistently in men. In this study, the differences could not be explained by only including established risk factors. Another study (5) demonstrated a relationship between glucose intolerance (IGT and type 2 diabetes) and lower social position based on occupation. In women, this relationship was independent of BMI and waist-to-hip ratio, whereas in men it was nonsignificant after adjusting for obesity. Moreover, an association between deprivation (measured as residency in a deprived area) and type 2 diabetes has been reported (1), showing an increased BMI within the diabetic population. However, in the latter study, information on BMI in the nondiabetic population was lacking.

In our study, low decision latitude at work and low SOC contributed in explaining socioeconomic differences in

Table 4—*RRs with 95% CIs in type 2 diabetes by socioeconomic group after adjustment for various of factors in women*

	High (High- and medium-level nonmanual employees)	Middle (Low-level nonmanual employees)		Low (Unskilled and skilled manual workers)	
			%*		%*
Crude estimate	1	3.2 (1.5–6.6)		2.7 (1.3–5.9)	
Adjusted for					
BMI	1	2.8 (1.3–5.9)	18	2.1 (1.0–4.5)	35
Physical activity	1	3.2 (1.5–7.0)	—	2.6 (1.2–5.8)	6
Smoking	1	2.5 (1.1–5.3)	32	1.9 (0.8–4.3)	47
FHD	1	3.1 (1.5–6.6)	—	2.6 (1.2–5.6)	6
BMI + physical activity + smoking + FHD	1	2.4 (1.1–5.2)	36	1.6 (0.7–3.8)	65
Decision latitude	1	2.5 (1.1–5.6)	32	2.0 (0.9–4.8)	41
SOC	1	2.9 (1.4–6.1)	10	2.4 (1.1–5.3)	18
Decision latitude + SOC	1	2.3 (1.0–5.2)	38	1.8 (0.8–4.3)	53
BMI + physical activity + smoking + FHD + decision latitude + SOC	1	1.4 (0.6–3.6)	81	1.0 (0.4–2.5)	100

Data are RR (95% CI) unless noted otherwise. All analyses are controlled for age (35–42, 43–50, and 51–56 years). *Percentage of the excess risk in type 2 diabetes explained by various factors. Categorization of factors: BMI (≤25, 25–30, and ≥30 kg/m^2); physical activity (high, middle, and low); smoking (never, 1–15, and ≥16 cigarettes per day); FHD (no/yes); decision latitude (high, middle, and low); SOC (high, upper middle, lower middle, and low).

type 2 diabetes risk among women. On the other hand, in men these factors did not contribute at all. Both low decision latitude at work and low SOC were more prevalent in men with middle and low socioeconomic positions. However, they were not apparently associated with type 2 diabetes (RR 1.4, 95% CI 0.7–2.8 and 1.3, 0.6–3.2, respectively). Importantly, psychosocial factors did not explain the relationship between socioeconomic position and IGT in women. This suggests that the impact of different factors varies through the progression of type 2 diabetes.

Type 2 diabetes and cardiovascular disease share some causes (7). Hence, it is interesting to compare epidemiological findings in type 2 diabetes with data in cardiovascular disease. In cardiovascular research, the inclusion of psychosocial variables has made important contributions (29). For example, in one prospective study (27), psychosocial factors such as depression, hopelessness, marital status, and social support contributed to ~50% of income differences in men with cardiovascular disease. In another study (30), psychosocial work environment characterized by low decision latitude contributed almost 50% to occupational differences in cardiovascular disease in men and women. In addition, one study (31) showed that 48% of the increased risk was explained by established risk factors, such as smoking, physical inactivity, and BMI, and 57% by psychosocial stress, such as poor coping, job stress, hopelessness, and social isolation. Taking these together, 82% of the excess odds were explained. However, in a recent study in women (32), low decision latitude could not explain the increased cardiovascular risk in the lowest occupational class.

The mechanism through which low socioeconomic position and psychosocial factors could relate to type 2 diabetes is not known. One might speculate whether the psychosocial factors are directly linked to established risk factors. However, in our previous study in women (14), the associations between psychosocial factors and type 2 diabetes persisted after adjustment for BMI, physical inactivity, smoking, and FHD. In addition, low socioeconomic position has been found to be associated with higher cortisol values in relation to perceived stress (33), and it has been argued that type 2 diabetes may be mediated by the physiological response to chronic stress (34).

It is not obvious why low decision latitude at work and low SOC were associated with type 2 diabetes (14) and also contributed to socioeconomic differences in diabetes risk in women but not in men. One explanation could be that work stress in women might reflect housewives who go out to work and are thus exposed to double stress. For this purpose, we analyzed the question, "How demanding is your work in the household?" The results did not show any association between type 2 diabetes and this variable (RR 1.0, 95% CI 0.6–1.8). Hence, we could not demonstrate that demanding work in the household influenced the effect of low decision latitude at work. Another explanation could be difficulties in the measurement of behavioral variables. However, the questions and circumstances under which the study population filled in the questionnaire were equal for men and women. Moreover, there is increasing evidence that low decision latitude at work is associated with coronary heart disease in men (17).

There are some methodological issues in this study that should be noted when interpreting the results. First, to explain socioeconomic differences in diabetes risk, we investigated to what extent the association between socioeconomic position and type 2 diabetes was confounded by psychosocial and established risk factors. This is based on the belief that all investigated factors (socioeconomic position, psychosocial, and established risk factors) are correctly measured. However, imprecise measures may bias the results, and the magnitude of such error is unpredictable in a multivariate context (35). Thus, the attenuated risks observed between type 2 diabetes and lower socioeconomic position after adjustment for different factors may be biased due to imprecise measures. It is also worth noting that our results should be interpreted with some caution due to the limited number of cases in our study. Second, as this is a cross-sectional study, we cannot exclude the possibility that belonging to a low socioeconomic group is a result of poor health status. On the other hand, those with already known diabetes were excluded from the study, and study subjects who had type 2 diabetes received their diagnosis after answering the questionnaire. It could be hypothesized, however, that the patients who were excluded because their diabetes was already known belonged to a more privileged socioeconomic group with good access to medical care. If so, although not likely to be a pronounced phenomenon in the present region of Sweden, our selected group of patients with diabetes would possibly be enriched by relatively underprivileged individuals. Thus, the associations of type 2 diabetes and socioeconomic position could be to some extent overestimated. However, we are lacking information on those patients excluded due to already diagnosed diabetes. Third, the study population answered questions about former lifestyles. However, case subjects were not aware of having the disease before filling out the questionnaire, and hence, possible misclassification due to recall bias is negligible.

In conclusion, our data show that in middle-aged men, 36–42% of the excess risk of type 2 diabetes was explained by established risk factors, whereas the assessed psychosocial factors played no role. In women, however, both established risk factors and psychosocial factors contributed and together explained 81–100% of the excess risk.

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