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An assessment of the interaction between socio-economic status and diabetes mellitus: the impact on cardiovascular disease, microvascular complications and diabetes prevalence.

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Submitted for the candidature for the degree of M.D.

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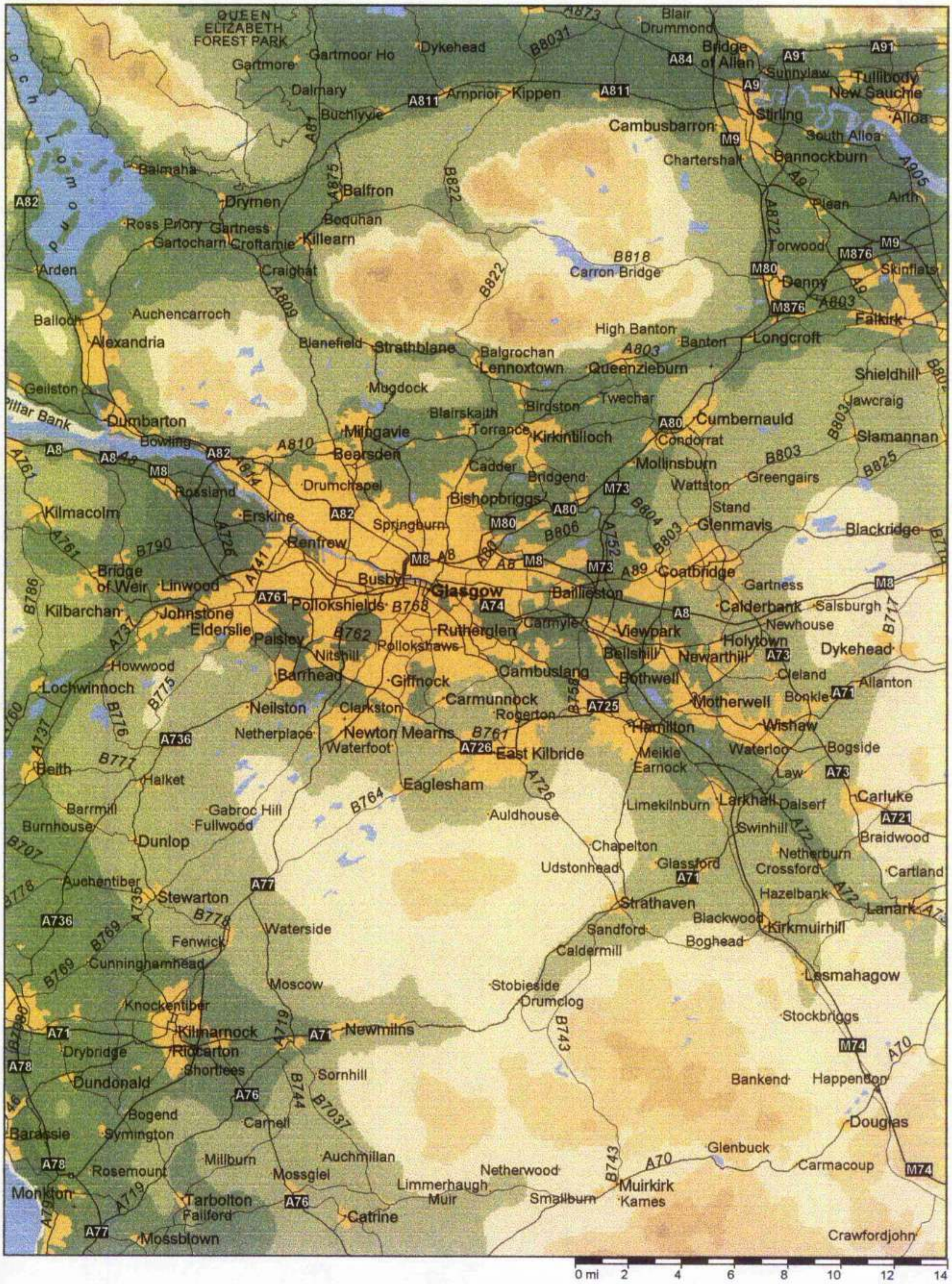

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I dedicate this thesis to
my wife Liz
and our children
Jonathan and Joanne

Declaration of candidate

I, Vincent Connolly declare that:

1. I am the author of the thesis entitled,

   An assessment of the interaction between socio-economic status and diabetes mellitus: the impact on cardiovascular disease, microvascular complications and diabetes prevalence.

2. This thesis, which is now submitted for the degree of Doctor of Medicine, has not been submitted for any other degree.

3. I conceived and developed the studies for the thesis although I consulted with others for advice.

4. I developed and verified the data collection and conducted all of the statistical analyses. The assistance of others in the collection of data is acknowledged in the thesis.

5. Unless otherwise stated all books and papers referred to have been consulted by me personally.

Signed

Date 15. 9. 98

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Hypothesis

- That low socio-economic status adversely influences the aetio-pathology of diabetes mellitus and the complications of diabetes mellitus

Objectives

- To determine if diabetic health is adversely affected by low socio-economic status.

- To establish the cardiovascular risk factor profiles within different socio-economic groups.

- To establish the prevalence of coronary artery disease within the diabetic population and across the socio-economic groups.

- To determine whether socio-economic status is independently associated with coronary artery disease in the diabetic population.

- To establish the prevalence of diabetes mellitus within the socio-economic groups.

- To assess the representation of persons with diabetes of low socio-economic status within the British Diabetic Association

Abstract of thesis

This thesis consists of four studies addressing the relationship between diabetes and socio-economic status.

1. Name: Cardiac risk factor clustering in diabetic persons of low socio-economic status (SES).

Objective: To ascertain the prevalence of obesity, smoking, hypertension, hyperglycaemia and hyperlipidaemia in a cohort of diabetic patients and in seven socio-economic categories for insulin dependent diabetes mellitus (IDDM) and non-insulin dependent diabetes mellitus (NIDDM).

Design: Cross sectional cohort of diabetic persons attending a hospital diabetes clinic.

Setting: Victoria Infirmary NHS Trust, Glasgow.

Subjects: 1,535 diabetic persons attending a hospital diabetes clinic.

Main outcome measures: Obesity, smoking, hypertension, hyperglycaemia and hyperlipidaemia in seven socio-economic groups.

Results: For NIDDM smoking prevalence was 10.9% in the most affluent group and 35.4% in the most deprived ($p<0.00001$); body mass index 27.6kg/m^2 in the most affluent group and 29.3 kg/m^2 in the most deprived ($p<0.002$). Both systolic ($p=0.036$) and diastolic blood pressure ($p=0.018$) were higher in the most deprived categories. For IDDM smoking prevalence was 13.3% in the most affluent group and 41.4% in the most deprived ($p<0.001$). Individuals with three or more CAD risk factors in addition to diabetes accounted for 4.3% of affluent IDDMs and 17.1% of

17.1% of the most deprived IDDMs ($p<0.00001$) and the respective percentages for NIDDM were 6.55% and 17.9% ($p<0.00005$).

Conclusions: This study confirmed an inverse gradient of exposure to the major CAD risk factors and SES.

2. Name: Socio-economic status and the vascular complications of diabetes mellitus.

Objective: To ascertain the prevalence of CAD and microvascular complications of diabetes in seven socio-economic groups. To establish whether SES is independently associated with CAD in persons with diabetes.

Design: Cross sectional prevalence study. Analysis of multiple coronary artery disease risk factors using multiple logistic regression analysis.

Setting: Victoria Infirmary NHS Trust, Glasgow.

Subjects: 1,505 persons with diabetes attending a hospital diabetes clinic.

Main outcome measures: Prevalence of coronary artery disease, retinopathy, proteinuria, neuropathy and foot ulceration in seven socio-economic groups with diabetes.

Results: The prevalence of CAD was 24.0% in the most affluent group compared to 30.1% in the most deprived ($p<0.015$); for those under 65 years the CAD prevalences were 17.2% for the most affluent and 31.4% in the most deprived group ($p<0.00018$). Coronary artery bypass graft rates in those with CAD were 19.2% for the most affluent group and 7.4% for the most deprived ($p<0.023$). Multiple logistic regression modelling with input of all five major CAD risk factors estimated an odds ratio of 1.72 for the most deprived group relative to the most affluent. There was a tendency for microvascular complications to be more common in the lower socio-economic groups. Aggregated microvascular complications were increased by a factor of 1.58 and 1.22 in the two most deprived groups ($p<0.011$). Diabetic foot ulceration was increased threefold across the socio-economic groups ($p<0.03$).

Conclusions: There is increased coronary artery disease among diabetes persons of low socio-economic status but less intervention in the form of coronary artery bypass grafting. The increased prevalence of coronary artery disease persists after accounting for other major coronary risk factors. Microvascular complications tend to be more common in the deprived groups in particular diabetic foot ulceration.

3. Name: Diabetes prevalence and socio-economic status.

Objectives: To establish the prevalence of known diabetes mellitus within five socio-economic quintiles.

Design: Cross sectional survey of general practitioner records

Setting: Middlesbrough and surrounding district (South Tees), population 285,157

Subjects: 4,313 persons with diabetes

Main outcome measures: Presence of diabetes and socio-economic score.

Results: The age-adjusted prevalence of diabetes in the district was 1.56% (95% confidence intervals 1.52-1.61%). Differences were detected between the socio-economic quintiles for males rising from 1.34% (95% confidence intervals 1.15-1.54%) in the most affluent group to 1.72% (95% confidence intervals 1.55-1.89%) in the most deprived group. For females the prevalence in the most affluent group was 1.08% (95% confidence intervals 0.90-1.27%) compared to the most deprived group 1.55% (95% confidence intervals 1.38-1.71). The overall prevalence of insulin treated diabetes was 0.38% with no significant trend across quintiles of SES.

Conclusions: There is an inverse relationship between SES and prevalence of diabetes. This difference is accounted for by increased prevalence of NIDDM in the more deprived groups.

4. Name: British Diabetic Association (BDA) membership among persons with diabetes living in Scotland by deprivation category.

Objectives: To establish the representation within the BDA of persons with diabetes within socio-economic groups.

Design: Survey of BDA membership records.

Setting: Scotland, population 5,032,295.

Subjects: 5,485 members of the BDA in Scotland with diabetes.

Main outcome measures: Membership of BDA

Results: Membership of the BDA was calculated at 11.7% in the most affluent septile and 2.7% in the most deprived septile ($p<0.000001$). This difference was common to both sexes ($p<0.00001$) and whether diabetes was insulin treated or not ($p<0.00001$).

Conclusions: Persons with diabetes of low socio-economic status are less likely to be members of the BDA, resulting in under-representation.

List of abbreviations

BDA	-	British Diabetic Association
BMI	-	Body mass index
CABG	-	Coronary artery bypass graft
CAD	-	Coronary artery disease
ECG	-	Electrocardiograph
IDDM	-	Insulin dependent (type 1) diabetes mellitus
NHS	-	National Health Service
NIDDM	-	Non-insulin dependent (type 2) diabetes mellitus
OPCS	-	Office of Population Censuses & Surveys
SES	-	Socio-economic status
SMR	-	Standardised mortality ratios

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Introduction to thesis

The single most important event in the history of diabetes was the discovery of insulin by Banting and Best in 1921, this revolutionised the course of the disease. Insulin prevented the hyperglycaemia and acidosis which culminated in dramatic weight loss and death. However, it later became apparent that insulin was not a complete cure and that complications peculiar to diabetes; retinopathy, nephropathy and neuropathy developed several years after treatment. In addition to this a higher incidence of coronary artery disease in diabetic groups was recorded. Thus the acute problems had been replaced by chronic complications. RD Lawrence recognised that diabetes was not a single entity and described two categories which we recognise as insulin dependent diabetes mellitus (IDDM) and non-insulin dependent diabetes mellitus (NIDDM). Subsequently, NIDDM has been associated with premature cardiac mortality because of the presence of other major cardiac risk factors, which may be part of the diabetic condition.

Inequalities in health have been well documented in the UK. In particular coronary and respiratory conditions occur more frequently in areas of poverty. These differences are in part but not completely accounted for by recognised risk factors. Diabetes is not considered to be a disease with a strong socio-economic gradient, quite the contrary, it has been described as a disease of affluence. Therefore, we may not expect to see the socio-economic gradient of cardiac mortality among the diabetic population which exists in the general population, because of the existing high risk of coronary artery disease.

The purpose of this thesis is to characterise the effect of socio-economic status on the disease of diabetes within the population. The diabetes clinic at the Victoria Infirmary, Glasgow had been recently computerised to assist with communication to the general practitioners and patients. The first study was to determine the risk factor profile of these patients and a socio-economic gradient was established. The next study progressed to a comprehensive documentation of risk factors, microvascular and macrovascular complications and the interaction between these elements and socio-economic status. The study population has been described in detail and compared with the characteristics of other study groups to facilitate comparison with other districts.

After taking up a post at Middlesbrough General Hospital, I was able to use the district diabetes register to examine the crude and age-adjusted prevalence of diabetes for the population, both sexes and within different socio-economic groups. I also explored the representation of persons with diabetes in the British Diabetic Association, as the membership of this organisation have been used for long term studies on diabetes development and progression.

The concept of this thesis evolved from the observation at diabetes clinics that patients with diabetes from deprived backgrounds particularly seemed to suffer from the attritional effects of the disease. This is an attempt to characterise these clinical observations.

Vincent Connolly

Chapter 1

The relationship between socio-economic status, health and diabetes mellitus

Introduction

There is a strong socio-economic gradient in ill health and mortality (Kunst, 1994; Marmot et al., 1986; Blaxter, 1987) and clear evidence that the difference between the most affluent and the most deprived members of society is getting wider (Feldman et al., 1989). One means of calculating this is by measuring the number of life years lost and this method shows a considerable increase in the number of life years lost in persons of low socio-economic status and that this is most pronounced in the younger age groups (Blane et al., 1990). Despite general improvements in survival, there remains a considerable gap between non-manual and manual classes for most causes of death (Jacobsen et al., 1994). Coronary artery disease is the leading cause of death in the UK. The Health of the Nation described the main cardiac risk factors as cigarette smoking, cholesterol, diet, hypertension, obesity, diabetes and physical inactivity. This has been the conclusion of other national and international organisations. (World Health Organisation, 1982; World Health Organisation 1984; American Heart Association, 1987; British Cardiac Society, 1987.)

For the purposes of this literature review, papers from third world countries have not been included. The profound poverty experienced in such areas and the combination of malnutrition and infectious diseases make it difficult to compare or extrapolate data to Westernised cultures. This is not intended to detract from the quality of research from these areas concerning poverty and health. Thus the papers reviewed originate predominantly from the UK, USA, Scandinavian countries and Germany.

Socio-economic status and health

The association between wealth and health has been well documented in the UK. This began in earnest in the nineteenth century, simply by recording death rates from various diseases. Subsequently, theories were developed and evaluated to explain patterns of disease. The first major success of this kind was John Snows deduction that cholera emanated from impure water supplies. He achieved this by mapping the geographical position of affected persons and noticed clustering of cases around water sources. This discovery predated any knowledge about the nature of vibrio cholerae which is the pathogen concerned. Clustering of poor health among groups of low socio-economic status has also been recorded.

Differentials in health were recognised and reported during the pre-war years and it was this evidence which provided an impetus for a National Health Service (Orr JB, 1936; M'Gonigle and Kirby,1936; Titmuss, 1938). More recently, area inequalities have provided a focus for research (Howe, 1982; Bradshaw et al 1982; Irving, 1981; Fox et al. 1984; Townsend et al. 1984; Ashton, 1984; West of Scotland Politics of Health Group, 1984; Thurnhurst, 1985; Thurnhurst CP, 1985; Betts; Sheffield Health Authority, 1986.)

In the UK, recording of social class by the Registrar General has provided an accessible measure of social class for most of this century and is published as part of the Registrar General's Decennial Supplements on Mortality. These reports have described increased mortality from disease in the lowest social class groups. This does not apply to the UK alone but is an international phenomenon whether recorded by occupation (Saull, 1971-75; Kitagawa and Hauser, 1973.) education (Holme et al., 1980; Salonen, 1982; Wilkinson, 1986; Valkonen, 1982.) or a combination (Dawber, 1980.). There are differentials whether Western or third world populations are studied.

During the early part of this century data relating to occupational class and mortality rates were reported by the Registrars General. In the early part of this century, infectious diseases were inversely related to social class, whereas coronary artery disease (CAD) mortality was more prevalent in higher social classes and other conditions including malignant neoplasia and peptic ulcers did not show any trend. Over the last fifty years each of these conditions is more prevalent in the lowest occupational classes. This has been replicated in other countries notably Finland (Valkonen 1982).

Doubts about the real nature of these differentials have been raised. One theory suggests that they are a statistical artefact caused by the expansion of skilled manual and non-manual classes at the expense of the unskilled. Alternatively, it has been proposed that health accounts for social class, poor health will lead to unemployment or less skilled occupations whereas good health will result in improved employment prospects, this will result in mobility between social class groups and thus explain the health differentials. These issues were addressed in longitudinal studies by Fox and Goldblatt (Fox and Goldblatt 1982) and by Marmot in the Whitehall study (Marmot 1978). As prospective studies they allowed analyses which indicated that these theories were of little significance in explaining health differentials. The Whitehall Study demonstrated a steeper mortality gradient within the British civil service than between the highest and lowest social classes (Marmot 1984). As, outlined in the next chapter, Measuring Socio-economic status, social class measures probably underestimate health differentials by not taking account of changes in mass employment, earning differential within the same occupation, fringe benefits, recent high unemployment and the effect of working partners increasing the family income. (Townsend, Phillimore and Beattie, 1986). This is supported by evidence generated from the Whitehall Study (Marmot 1978).

The publication of the Black report, completed in 1980, heralded a new interest in the interaction of material deprivation and health. The Black report (Department of Health and Social Security 1980) highlighted the excess all cause mortality experienced by persons of low SES, (table 1.1) as measured by social class (occupational class), and while acknowledging genetic, ethnic and behavioural circumstances were important considerations, SES or material deprivation, was the most important determinant of health. Social mobility and changing occupational patterns did not account for these differences (Koskinen 1985, Pamuk 1985). The report also indicated that improvements in the national health had not benefited low SES groups, indeed the differentials in SMRs between social class groups had widened (table 1.2).

SES and diabetes have a mixed association. Data from the OPCS, demonstrate that in the early part of this century Standardised Mortality Ratios (SMRs) for diabetes were higher in the higher social classes, but, this trend appears to have inverted over the course of this century (table 1.3), in a similar pattern to CAD, if diabetes follows the trend of CAD the gradient of diabetes morbidity and mortality will increase among the most materially deprived persons. Already during the 1980s there has been a rapid rise in deaths from diabetes (table 1.4). The predominant causes of diabetic mortality are end stage renal disease and coronary artery disease. Another problem to consider is the under-recording of diabetes on death certificates, this is estimated to affect 33% of such certificates (Fuller et al, 1983; Waugh, et al 1989) which could bias these figures.

Table 1.1 Mortality rates per annum for 15-64 year olds by sex and occupational class

Social class	Males	Females
I	3.98	2.15
II	5.54	2.85
IIIN	5.80	5.76
IIIM	6.08	3.41
IV	7.96	4.27
V	9.88	5.31
Ratio of V/I	2.5	2.5

Results expressed as rates per 1,000 of the population

Table 1.2 Mortality of men aged 15-64 years by occupational class: changes over the twentieth century

Social Class	1930- 32	1949- 53	1959- 63	1970- 72
I	90	86	76	77
II	94	92	81	81
III	97	101	100	104
IV	102	104	103	114
V	111	118	143	137

Table 1.3 Standardised Mortality Ratios (SMR) for diabetes, men aged 20-64 years in England and Wales by social class.

Social class	**1921-23**	**1930-32**	**1949-53**	**1959-63**	**1970-72**	**1979-83**
I	129	122	134	81	83	67
II	149	155	100	103	93	76
IIIN	93	95	99	100	111	113
IIIM					98	100
IV	75	82	85	98	111	123
V	66	69	105	122	128	155

From OPCS data

Table 1.4 Number of deaths for males and females from diabetes in England and Wales from 1980-1991.

	1980	**1986**	**1988**	**1991**
Males	1993	3156	3427	3562
Females	2788	4296	4423	4525

From OPCS data

Summary

The relationship between wealth and health is not constant but relates to changes in patterns of disease over time also. Infectious diseases which were the major killers of the poor at the beginning of this century have in turn been replaced by the atherosclerotic vascular diseases. The effect of socio-economic status is real and this has been confirmed in longitudinal studies, most notably the Whitehall Study. This study also indicated that the adverse effect of low socio-economic status on health may be more marked than previously thought, this may be the result of the fairly crude means available for measuring socio-economic status. Diabetes mellitus has traditionally not been associated with socio-economic circumstances in terms of disease development and progression.

Wealth distribution and health

The relationship between socio-economic status and health is usually conceived to be an inverse linear association, however, evidence from the UK suggests that this may not be the situation and there may be a threshold beyond which increases in wealth do not have any further improvement on health. The health and lifestyles questionnaire surveyed 7,000 persons aged 40-59 years in 1981. Age standardised comparisons of three measures of health, disease and disability, illness and psycho-social health with income indicated that from low to middle levels of income a steep decline in the experience of ill health, but, from middle to high incomes the improvement in health was negligible (Blaxter, 1990). Thus, the relationship between income and health is non-linear with a plateau effect from middle to high income. Wilkinson has analysed this effect for those earning less than 60% of average income and the proportion of unemployed with respect to changes in occupational mortality and found these to be strongly related, in contrast the effect is diminished for those in the higher earning categories (Wilkinson, 1990). From 1979 to 1989 the number of persons in the UK living at half average income (The European Community's definition of poverty) rose from 5 to 12 million (Department of Social Security, 1992) during this time period mortality for men and women aged 15-44 years in the UK has increased (Department of Health, 1990). The conclusion from this evidence is that a reduction in the proportion of persons in lower income will result in an improvement in national health.

Analysis of the effect of income distribution on health in other countries indicates that this is an important explanatory factor for the variation in health between countries. Countries with a narrow income distribution e.g. Sweden and Japan have higher life expectancy than those with broad income distribution e.g. UK. The effect of average income on life expectancy is less distinct (Wilkinson, 1992). This comparison is interesting because Japan and the UK had similar income distribution and life expectancy in the 1970's (Wilkinson, 1986). This divergence has been investigated and no other obvious explanation is forthcoming (Marmot and Davey-Smith, 1989).

Comparisons within the UK are also revealing. Mortality rates are higher in Glasgow than Edinburgh, this is evident at all ages and has been present since 1931. During this time Glasgow has been at a constant socio-economic disadvantage relative to Edinburgh (Watt & Ecob, 1992), this comparison is replicated between Middlesbrough and Sunderland (Phillimore & Morris, 1992).

It has been proposed on the basis of the association between income distribution and health that relative deprivation within society is as important because it leads to exclusion and isolation from society.

Summary

The socio-economic circumstances of an individual are not absolute but relative to the society in which the individual is living. Therefore the effect of socio-economic differentials on health is detectable around the world in nations with different patterns of disease. The evidence would suggest that patterns of health within a nation may be modified by alterations in its socio-economic circumstances.

Coronary artery disease and socio-economic status

One of the most important sources of information concerning the epidemiology of coronary artery disease (CAD) is the Framingham Heart Study conducted during the 1950's in Framingham, Massachusetts, USA. Primary risk factors for CAD were identified cigarette smoking, hypertension, elevated serum cholesterol, sedentary lifestyle and diabetes (Dawber, 1980). Of the identified cases of cardiovascular disease, only 50% were associated with these risk factors (Kuller, 1976). Further evaluation of Framingham data indicated that CAD in women was influenced by employment status, spouse's employment status and perceived financial status (Eaker et al., 1992)

An important study in establishing the association of SES with CAD was the Whitehall Study from the UK. This was a large survey of 17,530 civil servants from 40-65 years of age reported by Rose and Marmot (Rose and Marmot, 1978). SES was measured by employment grade which was strictly hierarchical in the British civil service in 1968 at the initiation of the study. The results of this study indicated that ischaemic electrocardiographic abnormalities were 72 % higher in the lowest employment grade compared with the highest and angina pectoris was 53 % higher across these grades. The 10 year cardiovascular mortality was 3.6 times higher in the lowest employment grade compared with the highest (Marmot et al., 1984).

In Scotland, the Scottish Heart Study (Woodward et al., 1982) reported on a group aged 40-59 years consisting of 10,359 persons randomly selected from throughout the country. They studied different degrees of CAD and different measures of SES, housing tenure, level of education, social class, each of these measures indicated that those of low SES had the highest incidence of CAD. The most sensitive measure was housing tenure, however, this probably relates to specific housing, social and economic conditions in Scotland.

Within the West of Scotland, the Renfrew and Paisley survey (Isles et al, 1989) was a study of mortality in 15,399 persons aged 45-64 years at baseline which examined the influence patient characteristics, obesity, smoking, blood pressure and social class on mortality. Weak but significant associations between increased smoking and low social class and low cholesterol and low social class were described.

The British Regional Heart study was conducted in 3 phases, the third phase which started in 1980, was a prospective study of cardiovascular morbidity and mortality . There were 7,735 men aged 40-59 years recruited from 24 towns throughout Britain, SES was measured by social class (Pocock et al., 1987). Follow up was over 6 years. Manual workers (low SES) were more obese, hypertensive, more likely to smoke and less physically active. There was a higher incidence of CAD among manual workers which was accounted for mainly by the higher prevalence of smoking and to a lesser extent by hypertension. After correction for these risk factors there was still an excess of CAD in manual workers which was not statistically significant.

Sex differences in the interaction between SES and CAD have also been noted. A study of CAD in England and Wales by Heller et al (Heller et al.,

1984) reported that comparatively the gradient from high SES to low SES is steeper for women than men (Table 1.5).

Studies outwith the UK, have also uncovered the strong inverse association between CAD and SES. East Finland is known to have a high incidence of CAD. In 1982 Salonen reported on 3,644 men aged 35-59 years (Salonen, 1982). The study looked at all cause mortality and SES. After controlling for cardiac risk factors such as age, smoking, blood pressure and serum cholesterol, low income and poor educational attainment were associated with excess all cause mortality and in particular CAD mortality.

In North America several studies apart from Framingham have reported on SES and CAD. An early study conducted in Baltimore by Lillenfield (Lillenfield, 1956) over the period from 1949-1951 was a retrospective analysis of death certificates recording SES, this involved 14,504 persons and SES as measured by quintiles of rental costs. Hypertensive or coronary deaths were higher in the lowest SES quintile, with a graded reduction to the lowest deaths in the highest quintile. No significant differences of overall arteriosclerotic deaths were noted between different the quintiles.

The Minnesota Heart Survey (Jacobs et al, 1986) was initiated in the 1980s, CAD risk factors have been recorded, health education programs initiated to modify risk factors while documenting CAD.

Table 1.5 Male to female ratio of SMR by social class from Heller et al.

Social Class	Male: Female SMR
I	1.5
II	1.2
III	1.0
IV	0.9
V	0.8

The Evans County Georgia Heart Study reported in 1971 on 7 year age adjusted incidence of CAD (Cassel et al, 1971) which suggested in contrast to the previously published data that men of high SES had a higher prevalence of CAD than those of low SES. Analysis of age banded sub-groups indicated that in younger men, aged 35-54 years, low SES was associated with a higher prevalence of CAD, while the inverse held true for older men. Unemployment or non-skilled manual labour was associated with a doubling of CAD incidence over the study period compared with professionals.

A large 5 year prospective study in 1968 of 270,000 men employed by the Bell System, USA was reported by Hinkle et al, 1968. This study measured educational attainment prior to entry into the Bell System and occupational status. They found that high educational achievement was associated with a lower incidence of CAD in comparison with those of low educational achievement. Low achievers who gained promotion within the corporation were not subject to a higher incidence of CAD.

SES and CAD has also been addressed by the US National Longitudinal Mortality Study (Rogot et al, 1992). Different racial and sex groups were studied. SES was measured by income and education. Each of the groups demonstrated an inverse relationship between low education and higher incidence of CAD, this was most marked in white women.
There is powerful evidence linking high prevalence of coronary risk factors to low SES. This relationship is most evident for smoking,

hypertension and obesity. The Whitehall Study initiated in 1968 reported on differences in smoking, hypertension, obesity, physical activity and plasma cholesterol levels. This has been supported in several other studies (Marmot, Shipley and Rose, 1984; Royal College of Physicians, 1983; Marmot, Rose, Shipley and Hamilton,1978; Davey-Smith, Shipley and Rose, 1990).

Summary

The Framingham Heart Study demonstrated that coronary artery disease results from the interaction of multiple coronary risk factors, some of which are subject to intervention. Deprived populations have an increased exposure to coronary risk factors but, even after accounting for these risk factors an excess of deaths from coronary artery disease persists in the most deprived populations.

Classification of diabetes mellitus

The demonstration of chronic hyperglycaemia is an absolute requirement for the diagnosis of diabetes. In 1979, the WHO guidelines for the diagnosis of diabetes (World Health Organisation Expert Committee, 1980) were universally accepted, this is not to say it is infallible, but, the diagnostic levels of blood glucose fasting blood glucose >7.8mmol/l or a random level >11.1mmol/l were based on the potential risk of developing the microvascular complications associated with diabetes (National Diabetes Data Group, 1979)

The generic use of the word diabetes relates to chronic hyperglycaemia, however, it reveals little about pathogenesis or treatment. Classification of diabetes type is principally on the individuals requirement for insulin. This can be gauged at presentation on the basis of the clinical symptoms and biochemical result, thus age less than 31 years, sudden onset of symptoms of polyuria and polydipsia, weight loss, presence of ketones and family history may provide clues to suggest a dependency on insulin. Therefore the diagnosis of insulin dependent (type 1) diabetes mellitus or IDDM is confirmed if there is a tendency to ketosis if the individual does not receive insulin.

Most other cases of diabetes come into the category of non-insulin dependent (type 2) diabetes mellitus (NIDDM), characterised by older age, obesity, insidious onset of symptoms and the absence of ketosis. However, this terminology masks the heterogeneous nature of NIDDM and the areas of diagnostic uncertainty. NIDDM may be sub-classified into obese and non-obese, the obese NIDDM patients display insulin resistance (Golay et al, 1988) and the non-obese NIDDM insulin deficiency (Reaven et al, 1989). Further confusion surrounding the classification is highlighted by the increasingly recognised requirement for insulin to control hyperglycaemia.

Diabetes may occur secondary to pancreatic disease, haemochromotosis, Cushing's syndrome, phaeochromocytoma. Diabetes may also be induced by drugs most commonly steroids. It may also occur in the context of genetic syndromes. A further interesting but unusual category of diabetes is Maturity Onset Diabetes of the Young (MODY) which is characteristically diagnosed in the second decade, in the absence of ketosis or weight loss but with a strong family history.

A final category to consider is impaired glucose tolerance which requires an oral glucose tolerance test to establish the diagnosis the blood glucose level of 7.8-11.0 mmol/l two hours after a 75 gram glucose load. This condition is important because of the risk of progression to overt diabetes (Jarrett et al 1979) and is associated with an increase in cardiovascular risk factors and development of macrovascular disease (Stern et al, 1985).

Epidemiology of diabetes mellitus

There is an intriguing pattern to the distribution of IDDM throughout the world. Northern Europe appears to have the highest incidence rates, Finland with 35 new cases per 100,000 (Tuomilehto J et al, 1992) having the highest in contrast to extremely low rates of 0.7 per 100,000 population in Korea (Ko et al, 1994). The incidence rates in the USA and Australia mirror those in Europe, but, the rates are much lower for Asians and Africans (Tajima et al, 1992).

In the UK, there is a suggestion of a North South divide with higher IDDM incidence rates in Scotland 20.1 per 100,000 compared to 17.8 in Oxford and 13.7 in Yorkshire, England per 100,00 (Patterson et al, 1988: Bingley et al, 1989: Burden et al, 1989)

There is a huge international variation in the prevalence and incidence rates of NIDDM. Among rural Melanesians and Eskimos the prevalence rates are less than 1%, but, the rates among populations which have undergone rapid 'coca-colonisation' such as the Pima Indians, 35% prevalence and Nauruan Islanders, 25% prevalence are much higher. Within the UK the estimated prevalence of known diabetes is reported between 1 and 2% (Neil et al, 1987; Williams DRR, 1985; Simmons et al 1989). Most UK studies have identified cases of diabetes from case records which probably results in under-ascertainment of cases, particularly those treated with diet alone or with no diagnosis recorded in the records, conversely the cases were not verified in the light of the introduction of the WHO criteria for diagnosing diabetes.

Epidemiology of insulin dependent diabetes mellitus (IDDM)

Insulin dependent diabetes mellitus (IDDM) develops in genetically susceptible individuals triggered by stimuli which may be infectious or environmental. The evidence for a major genetic component is the concordance between twins for IDDM (Kyvik et al, 1995), the increased risk of developing diabetes in the children of diabetic parents and the increased risk among sibs (Wagener et al, 1982). There are is an association with certain recognised genetic markers in the same chromosomal region as the Human Leucocyte Antigen (HLA) system.

The clustering in families is associated with the presence of particular HLA haplotypes, specifically DR3 and DR4 on chromosome 6 (Thorsby et al, 1993). The processing and presentation of antigens is probably influenced by HLA status leading to T-cell recognition of the antigen which results in the immune response culminating in beta cell destruction. Other genes have been associated with the development of IDDM including the insulin gene, chromosome 11q (Davies et al, 1994).

Prior to the development of IDDM various antibodies are detectable in the sera which are directed towards islets or insulin. The presence of these anti-bodies may allow profiling of at risk individuals so that future preventative measures may be targeted towards those who express these anti-bodies. The most important of these are islet cell anti-bodies, insulin auto-antibodies and glutamic acid decarboxylase antibodies.

There are twin peaks for the development of diabetes around ages 5 and 12 years which would suggest that exposure to a particular agent may occur around this time. Bovine serum albumin, dietary nitrosamines and coffee have been implicated in the pathogenesis of IDDM. Exposure to the coxsackie viruses particularly B4, mumps and congenital rubella have all been implicated in IDDM causation.

Epidemiology of non-insulin dependent diabetes mellitus

NIDDM is a heterogeneous condition, but consists mainly of obese insulin resistant patients and thin insulin deficient patients. There is a powerful genetic element associated with NIDDM. The identical twin concordance rates are high approaching 90% and the risk of developing NIDDM is increased by a factor of five in those with an affected sib (Yki-Jarvinen, 1994). However there are undoubtedly important environmental factors and two theories of NIDDM are plausible.

The 'thrifty genotype' theory (Neel, 1962) suggests that a genetic propensity for energy storage during times of famine would result in relative hepatic and skeletal muscle insulin resistance, but, the process of lipogenesis would continue under the influence of raised insulin levels. During times of plenty this mechanism would lead to insulin resistance and obesity. This theory is supported by evidence for defective insulin action in skeletal muscle, liver and adipose tissue (Reaven, 1988). However, despite examination of candidate genes, none has yet been identified.

The 'thrifty phenotype' hypothesis proposed by Barker and Hales in 1992 highlights the effects of poor nutrition during intra-uterine life and the first year of life. Those born of low birth weight then develop a programming of beta cell and or insulin action, for poor nutritional levels, thus in later life if these individuals develop adult obesity with insulin resistance the beta cell function will fail to produce adequate insulin levels resulting in NIDDM. In addition, hypertension, dyslipidaemia and coronary artery disease have been associated with low birth weight (Barker, 1995), this could potentially explain the association between diabetes, hypertension, dyslipidaemia and coronary artery disease. It may also explain the huge changes in NIDDM prevalence across the globe. However, one important aspect of the theory still to be clarified is the interaction with socio-economic status and its associations with maternal smoking and maternal obesity which could potentially explain poor fetal nutrition and adult obesity.

Obesity is an important element in the development of NIDDM. The best measure of obesity is Body Mass Index (BMI) calculated from the weight in kilograms divided by the height in metres squared. Obesity may then be graded (Bjorntop and Brodoff, 1992) as follows

Normal	20-25 kg/m^2
Grade 1 obesity	25-29.9 kg/m^2
Grade 2 obesity	30-40 kg/m^2
Grade 3 (morbid) obesity	>40 kg/m^2

Chan et al in 1994 reported on the relationship between obesity and NIDDM in a prospective 5 year follow up of 50,000 men. An exponential relationship was described. A BMI > 35 kg/m^2 was associated with a 40 fold increased risk of developing NIDDM. Potentially, prevention of obesity could prevent or delay the onset of NIDDM.

Summary

Genetics have an important role in the pathogenesis of NIDDM and to a lesser extent for IDDM. However, other important factors are required to interact with the genetic predisposition in order for an individual to develop diabetes. Some of these factors for NIDDM particularly are identifiable and potentially subject to intervention which may retard or prevent diabetes

Diabetes mellitus and mortality

There is surprisingly little data concerning diabetes related mortality in the UK. Overall, the effect of diabetes on mortality has probably been under-estimated because of the omission of the diagnosis of diabetes from one third of death certificates (Waugh et al, 1989) which precludes the use of national data. Fuller et al in 1989 reported on a cohort of patients and estimated diabetes mortality to be four times that of the background population, the risk was particularly high in pre-menopausal women who appeared to lose their protection from coronary artery disease relative to men. Analysis of death certificate data has indicated that circulatory diseases are recorded on half the certificates when diabetes is mentioned. The age standardised death rates for coronary artery disease for men and women were 13.0 and 12.1/100,000 per year (Stephenson and Fuller, 1991). Cohort studies of British Diabetic Association (BDA) members have reported on diabetic mortality through linkage with the Office of Population Censuses and Surveys (OPCS), however, the BDA cohorts are unlikely to be representative of the diabetic population and may present the best case scenario. Problems arise in attempting to analysing trends over time as the criteria for diagnosing the microvascular complications, particularly nephropathy have changed and the difficulty in recording diabetes prevalence in the background population.

Population based studies from Scandanavia have reported death rates twice the background population for under 14 year olds with IDDM (Diabetes Epidemiology Research International Study Group, 1991). This study described international variations in age-adjusted IDDM mortality, Japan 681/100,000 person years, Allegheny County, USA 230/100,000, Finland 171/100,000 and Israel 118/100,000, thus it is difficult to extrapolate data from other countries to a UK population.
Estimating the mortality associated with NIDDM is difficult for several reasons. As mentioned above there are many undiagnosed cases of NIDDM which may bias the calculations as may analysis of selected populations. Furthermore, the presence of multiple risk factors and the timing of their onset in relation to NIDDM and the onset of coronary artery disease complicate the study design and analysis of the interactions. Studies in the UK have demonstrated higher relative risks of mortality for younger individuals, a relative risk around 4 gradually decreasing with increasing age. The relative risk is higher for young women and circulatory diseases account for between 53-61% of deaths (Fuller et al, 1985; Waugh et al, 1989; Morrish et al, 1990).

Summary

Diabetes mortality is much higher than the background population. This is primarily the result of circulatory diseases. Accurate estimates of trends in diabetes mortality are difficult to obtain and the potential effect of socio-economic status on mortality even more difficult to characterise. The excess of deaths in young women is due to circulatory diseases. Cardiac risk factor intervention could potentially influence diabetes related mortality.

Coronary artery disease and diabetes mellitus

Diabetic patients experience higher CAD mortality than non-diabetic matched controls (Jarrett, 1984). Male mortality is doubled and female mortality quadrupled, the result of this is that young female diabetics lose the protection from cardiovascular disease normally seen in pre-menopausal females. Post infarction diabetics are more likely to develop cardiac failure (Abbott et al. 1988). CAD is the main cause of mortality in patients with diabetes, this was demonstrated in data from the Joslin clinic, (Marks and Krall, 1971) which indicated that in insulin dependent diabetes mellitus (IDDM) CAD mortality was more prevalent with older age at diagnosis and increased duration of diabetes, compared to mortality from end stage renal disease. In non-insulin dependent diabetes mellitus (NIDDM) CAD mortality predominates.

Summary

Diabetes is associated with between a two and four fold increased risk of coronary artery disease, thus it constitutes a coronary artery disease risk factor. When coronary artery disease is established in diabetic subjects it tends to be more diffuse and associated with increased cardiac failure and death.

Coronary artery disease risk factors and diabetes

Smoking

In the general population the case against smoking is clear, cigarette smoking is responsible for 25% of CAD deaths, the case for smoking cessation is also clear reducing mortality in post-infarct patients by 50% (Kannel and McGee, 1979).

The prevalence of smoking among diabetic subjects is equivalent to non-diabetics (Kesson and Slater, 1979) which is associated with increased atherosclerotic disease in diabetic subjects. This is supported by a study of 120,000 nurses in North America which found that CAD risk was increased by 8 fold in diabetics and 15 fold in diabetics who were smokers (Willett et al, 1987). Two further studies (Suarez and Barrett-Connor, 1984; Rosengren and Welin, 1989) have demonstrated similar findings. For IDDM patients, the Wisconsin study (Klein et al, 1989) reported a doubling of CAD death, similar evidence was found in the Pittsburgh study (Moy et al., 1990) of patients with long duration of IDDM, mortality at six years was 14% in smokers and 7% in non-smokers. NIDDM patients who smoke also have increased CAD mortality although this is not as high as for IDDM. The Wisconsin study reported a 34% six year mortality for NIDDM patients. The risk was 1.6 times higher for smokers. The Multiple Risk Factor Intervention Study (MRFIT) (Stamler et al., 1993) also described increased CAD mortality in diabetics who smoked. Exposure to multiple risk factors in diabetic patients was associated with an exponential rise in CAD mortality which was earlier and steeper than for non diabetics. Although the Bedford study (Jarrett, McCartney and Keen, 1982) did not associate early CAD death in diabetes with smoking. There is also evidence that cessation of smoking will reduce the risk of developing CAD.

Obesity

The powerful inverse relationship between obesity and socio-economic status is well established (Sobal and Stunkard 1989). Three possible explanations of this complex relationship have been suggested, obesity influences socio-economic status, socio-economic status influences obesity , or a common factor influences both obesity and socio-economic status (Stunkard and Sorensen, 1993). A prospective study of 10,039, 16-24 year olds found that obese women had lower incomes and completed less education, the pattern for men was similar but statistically weaker (Gortmaker et al, 1993). Two other studies have reported higher prevalence of obesity in downwardly mobile persons (Goldblatt et al, 1965; Braddon et al, 1986). In contrast, these studies have also demonstrated a relationship between parental education and socio-economic status to the prevalence of obesity in adulthood (Gortmaker et al, 1993; Goldblatt et al, 1965; Braddon et al, 1986). Using adopted children, to control for parental body mass index (BMI), no relationship between the BMI of parents or children were found, but an inverse relation between parental social class and the BMI of adoptees

(Teasdale et al, 1990). Interpretation of this data suggests a bi-directional relationship between obesity and socio-economic status.

Lean conducted a retrospective analysis of risk factors of diabetic patients from the Aberdeenshire area of Scotland that had died (Lean et al, 1990). Weight reduction in the first year following diagnosis was linearly related to prolonged survival, although the baseline body mass index at diagnosis was not. Analysis of Framingham data did suggest that obesity was associated with increased risk of CAD (Kannel and McGee, 1979) but this has not been supported from other sources (Pyorala et al, 1987; Hayward and Lucena, 1965).

Hyperlipidaemia

The role of cholesterol in the causation of CAD has been much debated, the debate has moved on to the cholesterol levels at which doctors should intervene. High cholesterol levels are associated with increased risk of CAD. (Rose and Shipley, 1986.)

Framingham data indicates that elevated cholesterol levels have similar effects on diabetics as on non-diabetics (Kannel and McGee, 1979) and raised triglycerides have also been shown to be related to subsequent CAD (West et al, 1983). The effectiveness of lipid lowering therapy has been well established although not specifically for diabetes (Lipid Research Clinics Program, 1984; Lipid Research Clinics Program, 1984; Frich et al, 1987; Peto et al, 1985). More recently the efficacy of reducing moderately elevated serum cholesterol levels, 5.5-8.0 mmol/l in a secondary prevention group with statin therapy has shown a reduction in all cause mortality with a major impact on CAD events and mortality. (Scandinavian Simvastatin Survival Study Group, 1995). A reduction of cholesterol of 10% is estimated to reduce the risk of CAD by 20-30% (Frich et al, 1987). Guidelines for the management of hyperlipidaemia (Study group of the European Atherosclerosis Society, 1988) are available and can be applied to diabetes with the consideration that diabetes itself constitutes a high risk category for CAD.

Hypertension

Hypertension is estimated to have a prevalence of around 50% in the diabetic population, (World Health Organisation Multinational study, 1985) but, other factors play important roles: genetics, obesity, heavy alcohol intake and dietary salt (Law et al, 1991). In IDDM patients the onset of hypertension is insidious and usually associated with the development of nephropathy, in contrast to NIDDMs who often have established hypertension at diagnosis (Simonsen, 1988). As a risk factor for CAD, hypertension is additive to diabetes (Kannel and McGee, 1979) and quadruples mortality rates (Davey-Smith et al, 1990; Dupree and Meyer, 1980).

The microvascular complications of nephropathy (Deckert et al, 1989; Parving et al, 1987; Anderson and Brenner, 1988; Parving and Hommel, 1989) and retinopathy (Teuscher et al, 1988.) also appear to be more common in hypertensive patients. It should be noted that nephropathy in turn causes hypertension.

The WHO criteria for diagnosing hypertension (World Health Organisation Multinational Study, 1985) are disputed, treatment is suggested at blood pressures over 160/95mmHg, the target blood pressure being 140/90 mmHg. Persuasive evidence suggests lower BP thresholds should be defined in diabetes (Drury and Tarn,1985; Marre et al, 1988) and should be defined on the basis of age.

Glycaemic Control

Confirmation that glycaemic control is important in the prevention of microvascular complications was demonstrated in the Diabetes Control and Complications Trial (DCCT Research Group, 1994). This study compared an intensive insulin therapy group with conventional insulin therapy. The primary end point was the development of significant retinopathy, but, other clinical outcomes were measured including neuropathy, urinary albumin excretion and macrovascular events. Patients treated were relatively young and there were few cardiac events, nevertheless, the risk of macrovascular disease was reduced by 41% (95% confidence intervals -10 - 68%) although this did not reach statistical significance.

Microvascular complications were substantially lowered in the intensive insulin therapy group retinopathy by 63% (95% CI 52-71), nephropathy by 54% (95% CI 19-74) and clinical neuropathy by 60% (95% CI 38-74).

There appears to be a glucose threshold below which the development of microvascular complications is unusual, this level would appear to be around 11 mmol/l 2 hours after an oral glucose tolerance test (Jarrett and Keen, 1976) This evidence is supported by a 25 year follow up study of IDDM and NIDDM patients, which related poor glycaemic control to microvascular complications.

Summary

Diabetic persons have a higher exposure to coronary artery disease risk factors particularly obesity and hypertension which are strongly associated with the condition. As a result many individuals with diabetes have multiple risk factors. In the context of diabetes some of these risk factors may have more effect on the pathogenesis of coronary artery disease. This would suggest that risk factor intervention for diabetic patients could result in a greater reduction in coronary artery disease related events in absolute numbers than for the general population.

Diabetes mellitus and socio-economic status

Few studies have concentrated specifically on diabetes and socio-economic status (SES). Robinson et al, in 1982 studied 174 patients attending hospital based clinics in London. Patients were classified on the basis of social class. For NIDDM, they reported a higher prevalence of smoking, higher body mass indices and higher mean serum cholesterol levels in lower social class groups although this was not statistically significant. They also found lower systolic blood pressure in lower social class men. In IDDM patients, they reported higher prevalence of smoking and higher triglyceride levels in women of low social class.

Kelly et al, have published data from Middlesbrough, UK. The study population of 1,528 was from a hospital based clinic. Townsend scores were used to measure SES, tertiles of the Townsend score were used for analysis, by this definition 241 were classified as deprived and 247 as prosperous, the remainder being of intermediate prosperity. Compared with patients in the prosperous category, the deprived patients were older, had a shorter duration of diabetes, were more likely to smoke and suffer from ischaemic heart disease and peripheral vascular disease. Treatment with insulin was less common in this group (Kelly et al, 1993). The main criticism of this paper is that there was no comparison with studies of diabetes epidemiology to indicate if the study group was representative of the diabetic population as a whole.

A further paper was published by Kelly et al, 1994 which concentrated on the treatment of diabetes and glycaemic control. This was also a cross sectional study using geographical mapping to locate deprived areas. Townsend scores were used as measures of deprivation. The results (table 1.6) indicate that patients from deprived inner city areas are older more obese, have a shorter duration of diabetes and less likely to be taking insulin therapy. Deprived areas had higher random blood glucose levels compared with the prosperous areas 12.0 mmol/l v. 10.4 mmol/l

Table 1.6 Results of a survey of the socio-economic profile of a diabetic population from Kelly et al, 1994

	Deprived	Other	Prosperous	Odds ratio	95% CI	p value
No. of patients	241	1040	247			
Age now (years)	58 (43-65)	57 (43-66)	54 (37-64)			0.018
Duration (years)	6 (3-13)	8 (3-15)	9 (4-16)			0.005
Weight (kg)	76.8 +/-1.0	77.2 +/-0.5	74.3 +/-1.0			0.074
Sex, male (%)	58.9	57.8	54.7	1.19	0.82-1.74	0.342
Insulin (%)	43.1	50.2	58.5	0.54	0.37-0.79	0.001

respectively (p=0.02) and higher glycated haemoglobin levels 8.61% v. 7.96% respectively (p= 0.02).

Data from the National Longitudinal Mortality Study indicates that in diabetic men and women low income was associated with increased all cause mortality. Low final education grade was also associated with higher SMRs in men over 25 years of age, this association was stronger for women than men. Income and the prevalence of diabetes were measured in the National Health Interview Study, (Adams and Benson, 1990) family's with income less than $10,000 had SMRs of 136.1 per 1,000, this compared with 68.9 per 1,000 in family's whose income was over $35,000.

An Israeli study (Medalie et al, 1974) explored the 5 year prevalence of diabetes in men over 40 years old, this found that those who had education to elementary school level had a 63% increase in the incidence of diabetes compared with those educated beyond high school.

Education is often used as a surrogate measure for socio-economic status although, it does have limitations when used in this manner. Studies using the last year of education have shown poor glycaemic control in the least educated groups for both men and women (Virtanen, 1982; Chaturvedi et al, 1996) There have also been studies which have not shown a difference in glycaemic control across the social strata (Robinson et al, 1982; Lundvigsson, 1977). Adults who had been educated to college standards across Europe were found to smoke less, exercise more, increased fibre intake and better lipid profile compared with those educated to primary or secondary school standard (World Health Organisation Multinational Study, 1985). Microvascular complications have been shown to be less prevalent in men educated to college standard. These differences were less marked for women than men (World Health Organisation Multinational Study, 1985; DCCT Research Group, 1994).

Educational status has, in IDDM patients from the USA, been associated with improved survival in men (Dorman et al, 1985). The same study also linked financial disadvantage with premature deaths in men under 45 years of age with IDDM.

Mortality rates in IDDM are much higher than the general population, it is estimated that in the 30-39 year age band mortality is 20-50 times higher, (Will and Connell, 1988; Valkonen, 1993). The impact of socio-economic factors and educational status are less clear but it has been estimated that at age 35 a man with a basic education has a 50% increased mortality risk compared with a college educated man (Diabetes Epidemiology Research International Mortality Study Group, 1991).

Summary

In the UK the relationship between socio-economic status and health is starting to be unravelled elsewhere proxy measures for socio-economic status such as educational achievement have been associated with increased mortality. The explanation for this remains elusive.

Epidemiology of the microvascular complications of diabetes mellitus

Microvascular complications are specific to diabetes mellitus. The development and progression of these complications are mainly related to the chronicity of diabetes and hyperglycaemia. The Diabetes Control and Complications Trial (DCCT) conducted on insulin dependent diabetic patients aged 13 - 39 years, demonstrated that the development of de novo complications could be prevented and the progression of early complications retarded by intensive management of hyperglycaemia (DCCT, 1993). These dramatic improvements have not yet been established for non-insulin dependent diabetes, results from the United Kingdom Prospective Diabetes Study (UKPDS) which addresses this issue may be available in the near future.

Retinopathy

Diabetic retinopathy is one of the commonest causes of blindness in Western countries. Large prospective studies have described the natural history of retinopathy.

Data about the progression of retinopathy was established by the Wisconsin Epidemiologic Study of Diabetic Retinopathy (WESDR)(Klein et al, 1984). IDDM was defined as those developing diabetes before thirty years of age. Retinopathy was assessed by four photographs of each retina and graded. The prevalence of diabetes rose steeply with duration of diabetes, from 1% at 5 years to 98% after 15-20 years of the disease. Proliferative retinopathy was uncommon prior to 10 years of diabetes but had a peak prevalence of 67% after 35 years.

The EURODIAB IDDM Complications Study (The EURODIAB IDDM Complications Study group, 1994) was a more recent study of 2,500 patients from 29 centres across Europe. Similar data to WESDR was described with a rapid increase in retinopathy prevalence between 5-15 years duration, with a plateau of 82% at twenty years. In patients who had had diabetes for 35 years duration proliferative retinopathy was found in 33%.

The development and progression of retinopathy during DCCT was reduced in the intensively treated groups as follows:

Progression from no retinopathy to sustained disease	76%
Progression from no retinopathy to microaneurysms	27%
Progression of background retinopathy to sustained retinopathy	54%
Progression of background retinopathy to proliferative retinopathy	47%
Progression of background retinopathy to laser therapy	56%

Paradoxically, trials involving intensification of glycaemic control in patients with established retinopathy have described a transient worsening of the retinopathy (The Kroc Collaborative Study Group, 1984; Dahl-Jorgensen, 1985).

Treatment of severe retinopathy by photocoagulation with argon laser can reduce the risk of blindness. The Diabetic Retinopathy Study (DRS) of 879 patients with proliferative retinopathy described a reduction from 38% visual loss in untreated patients to 16% in those treated with pan-retinal photocoagulation (DRS, 1978). The Early Treatment of Diabetic Retinopathy Study (ETDRS) for patients with non-proliferative retinopathy did not show a distinct improvement after laser treatment, but, for those with macular oedema focal photocoagulation reduced the visual loss rate from 33% to 16% (ETDRS,1991).

It should be noted that laser therapy does not restore visual loss, but, prevents deterioration, therefore, screening to detect retinopathy prior to visual loss is recommended on an annual basis (ADA, 1993).

Nephropathy

Diabetic nephropathy may be viewed in three stages (Nathan, 1993):

1. Microalbuminuria, urinary albumin excretion >/= 40 mg/day
2. Albuminuria, urinary albumin excretion >/= 300 mg/day
3. Advanced nephropathy, urinary albumin excretion >/= 300 mg/day and creatinine clearance below 70 ml per minute per 1.73m^2 of body-surface area

Progression of diabetic nephropathy to end stage renal disease requiring renal replacement therapy varies widely in different ethnic groups. In the UK, Asians compared to Caucasians develop nephropathy at a higher rate (Burden et al, 1992), in the US, Afro-Americans have the highest prevalence of diabetes and end stage renal disease (Cowie et al, 1989). It should be noted that most registers of patients with end stage renal disease consist of those referred for renal replacement, therefore those who are not referred because of age or other conditions will not be counted resulting in under ascertainment.

The approach to the management of diabetic renal disease involves two major areas:

1. **Glycaemic control**- Intensification of insulin regimens reduces glomerular hyperfiltration (Beck-Nielsen et al, 1985) and stabilises microalbuminuria (Feldt-Rasmussen et al, 1986). The DCCT indicated that progression to albuminuria could be reduced by 60%.
2. **Blood pressure control**- Hypertension accelerates the decline in renal function. A study of IDDM patients indicated that a systolic blood pressure greater than 140 mmHg was associated with a decline in glomerular filtration of 6% per year compared to 1% per year in those with a systolic blood pressure less than 140 mmHg (Walker et al, 1985). A target blood pressure of 120/80 mmHg for those with diabetes has been proposed (ADA, 1994). Angiotensin converting enzyme (ACE) inhibitors offer additional protection, as well as an anti-hypertensive effect, against diabetic nephropathy. A double blind

randomised study of 409 IDDM patients indicated that patients treated with captopril had a 50% reduction in the combined end points of death, dialysis and transplantation. There was only a small difference in blood pressure between the groups (Lewis et al, 1993).

Prompt management of urinary tract infections and dietary protein restriction are other aspects which should be addressed.

Neuropathy

Diabetic neuropathy is a heterogeneous condition with many clinical manifestations. Neuropathy may be defined on a clinical basis or on electrophysiological parameters. The Peripheral Nerve Society has defined diabetic neuropathy as:

> *A symmetrical sensorimotor polyneuropathy predominantly affecting the distal aspects of the lower limbs (Peripheral Nerve Society, 1995).*

This definition captures the majority of diabetic neuropathy but excludes several syndromes of diabetic neuropathy including third nerve palsy, other mononeuropathies, proximal limb neuropathies and carpal tunnel syndrome. Definitions and grading of neuropathy have been scored on the basis of clinical findings (Dyck 1988; Feldman et al, 1994).

The problem of definition affects the accuracy of data pertaining to the prevalence of neuropathy. A large clinical study on hospital patients in the UK, 6487 subjects, estimated the prevalence of neuropathy in NIDDM at 32.1% and 22.7% for IDDM (Young et al, 1993) but other studies have not described this difference in relation to diabetes type (Newrick et al, 1986). In a community based neuropathy prevalence study 16.3% of the diabetic population, n=1150, were diagnosed (Walters et al, 1992).

The DCCT indicated that progression of diabetic neuropathy was reduced by 60% in patients treated with an intensified insulin regime. Treatment of established neuropathy is symptomatic, mainly pain relief. Other complications related to autonomic neuropathy are rarer and difficult to treat such as diabetic gastroparesis and orthostatic hypotension. One of the major complication related to diabetic neuropathy is the development of diabetic foot ulceration which con lead to sepsis, gangrene and amputation.

Summary

The microvascular complications of diabetes result from the interaction of chronic hyperglycaemia with other factors most notably hypertension for retinopathy and nephropathy. Interventions to intensify glycaemic control and reduce blood pressure can delay the development and retard the progression of these complications.

St. Vincent Declaration

The health problems posed by diabetes in European countries of the World Health Organisation were addressed at a meeting at St. Vincent's in Italy in 1989. A declaration was agreed by the delegates which proposed guidelines concerning national and local approaches, provision of care, training and set targets to encourage improved delivery of care and the prevention of complications.

A reduction of one third or more of new diabetic blindness, a reduction of one third or more of persons entering end-stage diabetic renal disease, a reduction of one half or more in the rate of limb amputations due to diabetic gangrene, equivalent outcomes for diabetic pregnancy to the background population and a reduction in coronary artery disease. It may be noted that the target for coronary artery disease is less well defined than the other targets.

Summary

The link between low socio-economic status (SES) and a high prevalence of coronary heart disease within the general population is well established. This could be the result of a number of factors, increased exposure to cardiovascular risk factors in persons of low SES, increased prevalence of diabetes or adverse psycho-social features resulting in stress and depression. The link between diabetes, obesity, hypertension and dyslipidaemia, the metabolic syndrome, may in part explain the increased experience of coronary artery disease by persons with diabetes. Are the effects of SES simply the result of higher exposure to coronary risk factors or is there an independent association ?

The development of microvascular complications in both IDDM and NIDDM is the result of an interaction between genetic and metabolic factors, the most important of which are hyperglycaemia and duration of diabetes (DCCT, 1993). Chronic hyperglycaemia is a common factor in the development of microvascular complications. Microvascular complications tend to cluster in the same patients (Krolewski et al 1992). Maintaining near normoglycaemia is a difficult target. Understanding of diabetes, education and motivation are probably the main factors in determining an individual's ability to achieve this.

The effect of genetic factors on the progression of complications is not clear. Twin studies in IDDM show considerable variation in the development of retinopathy (Leslie et al, 1987) whereas progression of nephropathy is associated with a family history of hypertension (Krolewski et al, 1988). Whether hypertension is causal (Feldt-Rasmussen et al, 1987) or the result of incipient diabetic nephropathy (Mathiesen et al, 1990) is not yet clearly established. Specific factors may be particularly important with regard to particular complications, hypertension in the progression of nephropathy and retinopathy and smoking for foot ulceration. In considering the impact of socio-economic status it is necessary to account for these risk factors.

Chapter 2
Measuring socio-economic status

Introduction

In undertaking a study of health and socio-economic status (SES) it is important to assess the measures of SES which are available and consider which of these measures is most appropriate. Socio-economic status is a concept encompassing wealth, power, employment, housing and education which can relate to an individual or a population. Subsequently, there are several means by which it can be measured. The problem in measuring SES is in choosing measures specific to deprivation, which differentiate affluence from deprivation. Here, I review the measures of SES which are available and explain why I chose to use the deprivation scores of Carstairs and Morris in Glasgow. For the later study in Middlesbrough a different measure of SES was used which was felt to be more appropriate for that area, it is discussed in chapter 5.

Employment status

From the Registrar General of Great Britain, categories based on occupation have been available in the UK since 1911(Leete & Fox, 1977). The basis and rationale of the categories is as follows

> *These categories have been selected in such a way as to bring together, so far as is possible, people with similar levels of occupational skill. In general each occupation group is assigned as a whole to one or another social class and no account is taken of differences between individuals in the same*

occupation group, e.g. differences of education or level of remuneration. however, persons of a particular employment status within occupational groups are allocated ... by the following rules (Classification of Occupations, 1980)

The current six categories are as follows:

I, Professionals (e.g. doctors, lawyers, executives, accountants, university lecturer)

II, managerial and lower professionals (e.g. sales managers, teachers, nurse, member of parliament, police officer)

IIIN, non-manual skilled (e.g. clerks, shop assistants, auctioneer, secretary, estate agent)

IIIM, manual skilled (e.g. machinists, butcher, carpenter, cook, hairdresser)

IV, partly skilled (e.g. postmen, fisherman, barman, agricultural worker)

V, unskilled (e.g. labourers, porters, kitchen hand, window cleaner, refuse collector)

Devised from Classification of Occupations, 1980, P1-89, Appendices B1 and B2

Various modifications have been made in an attempt to improve the stratification of social class by occupation, these include Routh 1965 & 1980, the General Household Survey 1973, Sillitoe 1969, Woolfe 1971, National Foundation for Education Research, Butler and Bonham 1963, the Department of Employment, Hall and Jones 1950 and the best known modifications by Goldthorpe 1974 and Townsend 1979.

Occupation is a widely used measure of social class (Liberatos et al, 1988) in epidemiology studies. However, there are significant problems, it is a subjective measure which does not take account of modernisation of the work place or the changing patterns of work (Wilkinson 1986; Carr-Hill, 1987). There are also difficulties in the recording of retired people, as the last occupation is used rather than the main occupation, students and the unemployed.

Educational attainment

Education is also commonly used as a measure of SES (Liberatos et al, 1988) because it in part determines future occupation and thus status. It is usually recorded by questionnaire and expressed as an individual's age during their final year of education. This will not be influenced by adult illness, but, childhood illness could have an impact on the quality and quantity of education (Wadsworth, 1986). Problems arise in comparisons between different age cohorts, education to the age of sixteen years in the 1950s will be associated with different social and occupational factors compared with the same degree of education in the

1990's. Similarly, comparison between ethnic groups is limited because of differing social and occupational outcomes for an equivalent education.

Income

Income measures are important markers of SES because, income, provides access to housing, material goods and even to some extent to healthcare. Difficulties arise in deciding which income measure is the most appropriate whether it should be individual, family income or total assets and also whether benefits should be included and particularly measuring income for the retired. This data is not available in the UK, although it is kept by the Inland Revenue. It seems probable that despite these difficulties a measure for income would be the best measure of socio-economic status.

Living conditions

The material conditions under which people live are highly correlated with income and education and are indicators of lifestyle. Such measures have included ownership of housing, cars, washing machines, television and other material goods (Fox & Goldblatt, 1982; Kaplan & Salonen, 1990). These measures however may change over time whereas previously access to a telephone was considered a good differential between poverty and affluence this is less so now. Currently access to a car is widely accepted to be a good proxy for expendable income this may change in the future to other items of significant financial cost for example access to a computer.

Area based measures

Measures of socio-economic status (SES) based on geographical location have been used in a large number of studies. These may take account of single or multiple indices of SES within a defined area. These areas may be electoral wards, post code sectors, counties or health authorities. This method is criticised on the basis that it assumes that individuals within a district are homogenous with regard to the socio-economic characteristics of the area, known as the "ecological fallacy" (Robinson, 1950). In practice if the areas are chosen carefully the population within do have similar socio-economic characteristics with regard to housing, living conditions and income. It is advantageous in reflecting local problems which can be difficult to measure on an individual basis, these include overcrowding and quality of housing stock. This tapping of area characteristics which can not be individually analysed can be illustrated in these examples, in the first study the occupational distribution within a locality was associated with the timing of the decline of cardiovascular mortality (Wing et al, 1988) and residence in a poor area was associated with increased all cause mortality after individual SES was accounted for (Forsdahl, 1977).

Scientific study of large administrative areas including Health Districts and local authority areas will conceal intra-district variations of affluence and deprivation, this would result in an unrepresentative, homogenous picture. Calculation of scores for areas with a small population may result in unreliable analysis. Townsend used electoral wards (Townsend et al, 1988) although he expressed concern about changing boundaries and the arbitrary nature of many boundaries.

Combined measures of socio-economic status

As I alluded to earlier, many indicators of SES are inextricably inter-related to other factors which can result in "double counting". There are several measures which combine measures of SES with locality. The Department of the Environment (DOE) devised a measure of SES to assist weighting of central government grants to local authorities, the following indicators were included,

- persons unemployed
- overcrowded households
- single parent families
- households lacking exclusive use of basic amenities
- pensioners living alone
- residents with the head of the family born in the New Commonwealth or Pakistan

Of these indices, criticism is levelled at three of them as not being specific to deprivation. The inclusion of pensioners living alone implies all areas with a large proportion of pensioners living alone are areas of low

SES, this is clearly not the case and similar argument applies to single parent families and residents with the head of the family born in the New Commonwealth or Pakistan. While a significant proportion of such individuals may be of low SES, it is not necessarily because they are members of these categories.

Some measures in emphasise particular variables by giving them extra weighting, because Jarman's index was developed to measure demand on primary care resources, pensioners living alone were given extra weighting.

The Jarman score was developed to identify "underprivileged areas" which would provide a measure of general practitioners workload, however, it also includes population groups which are assumed to be deprived.

Carstairs and Morris recently produced a publication studying social deprivation and health in Scotland (Carstairs & Morris, 1991). Only four variables were used:

- ***overcrowding*** - persons in private households living at a density greater than one person per room as a proportion of all persons in private households
- ***male unemployment*** - proportion of economically active males seeking work

- ***low social class*** - proportion of all persons in private households with the head of the household in either social class IV or V
- ***no car*** - proportion of all persons in private households with no car

This classification was similar to Townsend`s except that he used the percentage of private households not owner occupied rather than low social class (Townsend, 1988). This classification uses unweighted variables and avoids double counting. The z score method was used in the calculation of the deprivation scores; the four variables are standardised to have a population weighted mean of zero and a variance of one. This ensures each variable has an equivalent effect. For each variable the Scottish mean is subtracted from the proportion for the post code sector, this is divided by the mean standard deviation. The equation for this is outlined in table 2.1.

Table 2.1 Calculation of deprivation score (Carstairs & Morris).

	Post Code	Mean*	S.D.*
Overcrowding	a	0.25	0.11
Male unemployment	b	0.13	0.07
Low social class	c	0.24	0.10
No car	d	0.41	0.19
Deprivation score	= (a -.25)/.11 + (b -.13)/.07 + (c -.24)/.10 + (d -.41)/.19		

* Means and standard deviations for Scotland

Deprivation scores were calculated for each post code sector, mean population 5,000 persons. The deprivation scores could then be grouped into one of seven deprivation categories, 1 representing the most affluent category and 7 the most deprived. The relationship of these variables to each deprivation category can be seen in table 2.2. The loss of variation by studying large areas is seen in table 2 where the difference between the most affluent and most deprived areas is seen at the level of post code sectors and the least difference at health board level.

Using census data

The deprivation scores of Carstairs and Morris are based on 1991 census data, therefore some limitations need to be taken into consideration. Firstly, the problem of underenumeration. The census was undertaken during the implementation of the Poll Tax, popular superstition at the time held that data may be used to prosecute those who did not comply. No data is available for 2.2% of the population, (Balarajan, 1994) more specifically men aged 20-29 years from inner city areas constituted the biggest group accounting for 9% nationally (Dorling & Simpson, 1993) Data for this group may then be inaccurate, it seems likely that social deprivation will be underestimated as persons on low income, unemployed or of no fixed abode will have been unwilling or unavailable to complete the census.

Table 2.2 Distribution of variables relating to material wealth and deprivation scores for the seven deprivation categories

	Affluent				Deprived			
Category	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**All**
No car	13.3	23.4	30.8	41.8	50.4	61.9	79.4	41.3
Male unemployment	4.0	5.8	8.3	11.5	15.9	20.3	30.6	12.5
Low social class	5.2	13.7	20.2	25.2	29.0	34.0	42.7	24.0
Overcrowding	8.0	14.1	19.6	25.0	31.2	38.4	48.4	25.4
Deprivation score	-6.02	-3.86	-2.01	-0.24	+1.96	+4.28	+8.36	

Table 2.3 Range of scores within small and large population sectors in Scotland

	Most affluent	Most deprived
Post code sectors	-7.3	+12.3
Deprivation categories	-6.02	+8.36
Local government districts	-5.65	+4.07
Health boards	-1.95	+2.50

Secondly, movement of persons into and out of different post code areas indicates that the data will be less reliable with time, this applies mainly to small areas where a small population shift could have a large effect on the population characteristics. This is less applicable to relatively large post code sectors.

Thirdly, in England and Wales post codes and enumeration districts are matched using grid references inaccuracies may arise with mismatching. In Scotland this problem is not relevant as post codes are mapped directly to enumeration districts (Majeed et al, 1995).

Finally, assigning an individual a deprivation score on the basis of the post code is to some extent dependent on how representative of the area that person is, however, when aggregated to larger datasets this limitation is much reduced.

Implementation of deprivation scores & categories

The Carstairs and Morris codes are practical to use and were employed for the studies described in chapters 3, 4 and 6. In chapter 5 a different deprivation score is used, which is described there. At the out-patient diabetic clinics patient details including address with complete post code are recorded onto a computerised database, this was verified using the Post Code Directory. On the basis of the post code sector a deprivation score and category was allocated to each individual.

Summary

Socio-economic status is a concept which is not easily measured, all of the current measures available in the UK have particular problems. Combination codes applying proxy measures for incomes to small areas provides one of the most effective and practical means of measuring socio-economic status. It is important to understand that the information is derived from census data and that there may be some particular problems with data collection for 1991 when interpreting the figures.

Chapter 3

Cardiac risk factor clustering in diabetic persons of low socio-economic status

Introduction

Reaven hypothesised that insulin resistance was the central component of a metabolic syndrome linking diabetes to hypertension, obesity, hyperlipidaemia and coagulation abnormalities which culminate in coronary artery disease (Laws & Reaven, 1993). This would suggest that risk factors would cluster among individuals identifying those at highest risk of developing coronary artery disease. Within the general population certain risk factors for coronary artery disease are known to be more common in the most deprived sections of the community e.g. obesity and hypertension. The picture of risk factor distribution between different socio-economic groups has not been described for a population with diabetes mellitus. The distribution may be different in those with diabetes for several reasons. Most diabetic patients have dedicated health education sessions, attendance at hospital may lead to earlier intervention and the condition of diabetes itself may result in a homogeneous population with similar cardiac risk factor exposure. Different risk factor prevalence between socio-economic groups would suggest the potential for favourably modifying the risk of coronary artery disease. Alternatively, equivalent exposure to risk factors would suggest that once insulin resistance has been established the development of coronary artery disease is determined and intervention is unlikely to influence this.

Between 1949 and 1953 the Standardised Mortality Ratios (SMR) for diabetic persons in social classes 1 and 5 were 134 and 105 (Average

100) respectively and by 1982-3 the SMR had fallen to 67 for social class 1 and risen to 155 for social class 5 (OPCS, 1987). Improvement in mortality figures may be the result of many social and economic reforms which occurred over this time period which may have favoured the most affluent members of society. Public health advice allowing individuals to modify their own risk factor profile has been adopted more enthusiastically by the more affluent members of society. The reason for reduced mortality in social class 1 is not clear, but may be related to correction of cardiovascular risk factors in this group in response to health education advice. Compared with the population as a whole, diabetic subjects experience an excess mortality associated with coronary artery disease (Kannel, 1985; Stamler et al, 1993; Barrett-Connor et al, 1991). A strong inverse correlation exists linking coronary artery disease in the non-diabetic population to socio-economic status, whether it is measured by occupation, social class or home ownership (Rose & Marmot, 1981; Fox & Goldblatt, 1982; OPCS, 1986; Woodward et al, 1990; Woodward et al, 1992). The relationship between socio-economic factors, diabetes and coronary artery disease merit further exploration.

Smoking, obesity, hypertension and hyperlipidaemia add to the already high risk of coronary artery disease mortality in diabetic persons (Standl et al, 1988; Morrish et al, 1991; Janecko et al, 1991). This risk is increased further by poor glycaemic control (Janecko et al, 1991). The St Vincent Declaration proposed a reduction in coronary risk factors to reduce morbidity and mortality from coronary artery disease (Krans et al, 1991). Study of the prevalence of these risk factors in different socio-economic groups may lead to the possibility of focusing preventative measures on areas where maximum effect may be gained.

Methodology

Population

The study group consisted of all patients attending the diabetic clinic (n=1553) at the Victoria Infirmary, Glasgow, UK in 1993. This consists of patients referred to the diabetic clinic, patients followed up over many years and patients admitted to hospital and being followed up at the hospital clinic. The patients are predominantly from south-east Glasgow which has areas from different ends of the socio-economic spectrum. There is a sizeable south Asian community within the hospital catchment area.

Setting

Glasgow was known as the second city of the British Empire through its rapid population growth during the Victorian era, along with the development of heavy engineering and shipping. The city's prosperity declined with these industries in the latter part of this century. Although there has been a recent revival, the post war state owned housing estates built on the outskirts of the city suffer from high unemployment, poor amenities and social deprivation. The high prevalence of coronary heart disease in the west of Scotland is well documented (Tunstall-Pedoe et al, 1986).

Data Collection

Information was collected from all the individuals attending the diabetic clinic over calendar year 1993. A computerised diabetes database (Paradox for Windows) was developed. Data from each clinic visit were recorded on clinic register forms which included, sex, date of birth, date of diagnosis, address with full post code, diabetes type, height, weight, smoking habit, blood pressure and also biochemical investigations glycated haemoglobin and cholesterol. Insulin dependent (IDDM) diabetes was defined as those requiring insulin within three months of diagnosis and all others as non-insulin dependent (NIDDM) diabetes.

Measuring socio-economic status

Socio-economic status was measured using the deprivation scores described by Carstairs and Morris in 1991. These are area based codes allocated to post code sectors. They are calculated from four measures of material wealth: proportion of persons living at a density greater than 1 per room (overcrowding), proportion of the population without access to a car (car ownership), proportion of persons living in households with the head of the household in social class 4 or 5 (low social class according to the Registrar General's classification) and proportion of economically active males seeking employment (male unemployment). An unweighted deprivation score is calculated from these variables. The deprivation scores were grouped into seven deprivation categories ranging from 1 the most affluent to 7 the most deprived. Each individual was allocated to a deprivation category on the basis of their post code.

Definition of variables

Glycated haemoglobin (HbA_{1c}) was measured by a monoclonal anti-body method (Dako Diagnostics, Ely, Cambridgeshire) with a normal range of 2.8 - 5.0%. Serum cholesterol was estimated by an enzyme method. (Boerhinger Mannheim, Sussex, UK) Blood pressure was measured using an automated blood pressure cuff (Lifestat 100, Washington, USA) in the sitting position. Height and weight without shoes were recorded and the body mass index (BMI) calculated. (weight(kg)/height(m^2)). Smokers were defined as those currently smoking one or more cigarettes daily.

Statistics

Data pertaining to BMI, cholesterol and glycated haemoglobin were expressed as medians with inter-quartile ranges for each category. These were then individually analysed in relation to social deprivation using analysis of variance. The number of smokers was expressed as a proportion of each category's population, using deprivation category 1 as the baseline. Chi-squared for linear trend was used to determine whether there was a statistically significant trend sequential trend between the socio-economic groups.. The number of risk factors experienced by each individual were counted on the basis of smoking one or more cigarettes daily, BMI > 30 kg/m^2 (Royal College of Physicians, 1983), cholesterol > 6.5 mmol/l (European Atherosclerosis Society , 1987), blood pressure >160/90mmHg (World Health Organisation, 1993) and HbA_{1c} > 7%, the highest quartile of the study population. Statistical significance was taken at $p<0.05$.

Results

The number of individuals attending the diabetes clinic at this time was 1553 and the majority of these patients were resident within the Greater Glasgow Health Board area. Table 3.1 shows, for each deprivation category, the number of subjects, the median age, duration of diabetes and the proportion of patients with IDDM. The proportion of subjects from ethnic minorities, decreased in the more deprived categories (p=0.024). The categories were broadly similar in terms of age and duration of diabetes. However, there was a statistically significant difference between the categories in terms of the distribution of diabetes type between the deprivation categories, there being proportionately more NIDDM in the deprived categories (p=0.005). Over 90% ascertainment was achieved for all measurements.

Table 3.1. Characteristics of study population by deprivation category (1= the most affluent, 7= the most deprived).

Deprivation Category	No. of subjects	% male	Median age (years)	Median duration (years)	% ethnic minorities[a]	% IDDM[b]
1	200	57	63	5	9	29.5
2	237	56	63	4	8	24.5
3	329	58	62	6	6	33.2
4	152	52	59	5	19	34.0
5	239	51	63	5	9	23.0
6	182	48	64	6	3	14.6
7	214	49	61	4	3	19.7

a= $p<0.02$, b= $p<0.01$

Tables 3.2 and 3.3 describe for IDDM and NIDDM respectively the median levels and inter-quartile ranges of BMI, HbA_{1c}, cholesterol, blood pressure and the percentage of smokers in each deprivation category. In both IDDM and NIDDM patients there are more smokers in the most deprived categories. Higher BMIs are evident in the most deprived categories of NIDDM subjects. Trends which indicate higher BMI, blood pressure and proportion smoking in the more deprived categories were demonstrated. Analysis of serum cholesterol levels in subjects below 70 years of age by deprivation category indicated a trend of higher cholesterol levels in the deprived categories (p=0.0277). When analysed for all patients systolic and diastolic blood pressure levels were higher in the deprived groups p=0.036 and p=0.018 respectively, however, when analysed by diabetes type blood pressure was no longer significantly related to deprivation.

There are differences between the risk factor distribution for IDDM and NIDDM. The IDDM population group have higher rates of smoking and higher HbA_{1c} values, the NIDDM group are more obese, hypertensive and higher cholesterol levels.

Table 3.2 Median values of cardiac risk factors by deprivation category in NIDDM.

Deprivation Category	BMI[a] (kg/m^2)	HbA$_{1c}$ (%)	Cholesterol (mmol/l)	SBP (mmHg)	DBP (mmHg)	% Smokers[b]
1	27.6	4.7	5.7	148	84	10.9
	24.3-31.5	3.8-6.45	4.9-6.4	131-170	78-94	
2	27.1	5.2	5.6	150	84.5	15.4
	24.3-30.3	3.9-6.4	4.8-6.2	134-170	78-94	
3	27.4	5.3	5.7	150	84	17.9
	24.8-31.3	4.2-6.6	5.0-6.7	136-171	75-93	
4	27.5	5.1	5.9	142	83	22.2
	25.4-31.9	4.15-6.45	5.1-6.7	128-167	77-92	
5	28.0	5.3	5.8	153	87	17.6
	25.1-32.0	4.0-6.5	5.0-6.6	136-167	79-92	
6	29.8	5.6	5.6	153	87	27.0
	26.5-33.2	4.4-7.0	4.9-6.7	139-170	79-93	
7	29.3	5.0	5.8	148	85	35.4
	27.1-32.9	4.1-6.75	5.0-6.5	133-167	78-94	

Results expressed as median with inter-quartile range
a = $p<0.002$, b = $p<0.00001$

Table 3.3 Median values of cardiac risk factors by deprivation category in IDDM.

Deprivation Category	BMI (kg/m^2)	HbA_{1c} (%)	Cholesterol (mmol/l)	SBP (mmHg)	DBP (mmHg)	% Smokers[a]
1	23.9	6.1	5.05	138	78	13.3
	22.5-26.6	5.05-8.0	4.4-6.1	122-158	68-85	
2	24.3	6.2	5.1	133	78.5	21.7
	21.9-26.6	4.9-7.5	4.2-5.6	119-150	70-87.5	
3	25.3	6.45	5.2	133	80	23.2
	22.8-27.8	5.1-7.8	4.4-6.0	122-150	71-88	
4	25.0	6.35	5.05	130	75	36.7
	22.8-27.8	5.0-7.7	4.4-6.1	115-153	70-83	
5	25.0	6.10	5.1	134.5	78.5	25
	22.9-27.3	5.2-7.7	4.3-6.1	122-155	70-87	
6	26.7	6.45	5.05	153	80.5	40.5
	22.4-30.7	5.6-8.4	4.05-5.65	123-171	76-95	
7	25.6	6.4	5.2	132	78	41.4
	22.3-29.1	5.2-7.8	4.2-6.0	121-145	70-84	

a = $p<0.001$

Table 3.4 describes the distribution of risk factors for IDDM and NIDDM between the seven deprivation categories. This is a simple unweighted summation of the total number of risk factors to which each individual is exposed. No weighting is given to any of the risk factors which are dichotomised as described in the methodology section. The proportion of persons with three or more risk factors rises sharply in the most deprived categories in IDDM ($p<0.00001$) and NIDDM ($p<0.00005$). The most affluent categories also have the highest proportion of persons with no additional risk factors. For both IDDM and NIDDM there was an adverse distribution of risk factors in the most deprived categories (see figures 3.1 and 3.2).

The NIDDM group had a higher exposure to cardiac risk factors, with more individuals experiencing multiple risk factors, and consequently less individuals with minimal risk factors. One notable feature is the high number of individuals with IDDM in the most affluent category with no additional risk factors.

Table 3.4 Percentage of risk factors for all patients with diabetes by deprivation category.

Deprivation category	No. of Risk Factors IDDM[a]			NIDDM[b]		
	0	**1-2**	**>3**	**0**	**1-2**	**>3**
1	46.8	48.4	4.3	21.9	69.5	6.5
2	26.5	67.3	6.1	21.3	70.9	7.7
3	26.3	68.7	5.0	16.8	69.5	13.7
4	26.7	42.3	11.1	19.0	67.0	16.7
5	37.8	53.3	8.9	21.9	60.0	18.1
6	20.0	60.0	20.0	10.3	57.3	24.8
7	22.8	60.0	17.1	14.1	67.9	17.9

a=p<0.00001, b=p<0.00005

Figure 3.1 Percentage of patients with IDDM with no risk factors and 3 or more risk factors by deprivation category.

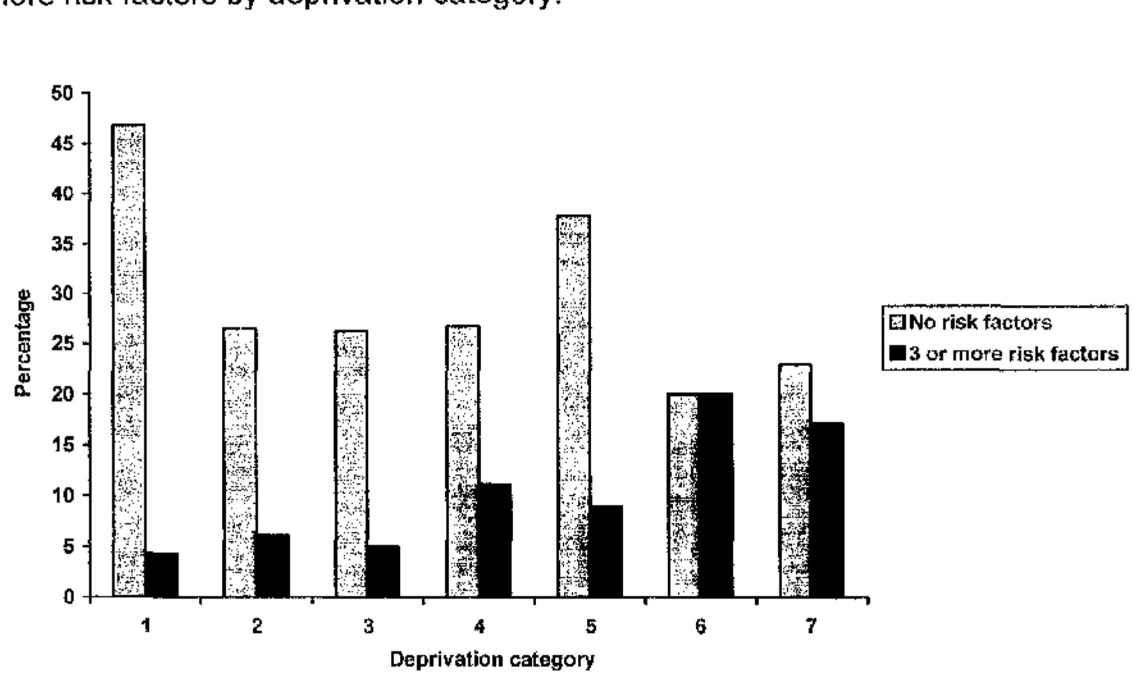
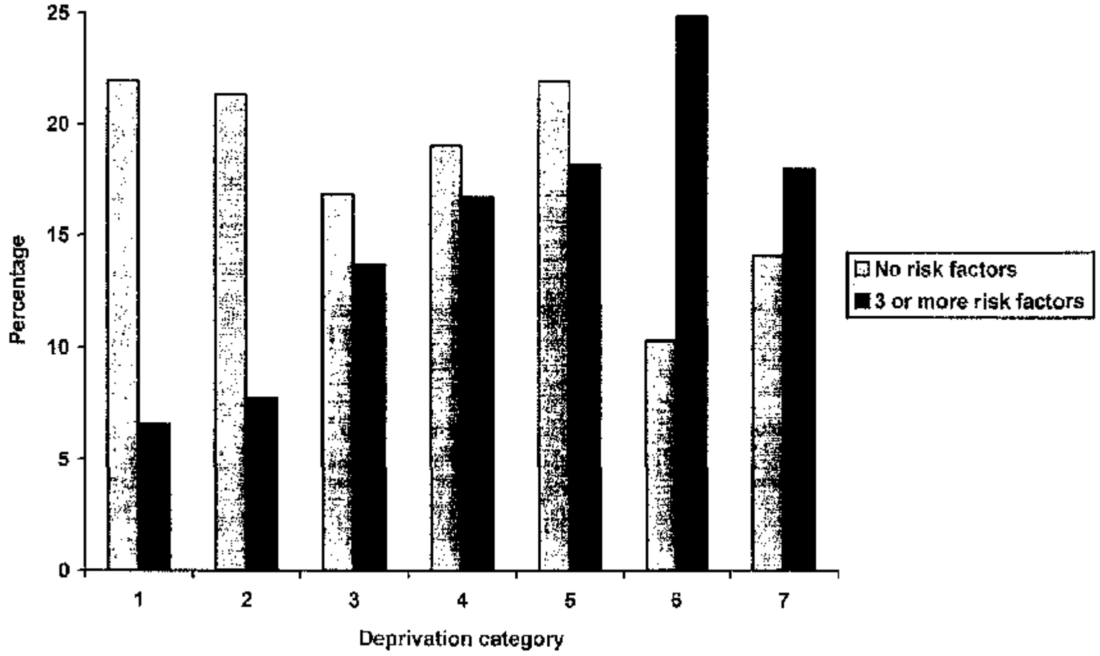


Figure 3.2 Percentage of patients with NIDDM with no risk factors and 3 or more risk factors by deprivation category.



Discussion

Using an area based index of socio-economic status and a diabetic clinic population this study demonstrated that smoking, obesity and hypertension are higher among diabetic subjects of low socio-economic status. These findings for a diabetic population are similar to those reported in the Whitehall study (Marmot et al, 1978). The higher prevalence of cardiovascular risk factors among diabetic subjects of low socio-economic status may in part explain the increased morbidity experienced by such patients reported in a study conducted simultaneously by Kelly et al, 1993.

Area based codes of socio-economic status (SES) describe the area in which an individual lives. Health resources could then be targeted towards these areas. The allocation of social class is dependent on the recording of occupational status. Inaccuracies arise in recording information for women (who are frequently assigned to their husbands occupation) for those who have retired and for those who have had to change occupation or retire prematurely through ill health, common experiences among diabetic subjects. The Scottish Heart Health study of the general population indicated that housing tenure was the most discriminatory measure of social status in relation to coronary heart disease (Woodward et al, 1992). This may be peculiar to the socio-economic circumstances in Scotland, other measures may be more relevant for other areas. These measures of socio-economic circumstances need to be kept under review as the environment changes other measures may be more pertinent. In the near future for example it may no longer be the case that housing tenure remains a good socio-economic discriminator following the transfer of a large proportion of state owned housing to the private sector.

The study cohort consisted of patients attending a hospital based diabetic clinic. By analysing the proportion of patients with IDDM in 10 year age bands we found our data consistent with that from the Southall Diabetes Survey (Mather et al, 1985). The reduced proportion of subjects with IDDM in the more deprived categories has been previously observed (Kurtz et al ,1988). Higher prevalence of diabetes in male subjects has also been noted (Williams, 1985).

The differences in risk factor distribution between NIDDM and IDDM is as predicted for the NIDDM group hypertension, hyperlipidaemia and obesity forming part of the insulin resistance syndrome. The low risk factor exposure in the most affluent categories especially. The IDDM group would suggest a willingness or opportunity to take advantage of health education advice.

There is accumulating data concerning diabetes and the interaction with socio-economic status. Similar results have been reported, in a study of 1246 patients from Middlesbrough UK over the same time period, low socio-economic status was associated with higher BMI, higher proportion of smokers, higher mean systolic blood pressure and proteinuria compared with diabetic patients of higher socio-economic status (Unwin et al, 1996) This study measured socio-economic status, using Townsend scores (Townsend , 1988) which have a correlation of 0.960 with Carstairs and Morris's deprivation scores.

The Glasgow clinic population have had health advice on smoking, obesity and lifestyle from diabetes specialist nurses, dieticians and medical staff, but, this appears to have had a more favourable impact on the persons from affluent areas resulting in the variation of cardiac risk factor prevalence between the socio-economic groups. The uptake of primary care health checks is lowest in the lowest social class (V) (Waller et al, 1990) suggesting that radical new approaches to health are required. Novel approaches may need to be implemented. Specific programs of health education for persons from areas low socio-economic status should be developed, explaining the benefits of risk factor correction within their environment. Health education will need to be more specific addressing issues as basic as how to shop healthily on a limited budget, how to prepare and cook foods, compliance with medication and where individuals living in unpleasant housing estates can go for exercise.

Chapter 4

Socio-economic status and the vascular complications of diabetes mellitus

Introduction

Macrovascular disease and in particular coronary artery disease is the major cause of mortality in diabetic persons. Although coronary artery disease is common in the general population diabetic males have double and diabetic females quadruple the incidence of coronary artery disease compared with the background population (Jarrett 1984). The link between diabetes, obesity, hypertension and dyslipidaemia, has insulin resistance as the central component of the metabolic syndrome which may explain the increased experience of coronary artery disease by persons with diabetes.

There has been a consistent inverse association between socio-economic status and the prevalence of coronary artery disease through out the Western world when total populations are studied (Rogot et al, 1992; Fox and Goldblatt 1982; Pearce et al, 1983; Smith et al, 1990). A proportion of this excess may be accounted for by adverse cardiac risk factor profiles among persons from areas of socio-economic deprivation. However, the excess of coronary artery disease in populations of low socio-economic status persists after accounting for major risk factors (Marmot et al, 1984). The presence of diabetes itself, as indicated above, constitutes a major cardiac risk factor, thus, a diabetic population provides a model of coronary artery disease in a high risk population. The major question to be addressed in this study is whether the adverse effect of socio-economic status on coronary artery disease prevalence among those with diabetes persists after accounting for the influence of major cardiac risk factors.

In contrast, the association between socio-economic status and microvascular complications has not been well researched in itself although the progression of microvascular complications has been well documented. The development of microvascular complications in both insulin dependent diabetes mellitus (IDDM) and non-insulin dependent diabetes mellitus (NIDDM) is the result of an interaction between genetic and metabolic factors, the most important of which are hyperglycaemia and duration of diabetes (DCCT, 1993). Chronic hyperglycaemia is a common factor in the development of microvascular complications. Microvascular complications tend to cluster in the same patients (Krolewski et al 1992). Maintaining near normoglycaemia is a difficult target. Understanding of diabetes, education and motivation are probably the main factors in determining an individual's ability to achieve this.

The effect of genetic factors on the progression of complications is not clear. Twin studies in IDDM show considerable variation in the development of retinopathy (Leslie et al, 1987) whereas progression of nephropathy is associated with a family history of hypertension (Krolewski et al, 1988). Whether hypertension is causal (Feldt-Rasmussen et al, 1987) or the result of incipient diabetic nephropathy (Mathiesen et al, 1990) is not yet clearly established. Specific factors may be particularly important with regard to particular complications, hypertension in the progression of nephropathy and retinopathy and smoking for foot ulceration. In considering the impact of socio-economic status it is necessary to account for these risk factors.

One of the concepts behind this study was to emulate the process at routine clinics, therefore, pragmatism, accuracy and relevance were crucial factors in determining the variables to be recorded and the method of recording. A functional database with facilities for data verification and validation was also important.

Methods

Data collection

All patients attending the Victoria Infirmary diabetes clinic during calendar year 1994, were included in the study. A questionnaire was completed during the consultation to facilitate recording of the study objectives. The interviews and examinations were conducted by myself, Dr Colin Kesson, Consultant Physician or by junior doctors working within the department, after they had been instructed about the study's definitions. Where juniors were in doubt advice was sought from myself or Dr Kesson.

During the period of the study there were 2,219 consultations by 1,505 patients, most patients being seen on a six monthly basis. Of these consultations, 844 were conducted by myself and 832 by Dr Kesson and 543 by junior medical staff. Individual patients seen were 635 by myself, 587 by Dr Kesson and 283 by junior medical staff.

The data were recorded onto proformas, biochemical data being entered later the same day. Patient details and characteristics were checked and medical details recorded, using the definitions described below.

Database

A diabetes database was developed based on Paradox for Windows, a relational database, using individual identification numbers, multiple tables were developed which were all linked via the identification number. In turn, each table was constructed from fields, one of these must include the identification number, providing the common link. For example, the table for patient characteristics consisted of fields for identification number, name, address, post code, date of birth etc. and the field for biochemical results also included identification number but in addition fields for glycated haemoglobin, serum cholesterol, blood glucose, serum creatinine etc. This database is Windows based and simple to use. It has other important properties including open database connectivity (OBDC) which facilitates transfer of data to other systems without adversely affecting the integrity of the data e.g. SPSS for analysis and it supported standard query language (SQL) allowing simple inquiries of the data.

The design of the database included several properties which enabled data validation. Data was checked at entry using field level validation which involved setting properties for each field to prevent erroneous entries. These included limiting the size of the field, the range of a field e.g. HbA_{1c} values to be from 1-20%, converting all string variables to upper case to facilitate comparison between string variables, only required characters to be entered into a field e.g. numerical fields will not permit the entry of letters or symbols and vice versa. Inclusion of these properties prevented errors from key board entry. The patient characteristics table required the use of an edit key to prevent accidental changes to the data and a confirmation key to verify that changes to the field were correct.

Data was also validated at a form level, which checks that data entered into different tables is consistent, this is known as relational dependency. Entry of biochemical data into a table under an identification number which is not in the patient characteristics table would be identified and prompt a check by the person entering the data. Dependencies were also checked, hence no date of diagnosis would precede a date of birth, or an individual diagnosed with IDDM not on insulin.

For statistical analysis the data were transferred to a Windows statistical package, SPSS, thus retaining the data integrity during transfer. SPSS is a flat file, only one case per record. It is not a relational system, but, data can be manipulated and filtered. It is viewed on screen as a flat file.

Data were entered by a secretary, secretarial assistant or myself. The data base was also used to generate letters to the patient and general practitioner which also acted as a form of data verification. In addition I performed 10% random checks to verify the data entry. In addition to these properties, outlying data was checked and data which demonstrated inappropriate fluctuations was checked e.g. large changes in body mass index. During the course of the study a large number of patients made several visits, this also served as a form of data validation.

Biochemical data was completed and updated by interrogating the pathology database and entering the data into the patients computerised record, using the patient identification number. Latest or only data was used for the analysis.

Selection of variables for analysis

The variables recorded are listed below:

Patient characteristics	Name
	Address
	Post code
	Date of birth
	Sex
	Ethnic origin
Lifestyle	Smoking habit- cigarettes per day
	Alcohol habit- units per week
Examination	Height
	Weight
	Blood pressure

Diabetes history	Date of diagnosis of diabetes
	Current diabetes treatment
	Use of a blood glucose meter
Diabetes complications	Presence of retinopathy (background, proliferative, laser therapy)
	Presence of neuropathy
	Presence of foot ulcer
	Presence of proteinuria
Laboratory results	HbA_{1c}
	Random blood glucose
	Serum creatinine
	Serum cholesterol
Coronary artery disease	Previous history
	Rose angina questionnaire
	12 lead ECG
	Coronary artery bypass graft
Diabetes treatment	Diet alone
	Sulphonylurea
	Biguanide
	Acarbose
	Insulin
Other medical treatment	

Recording patient characteristics

Names addresses and dates of birth were recorded as reported by the individual to the doctor. Ethnicity was classified in accordance with the individuals perception of ethnicity. Post codes were checked using the Royal Mails guide.

Definition of diabetes type

Diabetes has been defined according to WHO diagnostic criteria (WHO, 1980) where doubt has arisen an oral glucose tolerance test was used to clarify the diagnosis. Insulin dependent diabetes mellitus (IDDM) or type 1 diabetes was defined as those individuals requiring insulin therapy within three months of diagnosis which indicates dependency on insulin and a tendency to ketosis. All others were classified as non-insulin dependent diabetes mellitus or type 2 diabetes. For the purposes of comparison with other data diabetes was characterised as insulin treated and non-insulin treated, this is quite different from IDDM and NIDDM.

Diabetes history & treatment

The date of diagnosis was checked in the case notes or if this was not available checked with the general practitioner or taken at the patients word. Treatment was verified with the patients. A letter was generated to the patients and general practitioner containing this information and prompting it to be confirmed.

Definition of lifestyle & coronary artery disease risk factors

Each of the risk factors was calculated in the following manner. At each clinic visit patient's height is measured (M) and weight recorded (kg), from these body mass index was calculated, (weight (kg)) / (Height $(M)^2$). Smokers were defined as those currently smoking 1 or more cigarettes per day. A non-fasting venous blood sample was withdrawn for cholesterol (Boehringer Mannheim, Sussex, UK) and glycated haemoglobin, HbA_{1c}, analysed by monoclonal anti-body method (Dako Diagnostics, Ely, Cambridgeshire, UK). Blood pressure was recorded in the sitting position using an automated blood pressure cuff (Lifestat 100, Washington).

Definition of coronary artery disease

Clinical details were recorded of previously confirmed angina, myocardial infarction and coronary bypass grafts, if no previous history of coronary artery disease then the Rose questionnaire (Rose, 1962) was used, a positive history of angina was confirmed on the basis of responses to the Rose angina questionnaire (Shaper et al, 1984). Electrocardiography, 12 lead ECGs were recorded in those patients with no coronary artery disease. ECG changes indicative of coronary heart disease were Q waves (codes 1.1-3), ST depression (codes 4.1-4 or 5.1-3), left bundle branch block (code 7.1) or T wave inversion in accordance with Minnesota coding (Rose et al, 1982). Where patients had a history of other cardiac conditions including valvular heart disease and cardiomyopathies they were not recorded as having coronary artery disease.

Definition of microvascular complications of diabetes mellitus

The presence or absence of diabetic microvascular complications was established for each individual. The complications studied were retinopathy, neuropathy, nephropathy and foot ulceration.

Retinopathy

Prevalence rates of diabetic retinopathy are difficult to ascertain and compare, age, ethnicity, diabetes type and method of examination may impact on the results and detection rates. Comparison between studies is difficult because of the use of different criteria resulting in a wide variation in quoted prevalence rates. The Wisconsin Epidemiologic Study of Diabetic Retinopathy (WESDR) undertook photographic screening. Retinopathy affected as few as 2% with diabetes of less than 2 years duration and as high as 98% with over 15 years duration (Klein et al, 1984a, 1984b). Ophthalmoscopy has also been used for clinical characterisation of retinopathy (Leibowitz et al, 1980;. West et al, 1980; Dwyer et al, 1985.), in Poole UK 30% prevalence of retinopathy was recorded (Houston, 1982).

For this study, retinopathy was defined as the presence of one or more microanneurysms at ophthalmoscopy via dilated pupils with tropicamide eye drops. Where uncertainty arose about the diagnosis and grading of retinopathy arrangements were made for fundal photography, thereafter an opinion was sought from a consultant diabetologist or a consultant ophthalmologist. Retinopathy was graded as no retinopathy; background retinopathy, the presence of microanneurysms and blot haemorrhages; severe retinopathy, if pre-proliferative or proliferative changes or previous laser photocoagulation therapy.

Neuropathy

The definition of diabetic neuropathy may be clinical or electrophysiological. The clinical picture is variable ranging from mild sensory deficit, to diabetic amyotrophy, focal neuropathies, mononeuritis multiplex and autonomic neuropathies or a combination of these. Electrophysiological investigations are sensitive in detecting reductions in nerve conduction velocity, although subjects may be asymptomatic. For these reasons the quoted prevalences of neuropathy vary from 10-100% (Melton et al, 1987).

Diabetic neuropathy was diagnosed when the patient presented with clinical features consistent with one or more of the diabetic neuropathic syndromes. During the period of this study many of our patients were recruited to a study of diabetic neuropathy, these patients all had electromyographic (EMG) evidence of neuropathy although often completely asymptomatic, not all patients underwent EMGs, therefore it was not included as part of the diagnostic criteria.

Nephropathy

The development of proteinuria is preceded by a period of incipient nephropathy characterised by an increased excretion of urinary albumin, known as microalbuminuria. The prevalence of nephropathy is reported to be 15-20% in IDDM and from 3-16% for NIDDM (Garancini et al, 1988; Fabre et al, 1982).

Diabetic nephropathy was defined as persistent proteinuria i.e. urinary protein excretion > 0.5 g/day which was detected by routine dipstick testing (Albustix) at each clinic visit. Patients brought urine samples to the clinic for dipstick testing, if blood was present a urine sample was sent for culture and stain.

Diabetic foot ulcer

Ulceration of the diabetic foot occurs in the context neuropathy and or ischaemia (Edmonds et al, 1986), although the presence of foot deformity is important in affected individuals. Diabetic foot ulceration was diagnosed in the presence of an ulcer which penetrated the skin and was most likely to be the result of diabetes. Ulcers which were felt to be the result of other processes such as varicose ulcers were not included.

Laboratory data

At each visit, a non-fasting venous blood sample was withdrawn for, urea and electrolytes, cholesterol (Boehringer Mannheim, Sussex, UK) and glycated haemoglobin, HbA_{1c}, analysed by monoclonal anti-body method

(Dako Diagnostics, Ely, Cambridgeshire, UK). The laboratories analysed the samples the same day to enable entry of all the data pertaining to an individual to occur simultaneously.

Socio-economic status

Deprivation scores and deprivation categories were entered in accordance with the post codes as described in a previous chapter, Measuring Socio-economic status.

Management of diabetes

The management of diabetes was standardised. A diabetes management protocol was devised. Strict targets were set for glycaemic control and weight reduction, a target HbA_{1c} < 7% (two standard deviations above the non-diabetic mean) for IDDM and < 6.5% for NIDDM. Those with IDDM who had poor glycaemic control attended the Diabetes Nurse Specialist and dietician for advice and the importance of good glycaemic control was explained. For NIDDM, a similar policy was adopted, medication was gradually increased as appropriate to attain HbA_{1c} targets, secondary failure of control with oral hypoglycaemic agents led to the introduction of insulin therapy. Patients with a BMI>30kg/m^2 were invited to attend monthly dietician appointments to reinforce dietary advice and encourage weight reduction. For several years patients newly attending the diabetes clinic have been invited to classes of diabetes education. A young persons diabetes clinic was also organised which enabled the diabetes team to concentrate on the specific problems of IDDM in adolescents and young adults.

Statistics

Initial data concerning the study population are expressed as counts. Later tables use proportions to facilitate comparison between categories. Categorical data e.g. the presence or absence of coronary artery disease is summarised as proportions within the deprivation categories.

The chi squared test for linear trend is used to for calculations of the relationship between nominal, ordered or dichotomous data. This calculation is used to test the null hypothesis, that there is no progressive association between the measured factors and the deprivation categories. The categories are ordered from 1 the most affluent to 7 the most deprived for analysis. This test may be significant when an overall chi squared is not, as it has greater power for detecting trends, the converse is also true, the overall chi squared test for a table may be significant, but, unless there is a trend within the table the chi squared for linear trend test will not be significant.

Data with a theoretically normal distribution were analysed using the appropriate parametric tests (e.g. student's t-test, analysis of variance). The summary statistics used were means and standard deviations. Data with a skewed distribution were analysed using either contingency tables (categorical data) or an appropriate non-parametric test (Wilcoxon test, Mann-Whitney U-test). The summary statistics used were either frequency counts or medians and ranges.

Principles of multiple logistic regression analysis.

Research particularly the studies from Framingham and Whitehall have indicated that the development of coronary artery disease is dependent upon many risk factors, most notably, smoking, obesity, hyperlipidaemia, hypertension, diabetes and age. Calculation of the relative effects of these risk factors on the outcome of coronary artery disease is complex. One may compare those exposed to the risk factor and compare to those unexposed, this allows calculation of relative risk, but, smokers may be thinner than the rest of the population and this may result in an underestimation of the effect of smoking on coronary artery disease. An alternative to this method is to study smokers with similar cholesterol levels, ages and BMIs, stratification. The number of combinations, n, is calculated by 2^n. Therefore even by using large patient numbers and datasets, the number of patients within each subset such as diabetes type or sex may be too small to provide statistically significant results.

In an attempt to avoid these problems multivariate analyses have evolved. Logistic regression is one of these analyses. It requires that the variables or risk factors are dichotomised i.e. disease present or absent, risk factor present or absent. While this is an acceptable way of analysing smoking, other variables such as hypertension and cholesterol require a cut off value which is somewhat arbitrary for a continuous variable, although the levels chosen are indicative of an increased risk based on previous studies. Furthermore, dichotomising variables does not take account of the exponential association between the variables and the outcome e.g. the J shaped curve of cholesterol levels and mortality. The analysis assumes that the effect of each variable is isolated from the others. While this is useful for statistical purposes in reality risk factors often cluster together e.g. the obese hypertensive hyperlipidaemic with diabetes, syndrome X. The chance of the outcome, coronary artery disease being the result of the variable is represented by the odds ratio, i.e. the odds are the ratio of the event occurring to the probability of it not occurring.

A constant is included to account for the factors which may influence the outcome ,but, have not been included in the variable. The logistic regression equation may be expressed as

logarithm of odds = $a + (b_1 x_1) + (b_2 x_2) + \ldots + (b_n x_n)$

a = constant term

b = log weighting coefficient for a variable

x = the presence or absence (scored 1or 0, respectively) of a variable or its value

Thus the following may be inferred from the equation-

The b coefficients in a logistic regression equation provides a measure of the degree of association between each variable and its outcome,

odds ratio = antilog_e (b)

These odds ratios are often described as being corrected or adjusted for the presence or absence of other variables. Significance values can be applied to the b coefficients. The Wald statistic gives an indication of the errors attached to the estimates.

There are various models for logistic regression. Variables may be selected for inclusion or exclusion on the basis of statistical criterion i.e. forward or backward entry. Different combinations of variables will result in different odds ratios and therefore it is important to consider the biological evidence for risk factor inclusion or exclusion from the model. In the context of coronary artery disease, all variables known to significantly impact on the outcome have been included.

In order to establish the relationship between the variables, a correlation coefficient, r, is calculated. The value of r ranges from -1 to +1. A negative value implies that as one variable increases the other variable decreases, a positive value that both variables increase together, a value of zero indicates there is no association between the variables.

Characteristics of study population

The patients attend the clinic via referral from primary care, other specialities (medical and surgical) and also from the district paediatric diabetes clinic. The reasons for referral may be newly diagnosed diabetes, the detection of microvascular or macrovascular complications, a recent diabetic emergency or for diabetic education from the specialist diabetes nurse.

Setting

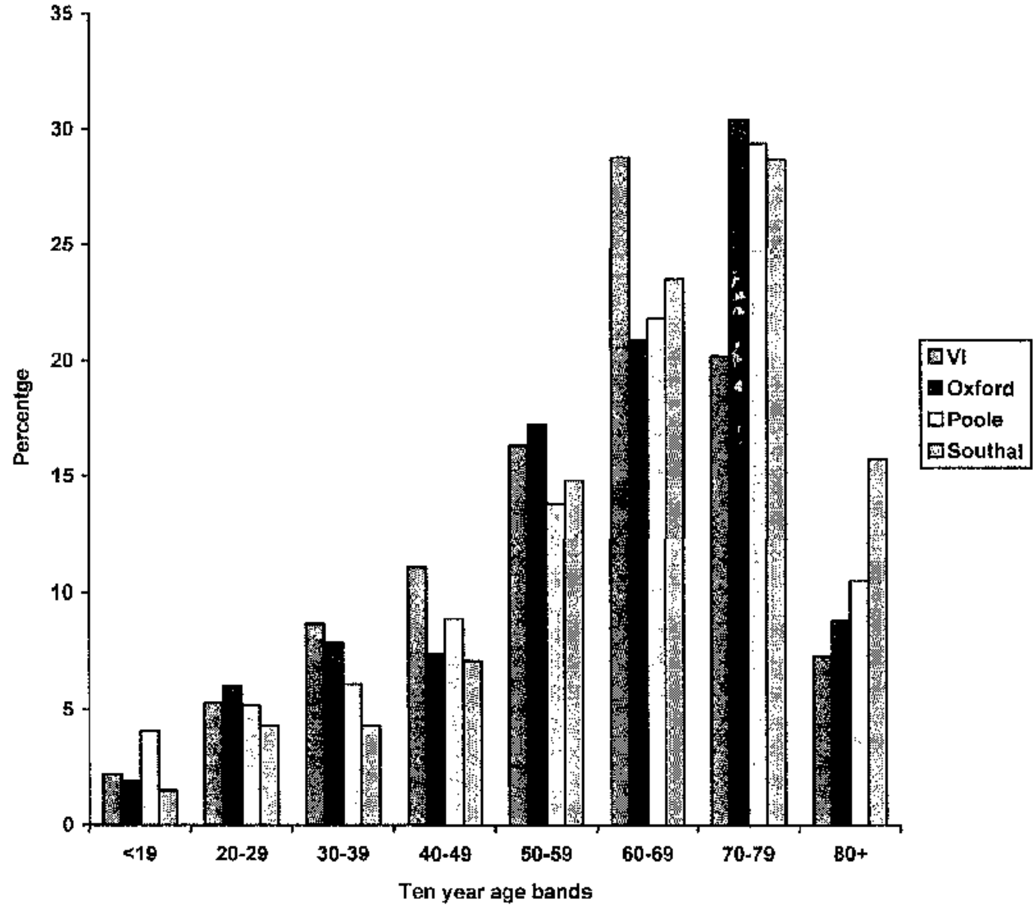
The population studied consisted of all diabetic patients attending the Victoria Infirmary NHS Trust, Glasgow, from (1/3/94 to 1/3/95). Situated within the City of Glasgow this clinic is in close proximity to other hospital based diabetic clinics and there is considerable flow of patients across these boundaries. At the turn of the century Glasgow was known as the second city of the Empire, at this time its population grew considerably with the development of heavy engineering and shipping. The city declined in the latter part of this century along with these industries, creating blackspots of unemployment and social deprivation. Post war council housing estates were constructed on the outskirts of the city but these were lacking in amenities, Castlemilk the largest council housing estate is situated with in the Victoria Infirmary's catchment area which also includes the affluent areas of suburban south-east Glasgow, Pollock, Clarkston and Giffnock. In addition, there is an inner city area around the hospital itself which is home to a thriving ethnic community.

Validation of study population: Comparison with UK diabetes population studies

The catchment area of the Victoria Infirmary is poorly defined and inevitably within a large city there is considerable two way flow across the hospital catchment boundaries, particularly as there are three large teaching hospitals within a small geographical area. Patients may attend a hospital diabetes clinic for particular reasons, the most relevant of these being insulin treatment, the development of the microvascular or macrovascular complications of diabetes or the presence of another significant co-morbid condition. In order to ensure the study population is representative, a comparison of the study population was made with the large diabetes prevalence studies of the early 1980's. This comparison is on the basis of the age-sex structure of these populations and the use of insulin, there are few population based studies in the UK recording the prevalence of diabetes complications.

The proportion of patients within each of ten year age bands was compared with data from three UK diabetes prevalence studies (Mather et al., 1985; Gatling et al., 1985; Neil et al, 1987) (see figure 4.1). Each of these studies demonstrated increasing prevalence of diabetes with increasing age, therefore a comparison was made to assess the proportion of the total study population represented within each ten year age band. The study population demonstrated a slightly higher percentage in the 30-39 year and 40-49 year age bands.

Figure 4.1 Percentage of study population within ten year age bands: a comparison with UK diabetes prevalence studies



The highest percentage was contained within the 60-69 year age band compared with the 70-79 year age band in the three prevalence studies. The percentage of patients in the 70-79 years and 80+ years tailed off in comparison with these studies. However, the general proportions of the population by ten year age bands is similar.

The proportion of persons treated with insulin by 10 year age bands were similar to the population based studies in Poole, Southall and Oxford (figure 4.2). Of 1505 cases 498 (33.1%) were taking insulin. This ranged from 100% in the under 19 years age category to 14.8% in the 80+ years age band (table 4.1). The most recent age specific prevalence study in Cleveland accurately matches the study population (Connolly et al, 1996).

A higher proportion of males to females has been described in population based prevalence studies (Williams et al, 1985; Connolly et al 1996). The explanation for this differential is not forthcoming, but it is real. The study population also reflects this intriguing finding with a male female ratio of 1.14:1.

Based on the age and sex distribution and the proportion of patients on insulin within ten year age bands the study population is similar to those described in the literature. This does not preclude that these patients being hospital based will have a relatively higher experience of the microvascular and macrovascular complications of diabetes.

Figure 4.2 Percentage of patients treated with insulin by ten year age bands: comparison with UK prevalence studies

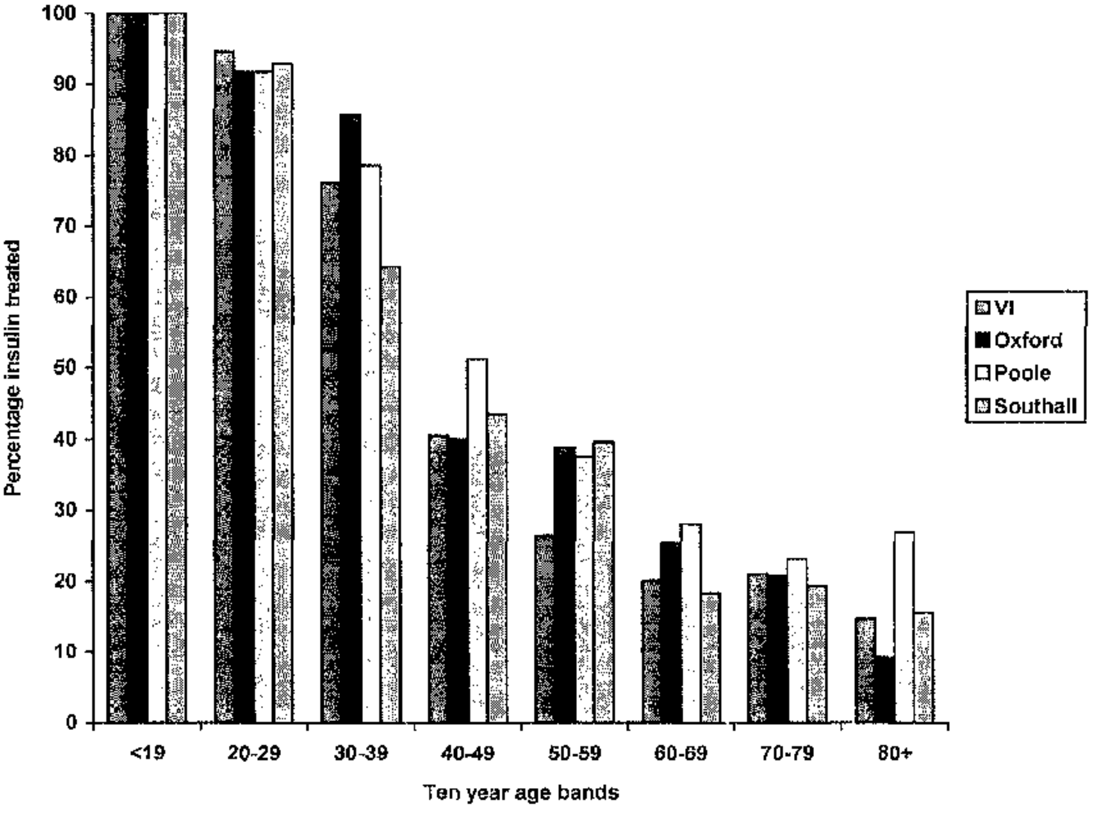


Table 4.1 Proportion of persons treated with insulin within ten year age bands.

AGE BANDS	No. of Subjects	% of total with diabetes	% on insulin
<19	31	2.1	100
20-29	73	4.9	94.5
30-39	121	8.0	76.0
40-49	153	10.2	40.5
50-59	226	15.0	26.5
60-69	398	26.4	20.1
70-79	280	18.6	21.1
80+	101	6.7	14.8
Missing	122		30
Valid cases	1383		468

Districts of residence

Many of the persons attending the clinic are not strictly resident within the catchment area of the Victoria Infirmary, using post codes the district of residence and health boards have been described. This information is important in determining if a large number of patients have selected to attend the Victoria Infirmary, which may result in some bias.

The patients attending the clinic are mainly resident in Glasgow City, 69%, a proportion are resident in areas surrounding Glasgow; 22.5% from Eastwood, an affluent suburb of Glasgow and 2.3% from East Kilbride a nearby 'new town' (table 4.2). Most of the remaining patients are from other areas around the West of Scotland and have long attended the clinic through preference or because they continue to work within the city. Another group of patients are patients who have moved out of Glasgow City but prefer to continue their diabetes care in Glasgow. One person attended university in Edinburgh, but, preferred to continue his diabetic care at the Victoria Infirmary. The patients current address is used as a contact point for communication. This has also been considered as the persons place of residence as it is where they spend the largest proportion of the year.

Therefore, the vast majority of patients 91.7% are resident within the boundaries of Greater Glasgow Health Board, 2.8% from Lanarkshire Health Authority and 2% from Argyll and Clyde (table 4.3). It is unlikely that there is a large bias of self selected patients attending the clinic.

Possibly, those patients who attend from a distance are by definition fit to travel, therefore they are more likely to be healthy and free of major complications.

Table 4.2 Local government districts of study population

Local Government District	Frequency	Percent
Argyll & Bute	1	0.1
Bearsden & Milngavie	2	0.1
Clydebank	1	0.1
Cuninghame	3	0.2
Dumbarton	2	0.1
East Kilbride	35	2.3
Eastwood	338	22.5
Edinburgh City	1	0.1
Falkirk	1	0.1
Glasgow City	1038	69.0
Hamilton	3	0.2
Inverclyde	3	0.2
Kilmarnock & Loudon	2	0.1
Kyle & Carrick	1	0.1
Monklands	2	0.1
Motherwell	2	0.1
Renfrew	23	1.5
Strathkelvin	2	0.1
Not Known	45	3.0
Total	**1505**	**100.0**

Table 4.3 Residency of study population by Health Board

Health Board	Frequency
Argyll & Clyde	30
Ayrshire & Arran	6
Forth Valley	1
Greater Glasgow	1380
Lanarkshire	42
Lothian	1
Not Known	45
Total	1505

Distribution of patient characteristics by deprivation category

Sex

Recording of data for sex was 100% complete. The study population had a higher proportion of males (53.2%) than females (46.8%), this was most pronounced in deprivation categories 1-5 and less pronounced in categories 6 and 7 (table 4.4); the proportion of males in deprivation category 1, 60.4% and in deprivation category 7, 48.7%, analysis of this data by chi squared for linear trend demonstrates that this difference in distribution between the sexes is significant (p=0.0259). This may reflect the relatively higher numbers of women living in deprived categories. This higher proportion of males is consistent with data from a prevalence study in Cambridge (Williams, 1985) (table 4.5) which demonstrated an increased prevalence of diabetes in males at each age band and with research from Connolly and Kelly in Cleveland.

In IDDM, there are proportionately more males (57.1%) to females (42.6%), but this difference is not significantly different between the deprivation categories suggesting that whatever factors responsible for this difference has a similar exposure across the deprivation categories. The picture in NIDDM is of a higher proportion of males in the more affluent categories, but, a higher proportion of females in the more deprived categories (p=0.014).

Table 4.4 No of persons in each deprivation category by sex for the total population.

Deprivation category	All diabetes		IDDM		NIDDM		
	Female	Male	Female	Male	Female	Male	Total
1	86	131	26	35	60	96	217
2	38	56	7	15	31	40	94
3	65	104	18	28	46	76	169
4	161	175	44	59	117	115	336
5	67	80	18	19	48	60	147
6	132	106	20	24	112	82	238
7	134	127	19	25	114	102	261
Total	**683**	**779**	**152**	**205**	**528**	**571**	**1462**
Percentage	**46.7**	**53.3**	**42.6**	**57.4**	**48.1**	**51.8**	**100**

Number of Missing Observations: 43 for deprivation category
6 for diabetes type and sex

All diabetes: chi-square for linear trend : 15.007, p=0.0001

IDDM: chi-square for linear trend 0.441, p=0.507

NIDDM: chi-square for linear trend 14.640, p=0.00013

Table 4.5 Age-sex rates for diagnosed diabetes in Cambridgeshire

Age Years	Prevalence (%) Male	Female
0-14	0.10	0.07
15-44	0.44	0.35
45-64	2.23	1.28
65+	4.50	4.12

From Williams, 1985

This is explained by the higher proportion of females over 70 years in deprivation categories 6 and 7 (31.9%) compared to males (23.9%). This difference may be accounted for by different exposure to the major risk factors for NIDDM among the different socio-economic groups. Several of the major diabetes risk factors, obesity, cigarette smoking and physical inactivity are more common among persons of low socio-economic status.

Age

Age was calculated from self reported date of birth (figure 4.3).The mean age of the study population was 58.4 years, standard deviation 16.8 years. The youngest person was 14 years old and the oldest 91 years. Within the ten year age bands there was a progressive increase in the number of persons to the 60-69 year age band which contained 398 persons, thereafter the numbers gradually declined. Comparison of age groups between the deprivation categories did not show any significant difference between the statistical descriptives for mean, median, and inter quartile ranges.

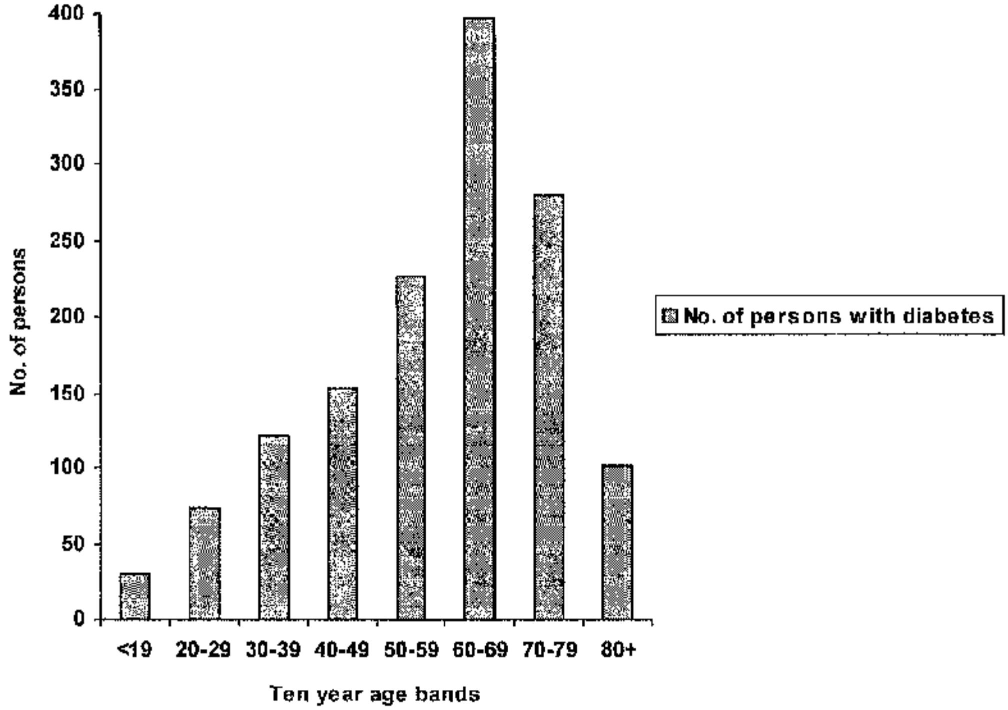
A date of diagnosis was established from the case records or, if this was not available from self reporting. The mean age at diagnosis of diabetes was 49.6 years, standard deviation 18.25 years, which ranged from a minimum of 1 year to a maximum of 88 years. The mean age at diagnosis for IDDM was 28 years and for NIDDM 56 years. Analysis of age within the seven categories revealed that the mean age at diagnosis was highest in deprivation category 3.

The mean age at diagnosis was lower in categories 6 and 7 than categories 1 and 2 but was not statistically significant (table 4.6).

Table 4.6 Current age (years) median and inter quartile ranges within each deprivation category

Deprivation category	Median	Percentile 25	Percentile 75	Minimum	Maximum
1	65	51	73	14	88
2	64	47	71	21	87
3	65	52	75	16	91
4	61	45	71	14	89
5	64	50	71	15	91
6	63	50	71	17	89
7	63	52	71	16	88

Figure 4.3 No. of persons with diabetes by ten year age bands



Duration of diabetes

From the date of diagnosis the duration of diabetes was also established. The mean duration of IDDM was 13.1 years, standard deviation 11.7 years and for NIDDM a mean of 7.5 years, standard deviation 6.4 years. There was no difference between the socio-economic groups for duration of diabetes, when calculated for diabetes type (table 7). This contrasts with Kelly's study in Cleveland (Kelly et al, 1993) where the deprived group had an average duration of diabetes of 6 years compared to 9 years in the prosperous group.

Table 4.7 Duration of diabetes (years) within deprivation categories

Deprivation category	Mean	Median	Percentile 25	Percentile 75
1	9	6	3	12
2	9	7	3	14
3	10	8	4	14
4	10	7	4	13
5	9	7	4	12
6	8	7	3	12
7	8	6	3	11

Ethnicity

Patients were classified into ethnic groups on the basis of surname. The overwhelming majority 92.1% of patients were Caucasians, 7.4% were of South Asian descent, 0.4% Chinese and 0.1% Afro-Caribbean (table 4.8). There was a peculiar distribution of ethnic groups within the area. There were less non-Caucasians living in deprivation categories 6 and 7 (chi squared for linear trend p=0.032). The largest proportion of non-Caucasians, mainly South Asians were resident in areas corresponding to deprivation category 4. These findings are explained by the presence of a South Asian community housed in tenements, with shops providing ethnic foods and fabrics situated near the Victoria Infirmary. In the large peripheral council housing estate of Castlemilk, the South Asian community is very small, however, in the more affluent suburban areas there is a significant population of South Asians. The distribution of Asian patients is important with regard to the prevalence of coronary artery disease in deprivation categories which have a high proportion of Asians as coronary artery disease has a higher prevalence in diabetic persons of Asian origin.

Table 4.8 Representation of various ethnic groups within the deprivation categories (expressed as percentage of total population).

Deprivation category	Caucasian	Asian	Afro-Caribbean	Chinese
1	90.8	9.2	0	0
2	91.7	7.8	0	0.5
3	93.8	6.1	0	0
4	80.6	18.6	0	0.8
5	90.0	9.0	0	1.0
6	96.9	1.9	0	1.2
7	96.9	2.6	0.5	0
Total	**92.1**	**7.4**	**0.01**	**0.5**

Insulin treated patients by deprivation category

IDDM constituted 24.3% of the study group, all others were classified as NIDDM, 75.2%. A significant number of persons with NIDDM were treated with insulin, when there was a failure to maintain satisfactory glycaemic control using maximal oral hypoglycaemic therapy. Of the NIDDM group 11.8% were insulin treated, but, there was no linear association with deprivation category. Overall the percentage of patients treated with insulin amounted to 33.2%, n=499 all others were non-insulin treated, 66.8% n=1006 (table 4.9). There were more insulin treated patients in the more affluent categories (chi-square for linear trend = 13.7, p=0.0002).

Table 4.9 Insulin treatment within deprivation categories

Deprivation category	Non-insulin treated	Insulin treated (%)
1	140	77 (35.5)
2	63	31 (33.0)
3	100	69 (40.8)
4	205	131 (39.0)
5	99	48 (32.7)
6	177	61 (25.6)
7	197	64 (24.5)
Column Total (%)	981 67.1	481 32.9

Missing =43

Chi squared for linear trend = 13.3, $p<0.0003$

Treatment of non-insulin dependent diabetes mellitus

The treatment modalities were recorded for each individual. Selection of therapy was based on achieving glycaemic control and where possible aiding weight reduction. Strict targets were set for glycaemic control, an $HbA_{1c} < 7\%$ for IDDM and $HbA_{1c} < 6.5\%$ for NIDDM. Medication was adjusted accordingly in a stepwise fashion. Several different treatment options were used, apart from insulin, there was diet alone, metformin only, sulphonylurea only, acarbose only or any combination of these. Insulin, sulphonylureas and metformin were the most commonly used treatments. Only two patients were taking a combination of insulin and metformin, because of poor glycaemic control, necessitating insulin, and gross obesity, therefore metformin was added in an attempt to minimise the insulin dose and prevent further weight gain. Selection of therapy was based on achieving glycaemic control and where possible aiding weight reduction.

Of the NIDDM population (table 4.10) 11.5% were taking insulin, 29.8% on diet alone 26.5% on sulphonylurea alone, 10.6% on metformin alone, and 21.6% on a combination of oral hypoglycaemic agents.

Comparison between the seven deprivation categories by chi squared for linear trend did not demonstrate any statistical differences in the use of insulin ($p=0.244$), oral hypoglycaemic agents ($p=0.328$) or diet alone ($p=0.903$).

Table 4.10 Treatment of non-insulin dependent diabetes mellitus (NIDDM) within deprivation categories (expressed as number of individuals)

Deprivation category	Insulin	Sulphonylurea	Metformin	Metformin & Sulphonylurea	Other	Diet Alone
1	17	37	21	35	4	42
2	9	23	3	14	3	19
3	23	35	8	19	1	36
4	30	62	22	37	2	80
5	9	26	15	22	1	35
6	19	49	21	43	3	60
7	23	58	27	52	3	55
Missing	5	9	3	3	0	9
Total	**130**	**299**	**120**	**225**	**12**	**336**

Post code sectors

The size of the post code sectors in this study ranged from 67 to 18,934 with a mean population of 7902, only 5% were resident in post code sectors with a population below 2,300. The deprivation scores range from -6.3 (affluent) to 12.32 (deprived) with a mean score of 1.13, SD 4.98, a similar distribution to Scotland as a whole. The mean percentage male unemployment is higher than Scotland, 12.5% (table 4.11), the percentage of household without a car is similar 41.2%, but overcrowding and social class IV & V are lower compared with 25.3% and 24.1% respectively in the total Scottish population. Valid data was available for 1459 individuals. Thus it would appear that the socio-economic profile of the study population has a higher deprivation score reflecting the higher level of male unemployment in the areas from which the study population live.

Table 4.11 Means and ranges of the four deprivation score variables within study population.

Variable	Mean (%)	Standard Deviation	Minimum (%)	Maximum (%)	Valid Data
Overcrowding	10.40	6.90	0	41	1459
Male unemployment	16.59	11.62	2	46	1459
Social Class IV & V	16.79	10.87	0	46	1459
No car	42.05	23.80	2	87	1459

Summary of patient characteristics

The study population has a similar age-sex distribution and insulin treatment prevalence within the age bands as the main UK diabetes prevalence studies. One third of the population are treated with insulin. The majority of patients are resident within Glasgow city and its environs, located within the Greater Glasgow Health Board area. The population consists mainly of Caucasians. There is a slight preponderance of males which is also consistent with data from diabetes prevalence studies. The population is representative of the wide spectrum of socio-economic status within Scotland.

Coronary risk factor prevalence within deprivation categories

The five main coronary risk factors were recorded at each patient visit, smoking, obesity, cholesterol, hypertension and diabetic control, to allow their effect to be taken into account when calculating the independent effect of socio-economic status.

Smoking

Smokers were defined as those currently smoking 1 or more cigarettes per day. 21.3% of the total population were smokers. There are trends of higher smoking prevalence in the young, and in the most deprived category. Those in the most deprived categories smoked more cigarettes 2.3 cigarettes daily than those in the most deprived group 4.6 cigarettes daily ($p<0.01$). The association between increased smoking prevalence and low socio-economic status was highly significant for NIDDM, but, did not reach statistical significance for IDDM because of high number of smokers in deprivation category 1. From deprivation category 2 to 7 there was a progressive increase in smoking prevalence (table 4.12).

Table 4.12 Current smoking habit within deprivation categories

Deprivation category	Non-smokers	Smokers	Smokers (%)
1	181	36	19.9
2	80	14	17.5
3	143	26	18.1
4	258	78	30.2
5	117	30	25.6
6	192	46	24.0
7	185	76	41.1
Total no.	1156	306	
Total %	79.1	20.9	

Chi squared for linear trend=11.34, $p<0.001$

Body mass index

At each clinic visit patient's height was measured (M) and weight recorded (kg), from these body mass index was calculated, (weight (kg)) / (Height $(M)^2$). Those resident within the most affluent areas were taller than there more deprived counterparts. In the study population males in deprivation category 1 were 3.2 cms taller than male in deprivation category 7 ($p<0.02$) and a difference of 1.7 cms in females ($p=0.057$).

A body mass index greater than or equal to 30 kg/m^2 signifies obesity associated with a significant health risk and may be considered a risk factor for coronary artery disease. In IDDM, the mean BMIs between the groups were not significantly different (table 4.13), but, were more subjects with a BMI>/=30 kg/m^2 the odds ratio in category 7 being double that of category 1 but this did not attain statistical significance ($p=0.051$). In NIDDM, the mean BMI was highest in the most deprived categories (table 4.14) the increased number of persons with a BMI>/=30 kg/m^2 was statistically significant ($p<0.0002$).

Table 4.13 Mean Body Mass Index of each deprivation category for IDDM

Deprivation category	Mean	SD	SE	95 % Confidence Intervals		
1	25.23	3.20	.41	24.41	TO	26.05
2	25.75	3.47	.74	24.21	TO	27.28
3	25.02	3.12	.46	24.10	TO	25.95
4	26.13	4.37	.43	25.27	TO	26.98
5	25.10	4.21	.69	23.69	TO	26.50
6	25.78	5.05	.77	24.23	TO	27.34
7	26.37	4.04	.62	25.11	TO	27.63
Total	25.68	4.03	.21	25.26	TO	26.10

$p=0.511$

Table 4.14 Mean Body Mass Index of each deprivation category for NIDDM

Deprivation category	Mean	SD	SE	95 % Confidence Intervals		
1	28.81	5.96	.48	27.86	TO	29.75
2	29.44	5.31	.63	28.19	TO	30.70
3	27.51	4.59	.42	26.68	TO	28.33
4	29.05	6.63	.43	28.19	TO	29.90
5	29.60	5.92	.57	28.47	TO	30.73
6	29.13	4.97	.36	28.43	TO	29.83
7	30.41	6.10	.41	29.59	TO	31.22
Total	29.21	5.84	.18	28.86	TO	29.55

$p<0.002$

Hypercholesterolaemia

A venous sample for serum cholesterol was checked for all patients. There was no association socio-economic status and serum cholesterol. Analysis of IDDM was not significant (p=0.621), nor NIDDM (p=0.523) (table 4.15). No pattern emerged from subgroup analysis by sex and age under 70 years. Dichotomising cholesterol at 6.5 mmol/l a calculation was undertaken to compare the proportion of patients with high cholesterol >/= 6.5 mmol/l in each deprivation category, the proportions were higher in the most deprived categories but did not reach statistical significance (table 4.16).

Table 4.15 Mean serum cholesterol within deprivation categories

Deprivation category	Mean	SD	SE	95 % Confidence Interval		
1	5.49	1.11	.08	5.33	TO	5.64
2	5.65	1.26	.14	5.37	TO	5.93
3	5.71	1.35	.11	5.49	TO	5.93
4	5.63	1.31	.08	5.48	TO	5.78
5	5.73	1.18	.10	5.53	TO	5.93
6	5.68	1.28	.09	5.50	TO	5.86
7	5.67	1.42	.09	5.48	TO	5.86
Total	5.64	1.29	.04	5.57	TO	5.71

Analysis of variance p=0.686

Table 4.16 Patients with serum cholesterol over 6.5 mmol/l by deprivation category

Deprivation category	Cholesterol < 6.5	Cholesterol>/=6.5 (%)
1	165	32 (16.2)
2	62	18 (22.5)
3	114	35 (23.5)
4	233	67 (22.3)
5	95	36 (27.5)
6	155	50 (24.4)
7	171	53 (23.7)
Column	995	291
Total	77.4	22.6

chi-square for linear trend = 3.63, p=0.057

Number of Missing Observations: 28

Glycated haemoglobin

Glycated haemoglobin is measured on every patient at the clinic, a monoclonal anti-body method is used (Novoclone, Dako Diagnostics). The non-diabetic range is 2.8 - 5%. An HbA_{1c} estimation greater than or equal to 7% was considered to indicate poor diabetic control and as such an increased risk of coronary artery disease (DCCT, 1993). No overall statistical difference was evident between the categories, although glycated haemoglobin in category 6 was significantly higher than the other categories (tables 4.17 & 4.18). For NIDDM, the data suggested a tendency to higher HbA_{1c} levels in the deprived categories although not statistically significant (tables 4.18 & 4.20), but analysis based on whether or not the patients are treated with insulin indicated that those on diet and/or tablets there was a significant association of higher glycated haemoglobin levels in the more deprived categories (p=0.035). This was most evident in females under 70 years of age (p=0.016).

Venous blood samples were taken for random blood glucose estimation at each visit. There was no statistical difference between the 7 groups for either IDDM or NIDDM (tables 4.21 & 4.22).

Table 4.17 Mean glycated haemoglobin (HbA_{1c}) by deprivation category for IDDM

Deprivation category	Mean	SD	SE	95 % Confidence Intervals		
1	6.38	1.92	.25	5.88	TO	6.885
2	6.30	1.76	.38	5.50	TO	7.10
3	6.65	1.87	.28	6.09	TO	7.21
4	6.56	1.83	.18	6.19	TO	6.92
5	6.50	2.19	.36	5.77	TO	7.23
6	6.67	2.21	.34	5.99	TO	7.35
7	6.44	1.57	.24	5.95	TO	6.93
Total	6.52	1.90	.10	6.32	TO	6.72

p=0.975

Table 4.18 Mean glycated haemoglobin (HbA_{1c}) by deprivation category for NIDDM

Deprivation category	Mean	SD	SE	95% Confidence Intervals		
1	5.80	2.02	.16	5.48	TO	6.12
2	6.11	2.01	.24	5.64	TO	6.59
3	5.76	2.15	.20	5.37	TO	6.14
4	5.83	1.86	.12	5.59	TO	6.07
5	6.04	2.01	.20	5.65	TO	6.43
6	6.25	2.10	.15	5.95	TO	6.54
7	6.07	2.09	.14	5.78	TO	6.35
Total	5.98	2.03	.06	5.86	TO	6.10

p=0.231

Table 4.19 Persons with IDDM and HbA_{1c} over 7% by deprivation category

Deprivation Category	HbA_{1c}<7%	HbA_{1c}>/=7% (%)
1	36	23 (39.0)
2	17	4 (19.0)
3	27	18 (40.0)
4	68	31 (31.3)
5	24	13 (35.1)
6	26	17 (39.5)
7	25	17 (40.5)
Column Total	223 64.5	123 35.5

Chi-Square for linear trend=0.242, p=0.622

Number of Missing Observations: 12

Table 4.20 Number of persons with NIDDM and HbA_{1c} over 7% by

Deprivation category

Deprivation Category	HbA_{1c}< 7%	HbA_{1c} >/= 7% (%)
1	114	41 (26.5)
2	51	20 (28.2)
3	95	27 (22.1)
4	170	61 (26.4)
5	78	27 (25.7)
6	131	64 (32.8)
7	147	69 (31.9)
Column Total	786 71.8	309 28.2

Chi-Squared for linear trend = 3.36, p<0.067

Number of Missing Observations: 29

Table 4.21 Random blood glucose values for NIDDM by deprivation category.

Deprivation category	Mean	SD	SE	95 % confidence intervals		
1	11.69	5.04	.41	10.89	TO	12.50
2	11.44	5.01	.60	10.24	TO	12.63
3	12.19	7.44	.68	10.85	TO	13.54
4	12.10	4.28	.28	11.54	TO	12.66
5	11.64	4.55	.44	10.77	TO	12.52
6	12.67	4.51	.32	12.03	TO	13.31
7	12.36	4.60	.31	11.75	TO	12.98
Total	12.12	5.00	.15	11.82	TO	12.42

p<0.394

Table 4.22 Random blood glucose values for IDDM by deprivation category.

Deprivation category	Mean	SD	SE	95 % confidence intervals		
1	12.00	5.62	.72	10.56	TO	13.44
2	12.23	4.29	.92	10.32	TO	14.13
3	12.53	5.65	.84	10.84	TO	14.23
4	12.89	6.11	.61	11.69	TO	14.10
5	12.87	5.75	.96	10.92	TO	14.81
6	12.74	6.45	1.00	10.73	TO	14.75
7	11.65	6.11	.94	9.75	TO	13.55
Total	12.48	5.84	.31	11.86	TO	13.09

p=0.917

Hypertension

Hypertension was defined as a blood pressure over 160/90 mmHg or if the patient was currently being treated with anti-hypertensive agents. Blood pressure is recorded in the sitting position using an automated blood pressure cuff (Lifestat 100, Washington). The overall prevalence of hypertension by these criteria was 51.6%, with considerable variation on the basis of diabetes type, 26.5% for IDDM (table 4.23) and 59.6% for NIDDM (table 4.24) which is probably related to the different age profiles of the IDDM and NIDDM groups. There was no association with socio-economic status.

Proteinuria

Proteinuria has been reported to be a marker for IHD. It may be that the presence of proteinuria reflects the presence of widespread organ damage as a result of microvascular disease. Albuminuria was measured quantitatively using Albustix (Boeringer Mannheim). Albuminuria was present in 24.4% of the total group; 21.8 % of IDDM and 25.2% of NIDDM (table 4.25). No association between the presence of albuminuria and socio-economic status was noted.

Table 4.23 Presence of hypertension in IDDM by deprivation category

Deprivation category	Normotensive	Hypertensive (%)
1	41	15 (26.8)
2	18	4 (18.2)
3	28	13 (31.7)
4	67	30 (30.9)
5	24	7 (22.6)
6	22	14 (38.9)
7	25	13 (34.2)
Total no.	225	96
%	70.1	29.9

Chi-Square for linear trend=1.461, p=0.23

Table 4.24 Presence of hypertension in NIDDM by deprivation category

Deprivation category	Normotensive	Hypertensive (%)
1	56	99 (63.9)
2	31	40 (56.3)
3	50	71 (58.7)
4	92	140 (60.3)
5	46	62 (57.4)
6	85	108 (56.0)
7	77	141 (64.7)
Total no.	437	661
%	39.8	60.2

Table 4.25 Presence of proteinuria for all diabetes by deprivation category

Deprivation category	Non albuminuric	Albuminuria (%)
1	164	53 (24.4)
2	69	25 (26.6)
3	133	36 (21.3)
4	256	80 (23.8)
5	116	31 (21.1)
6	173	65 (27.3)
7	194	67 (25.7)
Total no.	1105	357
%	75.6	24.4

Chi-Square for linear trend=0.36, p=0.55

The prevalence of coronary artery disease within the deprivation categories of a diabetic population.

Progressive trends of increasing risk factor exposure were determined using chi squared for linear trend. Multiple logistic regression was used to determine the relative effect of each of the risk factors on the presence of coronary artery disease. All of the variables were entered into the model, no inclusion or exclusion criteria were applied. The variables were dichotomised for the presence or absence of smoking, hypertension if blood pressure was > 160/90, obesity if body mass index > 30 kg/m^2, hyperlipidaemia if cholesterol > 6.5 mmol/l, poor glycaemic control if HbA_{1c} > 7% and ten year age bands. The model was constructed for patients aged 0-64 years (Norusis, 1985).

Of the total group, 25.4% had evidence of coronary artery disease; 26.3% among females and 24.5% among males (p=0.45). In the under 50 years age category the prevalence of coronary artery disease in women was 14.2% compared with 12.2% in males this difference is not statistically significant and emphasises that pre-menopausal females with diabetes lose the protection against coronary artery disease relative to males, enjoyed by their non-diabetic counterparts.

Table 4.26 Proportion of diabetic persons with coronary artery disease (CAD) and coronary artery bypass grafts (CABG) within deprivation categories.

Deprivation Category	% CAD[a] All ages	% CAD[b] < 70 years	% CAD with CABG[c]
1	24.0	17.2	19.2
2	25.5	22.9	8.3
3	18.3	11.8	16.1
4	22.9	21.1	3.9
5	27.2	25.2	10.0
6	28.2	26.0	6.0
7	30.1	31.4	7.4

Chi squared for trend	Degrees of freedom	Significance
a 5.88	1	0.015
b 14.03	1	0.00018
c 5.11	1	0.023

The prevalence of coronary artery disease by diabetes demonstrated a large difference from 14.2% in IDDM to 28.9% in NIDDM. This difference is a reflection of the age difference between the two types of diabetes.

The prevalence of coronary artery disease within 10 year age bands was as follows: 10-19 years, 3.2%; 20-29 years 5.5%; 30-39 years, 11.6%; 40-49 years 17.6%; 50-59 years, 23.9%; 60-69 years 29.9%; 70-79 years, 35.7%; 80-89 years, 27.7%. This indicates a progressive increase in CAD to the 70-79 year age band. The drop off at 80-89 years may reflect a survival effect (table 4.26).

The relative effect of cardiac risk factors on the presence of CAD was as follows: 27.9% of smokers had CAD compared with 26.3% in non-smokers (NS); 24.7% with an elevated HbA_{1c} compared with 25.9% in those with acceptable HbA_{1c} values (NS); 29.0% of those with a BMI > $30kg/m^2$ compared to 23.7% with BMI <30kg/m2 ($p<0.03$); 31.8% of those with serum cholesterol >6.5mmol/l compared to 23.2% in those with cholesterol <6.5mmol/l ($p<0.003$); 27.3% of those with hypertension compared to 23.5% in those without (NS); 25.7% if proteinuric, 25.1% if no proteinuria (NS).

Analysis of those under 70 years of age was similar: 20.7% in smokers, 23.4% in non-smokers (NS); 27% if BMI > 30 kg/m^2, 20.6% if BMI < 30 kg/m^2 ($p<0.02$); 29.2% if cholesterol > 6.5mmol/l, 20.9% if < 6.5mmol/l ($p<0.02$); 25% if hypertensive, 20.7% if normotensive (NS); 21.2% if poor diabetic control, 23.6% if adequate diabetic control (NS); 23.4% if proteinuric, 22.5% if no proteinuria (NS).

Coronary artery disease was more common in the deprived categories ($p<0.02$). This pattern was not evident when analysis was done by diabetes type. The association of CAD with low socio-economic status was stronger for women ($p=0.031$, Spearman correlation) than for men ($p=0.147$, Spearman correlation). The association was statistically more significant when patients under 70 years of age were analysed ($p<0.0002$).

Patients who have had coronary artery bypass grafts were also noted, when they are excluded from the total number of patients with IHD the association remains ($p<0.004$).

There were 33 patients who had undergone coronary artery bypass grafting, this constituted 9.5% of those with coronary artery disease. The proportion of patients in category 1 with coronary artery disease who have had coronary artery bypass grafting (CABG) was 19.2% compared with 7.4% in category 7 (chi squared for linear trend, $p<0.03$). Among those with coronary artery disease, patients selected for CABG were equally likely to be smokers, obese, hypertensive, hyperlipidaemic and hyperglycaemic (NS).

The results of the multiple logistic regression analysis are contained within table 4.27 (Norusis, 1985). The odds ratios expressed for each of the cardiac risk factors are on the basis of the presence or absence of the risk factor as described above. For the deprivation categories the odds ratios are expressed relative to the baseline which is deprivation category 1. Thus the odds ration for CAD in deprivation category 7 to deprivation category 1 is 1.717. There is a progressive rise in the odds ratio from deprivation categories 5 to 7. The odds ratio also rises progressively for ten year age bands. For the other major cardiac risk factors the odds ratio is around 1.

Table 4.27 Multiple logistic regression analysis for coronary artery disease for diabetic persons under 65 years of age

Variable	B	S.E.	Wald	df	p value	R	Odds Ratio
BMI >30kg/m2	-0.0388	0.1071	.1313	1	0.7171	.0000	.9619
Cholesterol >6.5mmol/l	-0.0883	0.1191	.5504	1	0.4581	.0000	.9155
Deprivation categories			14.5725	6	0.0239	.0611	
Deprivation category 1-2	-0.3261	0.2843	1.3157	1	0.2514	.0000	.7217
Deprivation category 1-3	-0.0892	0.3766	.0560	1	0.8129	.0000	.9147
Deprivation category 1-4	-0.9419	0.3863	5.9442	1	0.0148	-.0756	.3899
Deprivation category 1-5	0.1060	0.2052	.2667	1	0.6055	.0000	1.1118
Deprivation category 1-6	0.2298	0.2991	.5902	1	0.4423	.0000	1.2583
Deprivation category 1-7	0.5406	0.2219	5.9367	1	0.0148	.0755	1.7170
HbA_{1c} >7%	0.0206	0.1053	.0381	1	0.8453	.0000	1.0208
Hypertension	0.1032	0.1072	.9266	1	0.3357	.0000	1.1087
Smoker	0.0511	0.1158	.1947	1	0.6591	.0000	1.0524
Ten year age bands			20.9105	5	0.0008	.1257	
Ten year age bands 2-3	-5.3375	9.5848	.3101	1	0.5776	.0000	.0048
Ten year age bands 2-4	0.1102	1.9675	.0031	1	0.9554	.0000	1.1164
Ten year age bands 2-5	0.5214	1.9400	.0722	1	0.7881	.0000	1.6843
Ten year age bands 2-6	1.1848	1.9300	.3768	1	0.5393	.0000	3.2700
Ten year age bands 2-7	1.6849	1.9264	.7649	1	0.3818	.0000	5.3917
Constant	-2.8946	1.9247	2.2618	1	0.1326		

Ten year age bands 10-19 years=2
20-29 years=3
30-39 years=4
40-49 years=5
50-59 years=6
60-69 years=7

Prevalence of microvascular complications and socio-economic status

The presence or absence of diabetic microvascular complications was established for each individual. The complications studied were retinopathy, neuropathy, nephropathy and foot ulceration. Latest or only data was used from the computerised database in the recording of these complications.

The presence or absence of each of these complications was recorded for each individual in the data base and linked to a file containing the patient characteristic information and details of the socio-economic status using the deprivation score.

One or more diabetes complications either retinopathy, neuropathy, retinopathy or foot ulceration were present in 40.1% of the study group. Overall, low socio-economic status was associated with a higher prevalence of microvascular complications (p=0.011) (table 4.31). The patterns of each microvascular complication were different.

Retinopathy

Of the total population 17.9% had evidence of diabetic retinopathy by these criteria; 22.4% for IDDM and 16.6% for NIDDM. Background retinopathy accounted for 62.6% and severe retinopathy 37.4%. The presence of retinopathy was not associated with socio-economic status for the whole population or for IDDM nor NIDDM (table 4.28).

Analysis of the under 70 years age group indicated retinopathy was more common in the deprived categories (table 4.29) this did not reach significance on linear testing ($p=0.074$).

Using a multiple logistic regression model including age, duration and glycated haemoglobin, the most significant factor in the development of diabetic retinopathy was duration of diabetes ($r=0.210$, $p<0.0001$).

Table 4.28 Persons with diabetic retinopathy by deprivation category for all diabetes

Deprivation category	No retinopathy	Retinopathy (%)
1	180	37 (17)
2	75	19 (20.2)
3	145	24 (14.2)
4	284	52 (15.5)
5	124	23 (15.6)
6	180	58 (24.4)
7	211	50 (19.2)
Total no.	1199	263
%	82.0	18.0

Chi-Square for linear trend=2.29, p=0.130

Table 4.29 Presence of retinopathy by deprivation category for persons under 70 years

Deprivation category	No retinopathy	Retinopathy (%)
1	132	25 (15.9)
2	55	15 (21.4)
3	98	12 (10.9)
4	221	35 (13.7)
5	93	18 (16.2)
6	131	42 (24.3)
7	156	38 (19.6)
Total no.	886	185
%	82.7	17.3

Chi-Square for linear trend=3.19, p=0.074

Neuropathy

Clinical features of neuropathy were present in 5.2% of the study group. There was no association with socio-economic status when subgroups based on sex, age or diabetes type were analysed.

Nephropathy

By these criteria nephropathy was present in 24.5% of the total population, 21.9% of IDDM and 25.2% of NIDDM. There was no evidence of an association with socio-economic status overall (table 4.30) or within subgroups based on diabetes type, age and sex. The most powerful predictors of nephropathy were duration of diabetes, glycaemic control and hypertension.

Foot Ulcer

Foot ulcers were present in 1.7% of the population, 60% of which involved patients from deprivation categories 6 and 7. The presence of a foot ulcer correlated with increasing social deprivation. The odds ratio of ulceration in categories 6 and 7 were 3.74 and 3.00 relative to category 1 (chi squared for linear trend p=0.03) (table 4.32). This association remained after accounting for age and smoking. 40% had clinical evidence of neuropathy, but this was not related to deprivation.

Table 4.30 Presence of neuropathy by deprivation category

Deprivation category	No neuropathy	Neuropathy	Total
1	201	16 (7.4)	217
2	90	4 (4.3)	94
3	163	6 (3.6)	169
4	318	18 (5.4)	336
5	141	6 (4.1)	147
6	221	17 (7.1)	238
7	250	11 (4.2)	261
Total no.	1384	78	1462
%	94.7	5.3	100.0

Chi-Square for linear trend=0.355, p=0.55

Table 4.31 Ratio of diabetic patients with diabetic foot ulcers within deprivation categories

Deprivation Category	No with foot ulcer present	Odds ratio
1	2	1.00
2	1	1.16
3	3	1.94
4	2	0.64
5	2	1.48
6	8	3.74
7	7	3.00

Deprivation category 1 baseline odds ratio of 1 for comparison
p=0.03 chi squared for linear trend

Table 4.32 No. of persons with one or more microvascular complications of diabetes within deprivation categories.

Deprivation category	Complications	Free of complications	Odds ratio
1	86	131	1.00
2	35	59	0.90
3	59	110	0.82
4	129	207	0.95
5	57	90	0.96
6	121	117	1.58
7	116	145	1.22

chi squared for linear trend 6.49, p=0.011

Discussion

Study design

The study was cross-sectional rather than prospective and hence describes association of factors rather than causation. Nevertheless, the associations described need to be explained in the context of established scientific evidence. The main advantage of cross-sectional studies in comparison to prospective studies is the element of time, to conduct a similar prospective study may require ten years or more of follow up, which is expensive and requires rigorous follow up of subjects and data. If the cross-sectional studies establishes the association then it would be reasonable to develop a protocol for a prospective study.

Study population

The population under investigation although not a geographical population compared favourably with the three surveys of age-sex specific diabetes prevalence, furthermore the comparison of insulin treatment with these surveys was also similar, which indicates that the study results are not skewed by these factors and indeed the results may be extrapolated to other areas.

Other interesting aspects of the population was the higher proportion of women in the most deprived categories, again, this information has been established for the general population. Intuitively one may suspect that the proportion of individuals with NIDDM would be higher among the most deprived categories because of a higher exposure to obesity in particular which is implicated in the development of NIDDM.

Coronary artery disease prevalence

The weakness of a cross sectional study is evident in the data pertaining to smoking. There was little difference in coronary heart disease prevalence between smokers and non-smokers. This is likely to reflect those patients who have stopped smoking following the diagnosis of angina or myocardial infarction, but, nonetheless smoking has been an important aetiological factor in the development of disease. This may also be accounted for by the need to enter data on a categorical basis for the purposes of the analysis, hence similar risk is apportioned to those who smoke 1 cigarette daily compared to 40 cigarettes daily.

There is however clear evidence of an increased experience of coronary artery disease among those of low socio-economic status, furthermore, this is most marked in the persons below 70 years of age. This is further supported from the multiple logistic regression equation demonstrating that persons of low socio-economic status have a higher association with coronary artery disease, but, it should be noted that the R value is very low indicating that low socio-economic status itself does not account for all of the increased association. Material deprivation, however, is significantly associated with the presence of coronary artery disease after accounting for the effects of other risk factors.

The most concerning aspect of this analysis however is the differential between the socio-economic groups with regard to coronary artery bypass grafts, these were almost three times more common in the most affluent category compared with the most deprived. The process by which an individual with coronary artery disease arrives at the situation of a coronary artery bypass depends on symptoms, referral to a specialist centre and acceptance for surgery. This process may be more difficult for more deprived members of society for several reasons, lack of awareness of the procedure and its benefits, non-acceptance for surgery because surgical risk most importantly smoking and obesity, which are more common in this population group and the presence of other co-morbid conditions, particularly Chronic Obstructive Airways Disease (COAD). Therefore there is a paradox, the risk factors which have resulted in the need for coronary artery bypass graft surgery may ultimately prevent surgery. One other factor to consider in the interpretation of these results is a survivor effect, the individuals from the most deprived background carry the highest risk of post-operative morbidity. Even after accounting for these factors it is unlikely that medical reasons alone account for the large differential between the socio-economic groups.

This data has demonstrated that in a population with diabetes, low socio-economic status is associated with coronary artery disease after accounting for the effect of major cardiac risk factors.

Microvascular complications

The major determinants of microvascular complication evolution are glycaemic control and duration of diabetes. Socio-economic status has some impact on complications most notably foot ulceration and to a lesser extent retinopathy although this was not statistically significant.

The prevalence for each complication was lower than quoted in major prevalence studies, several factors may account for this. Under ascertainment of complications may have resulted particularly where relatively junior staff were examining the patient, however, many of the patients were seen twice and latest or only data used, therefore, it would appear that this would not be a major problem. The patients attending the clinic had a shorter duration of diabetes than that described in prevalence studies, which would result in a lower prevalence of all of the microvascular complications The reasons for this have not been addressed, but it may be the result of increased cardiovascular mortality or a failure to attend clinic appointments by persons with long-standing diabetes will lead to a relatively higher proportion of recently diagnosed patients who have been newly referred to the clinic.

Studies which have compared ophthalmoscopy with photographic screening have demonstrated a higher detection of retinopathy using combined screening modalities and have also demonstrated improved detection with increasing operator experience (Buxton et al,1991). The detection of neuropathy may also be enhanced by the use of biosthesiometer or the use of electromyographic investigations, however, it has been suggested that EMG will show evidence of diabetic neuropathy in all patients with disease of over ten years duration (G Jamal , personnel communication). In addition, EMG recordings may be influenced by the blood glucose at the time of testing. It was felt that this did not provide information which was as clinically relevant as the pragmatic approach adopted for the organisation of diabetes services.

The major impact of socio-economic status on complications is the development of foot ulceration. Interestingly, patient education, properly fitted footwear and meticulous attention to foot hygiene are all measures whereby ulceration may be preventable. Low educational attainment and lack of available finances for appropriate foot wear would both potentially increase the risk of ulceration. These are areas where improved delivery of advice could be beneficial.

Socio-economic status is important in that factors pertaining to education and management of diabetes may impinge on an individuals capabilities in an adverse manner. A population based study screening for diabetes complications which aimed at including patients who had not been attending hospital or general practitioner clinics would provide a definitive answer to microvascular complications, diabetes control and socio-economic status.

Summary

The role of low socio-economic status in the pathogenesis of coronary artery disease in those with diabetes is mediated in part through increased exposure to major coronary risk factors, in addition there is a further effect associated with socio-economic status which may be related to other risk factors such as hypertriglyceridaemia and prothrombotic factors or an effect of socio-economic status itself. Microvascular disease in general is less affected by socio-economic status with the main determinants of onset and progression being chronic hyperglycaemia and duration of disease. Amputations as a result of diabetic foot ulceration shows a clear trend of increasing prevalence in the lower socio-economic groups. The development of the macrovascular complications of diabetes is related to an individuals socio-economic status.

Appendix 1

Rose Angina Questionnaire

A. Chest pain on effort

1. Have you ever had any chest pain or discomfort in your chest ?

    Yes / No

    (If no diagnosis is no angina, if yes proceed to next question)

2. Do you get it when you walk uphill or hurry ?

    Yes / No* / Never hurry or walk uphill

    (At * proceed to section B)

3. Do you get it when you walk at an ordinary pace on the level ?

    Yes / No

4. What do you do if you get it while you are walking ?

    Stop or slow down / Carry on*

5. If you stand still, what happens to it ?

    Relieved / Not relieved*

6. How soon ?

    10 minutes or less / more than 10 minutes*

7. Will you show me where it was ?

    Sternum (upper or middle) / Sternum (lower) / Left anterior chest /

    Left arm / Other

8. Do you feel it anywhere else ?

    Yes / No

B. Possible Infarction

9. Have you ever had a severe pain across the front of your chest lasting half an hour or more ?

    Yes / No

Angina is defined as being present in subjects who answer as follows:

Q.1	Yes
Q.2 or 3	Yes
Q.4	Stop or slow down
Q.5	Relieved
Q.6	10 minutes or less
Q.7	(a) Sternum (upper or middle or lower) or (b) left anterior chest and left arm

Angina may be graded according to severity

Q.3	No = Grade 1
	Yes = Grade 2

Pain of possible infarction is defined as being present in subjects who answer as follows

Q.9	Yes

Chapter 5

Diabetes prevalence and socio-economic status.

Introduction

For many years diabetes has been considered a disease of affluence. On an international basis diabetes has been more common in Western societies, however, the Westernisation of lifestyles among the Pima Indians and Nauruan islanders and the development of obesity has resulted in a diabetes prevalence of up to 50%. Both genetic and environmental factors are important in the pathogenesis of NIDDM (Jarrett, 1989; Barrett-Connor 1989). High prevalence of obesity within a population is associated with a high prevalence of diabetes and is thus regarded as a risk factor which may be modified thus reducing the risk of diabetes (Barrett-Connor, 1989; Chan et al 1994). Cigarette smoking has been associated with the subsequent development of diabetes in some studies (Perry et al, 1995; Rimm et al, 1993; Feskens and Kromhout 1989) but not in others (Wilson et al, 1986). In the UK obesity and cigarette smoking are more common among persons of low SES. Moderate alcohol consumption is thought to be protective with regard to the development of diabetes (Rimm et al, 1995).

Increased incidence of diabetes in deprived towns has led to the suggestion that there is an environmental factor which predisposes to diabetes and in particular non-insulin dependent diabetes (NIDDM) (Barker et al, 1982). The impact of lifestyle on the development of diabetes is controversial, although diabetic persons of low socio-economic status have increased exposure to cardiac risk factors and poorer health than more affluent persons (Kelly et al, 1993; Connolly and

Kesson 1996). Low birth weight babies who become obese in later life are at high risk of diabetes (Barker et al, 1992). Low birth weight and adult obesity are more common in persons from socially deprived areas.

The highest prevalence of coronary heart disease occurs in the lowest social class (Rose and Marmot, 1978). This increase can not be accounted for simply by higher exposure to known risk factors such as smoking (Kuller, 1976). A higher prevalence of diabetes in deprived areas could explain part of this risk. We therefore completed a cross sectional population based study of known diabetes in South Tees.

Method

Area

The South Tees area consists of Middlesbrough and Langbaurgh-on-Tees (now Redcar and East Cleveland), both of which were until recently part of Cleveland. There is a similarity to Glasgow, as the industrial area has developed around the river Tees and is known for steelworks, heavy engineering and chemical works. The population is largely Caucasian, with a sizeable community of Irish descent. Ethnic minority groups constitute only 4.4% of Middlesbrough's population and 0.7% of Langbaurgh-on-Tees. Over the last forty years the population of Middlesbrough has declined while that in Langbaurgh-on-Tees has increased.

Table 5.1 Factors pertaining to material wealth: comparison of South Tees with England & Wales

	Middlesbrough	Langbaurgh-on-Tees	England & Wales
Overcrowding	2.4	1.6	2.1
No car	47.6	37.8	32.4
Social class IV & V	26.6	25.2	18.1
Male unemployment	16.0	13.0	9.6

Expressed as percentages

Middlesbrough itself has some of the most deprived areas in Northern England and Wales while Langbaurgh-on-Tees is a more affluent district which includes small country towns and villages (table 4.1).

Data collection

A community based diabetes register for 1994 recorded all known cases of diabetes in the South Tees Health Authority (population 285,157). This information was collected by a research sister who visited 49 general practices surveying the records for patients with known diabetes and data from the hospital diabetes register. The information was collected on a proforma with details for patient characteristics, treatment, complications and the presence or absence of microvascular and macrovascular complications. There were 4,313 patients detected, age adjusted prevalence 1.57%. Patients were classified as IDDM when diagnosed before age 31 and currently taking insulin, all others as NIDDM.

Measuring socio-economic status

Socio-economic status was measured using a deprivation score derived from 9 variables-

- male unemployment
- manual workers
- one parent households
- health and disability
- pensioners living alone
- no car households

- overcrowded households
- living in local authority rented accommodation
- living in privately rented property

The nine variables were combined to produce a single disadvantage score for each ward. These variables were selected specifically for the district. Variables were unweighted and Z transformed. On a ward level there is little variation in population size, therefore z-scoring is particularly appropriate. The socio-economic status inferred by the score is similar to the deprivation categories of Carstairs and Morris, highly negative scores imply high socio-economic status and high positive scores low socio-economic status. There is a strong correlation with Townsend scores of 0.98.

Within the South Tees area the two main districts of Middlesbrough had a ward average deprivation score of 2.5 (Range 13.2 to -14.5) and Langbaurgh-on-Tees ward average -1.0 (Range 12.0 to -14.3). A variability measure has also been calculated to provide an index for the variation in socio-economic circumstances within the wards. A high score suggests high variability within the ward, whereas a low score implies conformity across the ward. In Middlesbrough the average variability was 1.0 (range 0.3 to 2.1) and in Langbaurgh -on-Tees 1.0 (range 0.3 to 2.1) (tables 5.2 & 5.3).

Table 5.2 Disadvantage scores and variability in Middlesbrough wards

Ward	Disadvantage	Variability
Thorntree	13.2	0.5
St. Hilda's	13.1	1.2
Beechwood	12.5	1.0
Pallister	11.4	0.5
Southfield	8.8	0.7
North Ormesby	8.6	0.7
Ayresome	8.6	1.3
Grove Hill	7.7	1.6
Beckfield	7.5	1.5
Hemlington	7.3	1.7
Park End	7.1	0.3
Easterside	6.5	0.6
Berwick Hills	5.4	0.5
Westbourne	4.9	0.3
Stainton	3.9	2.1
Gresham	3.1	0.5
Linthorpe	-1.6	0.9
Park	-2.8	0.5
Newham	-4.3	1.4
Kader	-7.6	0.6
Brookfield	-8.6	0.7
Marton	-8.6	0.7
Acklam	-9.6	0.7
Kirby	-10.2	0.5
Nunthorpe	-14.5	0.9
Average	**2.5**	

Table 5.3 Disadvantage and variability in Langbaurgh-on-Tees wards

Ward	Disadvantage	Variability
Grangetown	12.0	0.7
South Bank	9.6	1.1
Kirkleatham	5.8	2.0
Eston	3.2	1.4
Newcomen	2.2	1.5
Loftus	2.2	1.2
Coatham	2.1	0.5
Dormanstown	2.0	1.4
Guisborough	1.7	1.0
Skinningrove	1.1	0.8
Skelton	-0.3	1.3
Teesville	-1.4	1.1
Saltburn	-2.8	1.1
Brotton	-3.0	1.1
Redcar	-3.1	0.8
Ormesby	-4.3	1.1
Normanby	-5.1	1.8
St. Germain's	-5.5	1.3
Longbeck	-6.4	0.8
Belmont	-8.4	1.1
West Dyke	-9.2	0.8
Hutton	-14.3	0.5
Average	**-1.0**	

Patients were allocated a deprivation score on the basis of ward of residence and grouped into quintiles. The quintiles based on deprivation score and populations therein were as follows:

< -8.96 most advantaged	*(pop. 27,593)*
-8.96 to -3.42	*(pop. 65,577)*
-3.42 to 2.12	*(pop. 76,149)*
2.12 to 7.66	*(pop. 62,439)*
>7.66 most disadvantage	*(pop. 56,619)*

Analysis was of ten year age bands and within deprivation quintiles. All data, except where specifically indicated, is age adjusted to the England and Wales population.

Results

Prevalence

The crude prevalence of diabetes was 1.50% (95% confidence intervals, 1.45-1.54) age adjusted to England and Wales population 1991, 1.56% (95% confidence intervals, 1.52-1.61); there was a significantly higher prevalence in males 1.75% (95% confidence intervals, 1.68-1.82) compared to females 1.39% (95% confidence intervals, 1.32-1.45). The prevalence of insulin treated diabetes was 0.38% which is similar to previous studies although the proportion for the study population was lower because of the increased numbers of non insulin treated patients detected.

The age-specific prevalence of NIDDM, 1.19% indicates an increase compared with previous UK studies (Gatling et al, 1985; Mather et al, 1985; Neil et al, 1987). The prevalence of IDDM, 0.38%, is similar to those studies (table 5.4).

Socio-economic status

There was a significant trend between the prevalence of all diabetes and quintile of deprivation score in both men and women (x^2 for linear trend, $p<0.001$) (figure 5.1), however, this effect was mainly accounted for by variations in the prevalence of NIDDM. In men the prevalence for NIDDM in the least deprived quintile was 1.34% (95% confidence intervals, 1.15-1.54) compared to 1.72% (95% confidence intervals, 1.55-1.89) in the most deprived; in women the prevalence in the least deprived was 1.08% (95% confidence intervals, 0.90-1.27) compared to 1.55% (95% confidence intervals, 1.38-1.71) in the most deprived. Figures 5.2 and 5.3 describe the variation in diabetes prevalence for males and females respectively within ten year age bands and indicate the most marked variation occurs in the middle years and is more pronounced among females than males. There was no significant trend in the prevalence of IDDM by quintile of deprivation score.

Table 5.4 Age specific prevalence of diabetes: comparison of South Tees data with three major UK studies.

Age Band	South Tees	Oxford	Poole	Southall
0-9	0.05	0.05	0.06	-
10-19	0.20	0.1	0.24	0.12
20-29	0.37	0.38	0.42	0.37
30-39	0.58	0.63	0.41	0.44
40-49	1.12	0.71	0.77	0.76
50-59	2.57	1.58	1.29	1.32
60-69	4.41	2.21	2.01	2.37
70-79	4.93	4.22	3.53	3.71
80+	4.84	2.86	3.20	5.90
Age adjusted prevalence	1.56 (1.52-1.61)	1.04 (0.94-1.14)	0.95 (0.89-1.02)	1.05 (0.93-1.18)

95% confidence intervals in parenthesis

Figure 5.1 Age adjusted prevalence of known diabetes by quintile of deprivation score

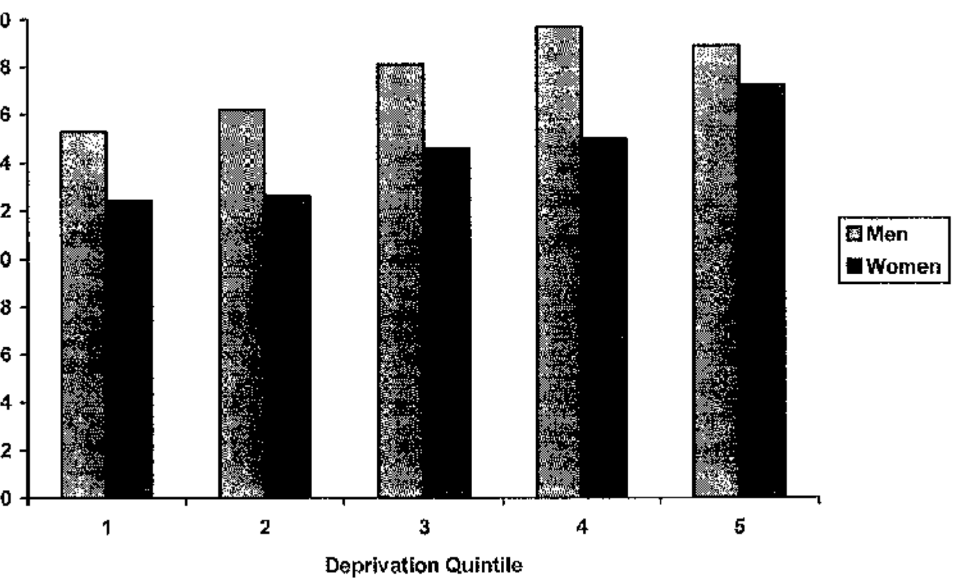
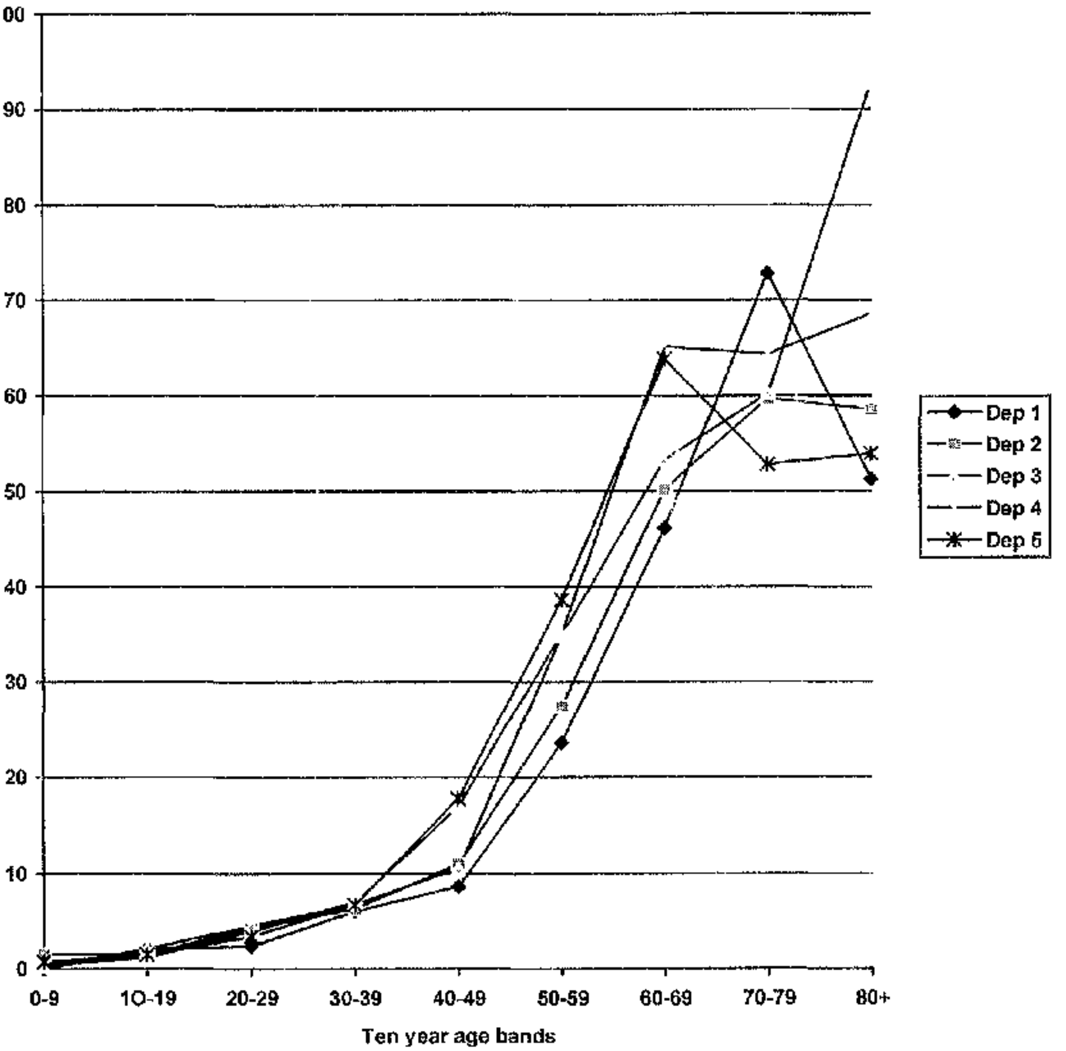


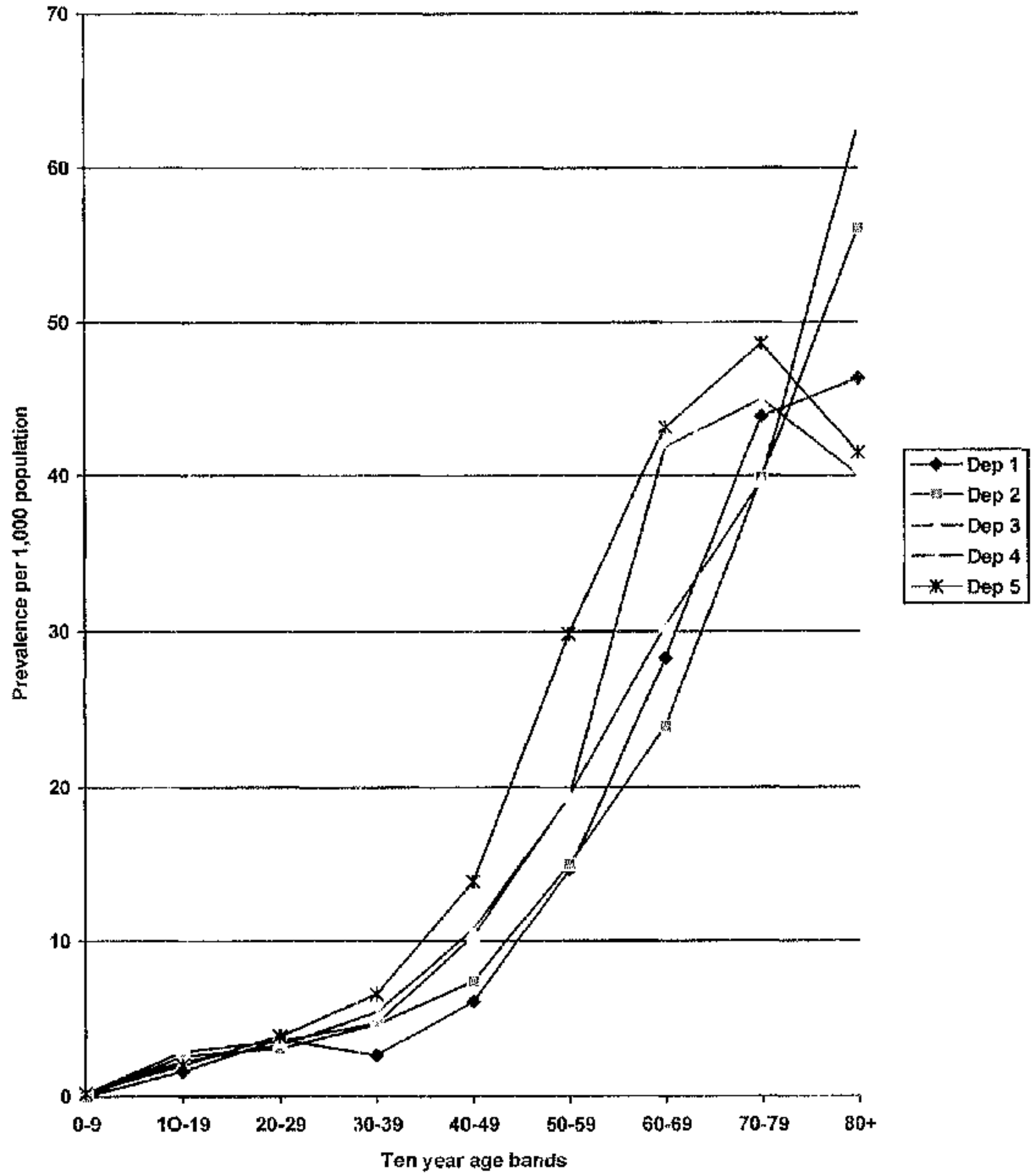
Figure 5.2 Male prevalence of diabetes in South Tees within ten year age bands for quintiles of socio-economic status



Dep 1 = most affluent quintile

Dep 5 = most deprived quintile

Figure 5.3 Female prevalence of diabetes in South Tees within ten year age bands for quintile of socio-economic status



Dep 1 = most affluent quintile

Dep 5 = most deprived quintile

Discussion

General practitioner and hospital records were surveyed for the diagnosis of diabetes, these were checked by a research sister, however there may be a degree of under detection of diabetes particularly if patients were being treated for diabetes although not registered as such in the case records. Over diagnosis of diabetes does not appear to have been a significant problem. Detection of IDDM is made easier by the requirement for insulin, however, NIDDM may be more difficult to detect as a significant proportion of persons will be controlled on diet alone and an unknown number may remain undetected, being asymptomatic of hyperglycaemia.

The prevalence of diabetes by age and sex is higher in older age groups than previously reported in UK prevalence studies, this being accounted for by increased detection or incidence of NIDDM. Note that these studies were conducted in Southern England and this is the only reported study of age-sex diabetes prevalence in the Northern part of the UK, which is probably important given the wide economic gulf which developed within the UK during the 1980s which was recognised as a North-South divide. This may explain the different prevalence of diabetes in the Middlesbrough area compared to Oxford, Poole and Southall.

An increased incidence may be the result influences from the environment or changes in lifestyle, such as the increasing prevalence of obesity, but the results are more likely to be the effect of increased diabetes awareness and detection. The increased prevalence of diabetes in males is unexplained, but, consistent with other studies (Williams et al, 1985), it may be the result of the insulin resistant effects mediated by androgens.

World-wide there is also evidence for increased diabetes prevalence in persons of low SES, in the USA low income was associated with a higher prevalence of diabetes (Adams et al, 1990) and in Israel the incidence of diabetes was inversely related to educational attainment (Medalie et al, 1974).

Higher diabetes prevalence in the most deprived areas could be due to various factors, including obesity and reduced physical activity causing decreased insulin sensitivity. Smoking and unhealthy diet have also been implicated in NIDDM causation. The major cardiac risk factors are also NIDDM risk factors. Targeting these risk factors may have a double benefit.

Diabetes in the UK is following the trend previously set by coronary artery disease; what was once a disease of affluence is now a disease of poverty. The high prevalence of diabetes has implications for resource allocation, since deprived persons not only experience a higher prevalence of diabetes , but, also of its complications.

Chapter 6
British Diabetic Association membership among persons with diabetes living in Scotland by deprivation category.

Introduction

Diabetes has become an important issue in health politics particularly since primary care has been asked to manage NIDDM patients. Patient organisations are in a position to influence governments with regard to health policy. This influence is in part related to size, representation and membership profile. The British Diabetic Association (BDA) represents patients, relatives and health care professionals. The decision by a person with diabetes to become a member of the BDA implies a positive attitude towards diabetes, in comparison with those who chose not to. Members of the BDA are able to raise issues and effect policy for diabetes related issues at both local and national levels.

There are health and financial issues which particularly relate to diabetes and low socio-economic status. Diabetic persons of low socio-economic status have a higher prevalence of cardiac risk factors Connolly et al, 1993) and higher morbidity (Kelly et al, 1993) than more affluent counterparts. Persons living in areas of low socio-economic status use healthcare resources differently for example lower attendance at health checks than persons in areas of high socio-economic status. Financial issues centre around the cost of insulin needles, blood glucose meters, hospital attendance and diet. In a wider social setting diabetic persons may encounter problems with education, employment (Ardon et al, 1987) and financial services (Frier et al, 1984). As many of these problems are likely to be worse in socially deprived persons, improving representation from socially deprived groups will clarify these issues.

Members of the British Diabetic Association have been used to form cohorts for studies of diabetes epidemiology particularly mortality. These studies could be subject to selection bias if the membership of the BDA was not representative of the total population.

Method

The BDA provided a list of members with diabetes from Scotland including treatment type, sex and post codes. Socio-economic status was measured using the deprivation categories of Carstairs and Morris described earlier. These were allocated to post code sectors (Carstairs and Morris, 1991) The scores were then grouped into one of seven deprivation categories ranging from 1 the most affluent to 7 the most deprived.

Using census data, the expected numbers of diabetic patients in each category were calculated. This assumed a uniform prevalence of 1.5% for all diabetes in each deprivation category. Recent estimates suggest one quarter are insulin treated (Connolly et al 1995).

Statistics

The data was analysed using the epidemiology statistical package from the Centre for Disease Control in Atlanta. Chi-squared for linear trend was used to compare the prevalence rates between the deprivation categories. A diabetes prevalence of 1.5% was assumed across Scotland in each deprivation category, of which 25% were assumed to be insulin treated.

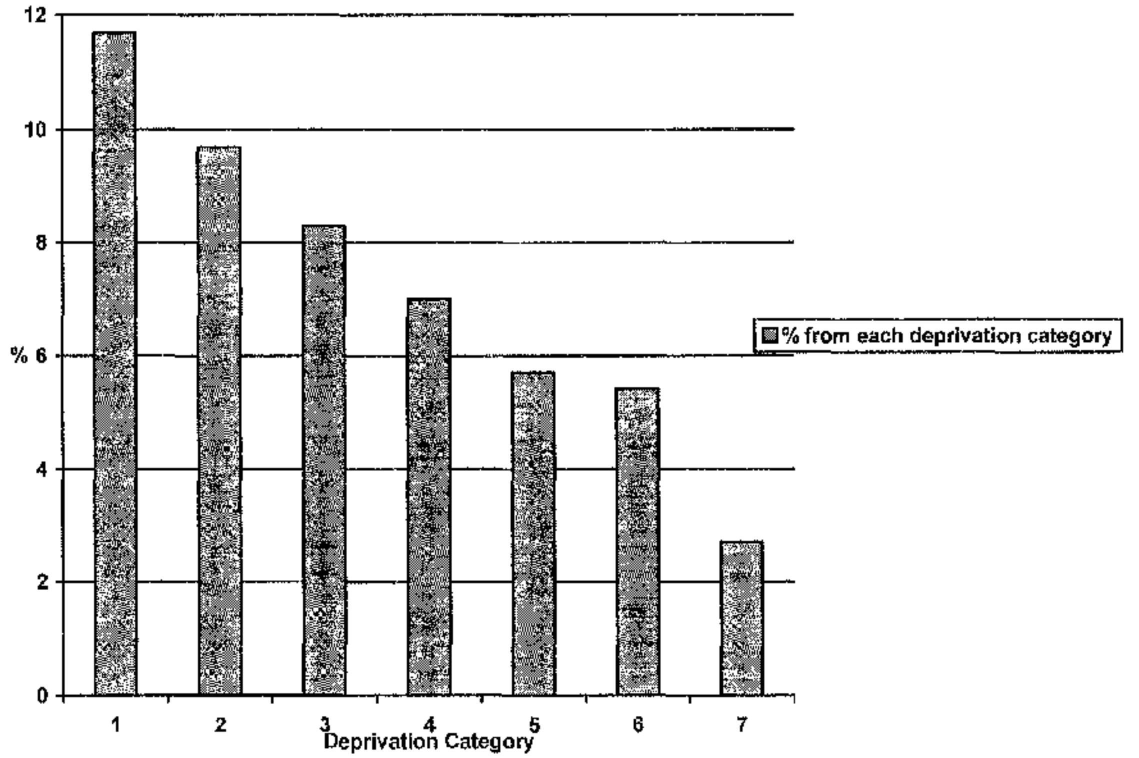
Results

The total number of members resident in Scotland was 5,649 with diabetes. Diabetes treatment and deprivation categories were known for 5307. There were an estimated 75,484 diabetic persons in Scotland (table 6.1), of which 18,871 persons were estimated to be insulin treated. This suggests 7.5% of those with diabetes are members of the BDA, 18.6% of insulin treated patients and 3.2% of diet and tablet treated patients. Membership of the BDA was lower in the deprivation categories with odds ratios for categories 1 to 7 of 1.00, 0.81, 0.68, 0.57, 0.45, 0.43 and 0.21 respectively ($p<0.00001$). Figure 6.1 shows the comparative representation within each deprivation category.

Table 6.1 Estimated numbers of persons with diabetes and BDA members in Scotland by deprivation category.

Deprivation Category	Total Population	Estimated no. with diabetes	No. of BDA members
1	305,868	4,588	536
2	691,280	10,369	1,003
3	1,095,583	16,434	1,362
4	1,282,976	19,244	1,350
5	743,689	11,155	632
6	571,901	8,579	463
7	340,998	5,115	139
Total	**5,032,295**	**75,484**	**5,485**

Figure 6.1 Percentage of total (expected) no. of diabetic persons in Scotland who are members of the BDA in each deprivation category, 1=most affluent, 7=most deprived.



The association of low BDA membership and high deprivation was evident among those with insulin treated diabetes n=3518, p<0.00001, those treated with diet or tablets n=1789, p<0.00001 and in males n=2692, p<0.00001 and females n=2763, p<0.00001.

Discussion

The measure of socio-economic status used in this study includes factors that relate only to material wealth, unlike other measures which include health measures and selected population groups (Jarman 1983; DoE, 1983). We can say that socio-economic deprivation is an important factor in the constitution of the BDA's membership. There is evidence to suggest that non insulin dependent diabetes (NIDDM) has a higher prevalence in deprived communities, (Simmons et al, 1989; Connolly et al, 1996) this would suggest that an even smaller proportion of diabetic persons from deprived communities than we have estimated are members of the BDA. This would increase the disparity in representation between the most affluent and deprived groups.

Membership of the BDA is also strongly influenced by modality of treatment, a high proportion of insulin treated patients being members. This is undoubtedly because diabetes requiring insulin treatment is perceived to be more serious than that requiring diet or tablets. This perception is inaccurate as the effect of diabetes complications is as severe in those treated with tablets alone.

This finding also has important implications for studies using BDA members as study cohorts. Previous studies have shown that general medical and diabetes related mortality are influenced by socio-economic factors. As persons of low socio-economic status are less likely to be members of the BDA, then such studies will underestimate, smoking, obesity and diabetes associated morbidity and mortality.

The finding of low membership among diabetic persons of low socio-economic status raises important issues. Membership fees include a differential to promote membership in such categories, (see table 6.2) therefore cost is likely to be a factor in some but not all cases. Payment methods by cheque or credit card are also more difficult, if there is no direct access to banking further charges will be incurred. The feeling of not belonging to society, social isolation and loss of self esteem among many deprived persons are probably important factors. Overcoming these problems may not be possible for individual organisations.

The agenda of the BDA includes the following (a) define diabetes related issues which will be confronted in the next 10 to 20 years, (b) increase membership and participation, (c) address local issues relating to diabetes services and (d) to encourage diabetes research. Issues relating to access to diabetes care, free monitoring equipment, free needles and appropriate diabetes education can be addressed at a local level. It is advised that the membership of local diabetes service advisory groups (LDSAG) include lay members who are likely to be BDA members. The specific problems facing diabetic persons in deprived areas may not be represented. Provided funds are available, an offer of free membership to select categories of patients may be possible.

Solving these problems requires debate between diabetes health care professionals and diabetic persons from socially deprived areas. It is essential that membership of the BDA is promoted to encourage this.

Summary

Diabetic persons of low socio-economic status are not proportionally represented among the membership of the British Diabetic Association which is the major representative body in the UK for diabetes, despite a favourable structuring of fees. One of the means by which the problems of socio-economic status and diabetes may be discussed and tackled is through the BDA.

Table 6.2 Annual membership fees for the British Diabetic Association.

Membership category	Current Rate (£)	New Rate (£)
Reduced	3	4
UK annual	12	15
UK life	210	210
Child	3	5
Family	15	20
Pensioner Life	50	50
Overseas Annual	25	30

Chapter 7

Conclusions

Limitations of thesis

Several important aspects of this thesis need to be considered when interpreting the results and considering the applicability of the findings to other populations. These are discussed below.

Study population

The cardiovascular studies described in chapters 3 & 4 are based on a cohort of persons attending a hospital diabetes clinic. This could potentially bias the results with varying effects. The study group may be unrepresentative of the general population with diabetes, although the study population was compared to other UK population groups for age and sex distribution, these studies involved population groups from Southern England which may not be the ideal comparative populations. These three studies were geographically distant from the West of Scotland and are not representative of the urban population studied in this thesis. Furthermore, the studies from the mid-eighties have low prevalence levels of NIDDM, which may represent low detection rates which have since improved with greater awareness of diabetes among the general population and health care professionals, particularly primary care, or a genuine rise in the prevalence of NIDDM over the last ten years. Recently, the Diabetes Audit and Research In Tayside Study group (DARTS) have published details of diabetes prevalence in Tayside, Dundee and the surrounding area, reporting a prevalence of diabetes of 1.94% detected using electronic capture-recapture linkage (Morris et al, 1997), this study may be a better comparator for future studies.

Despite the problems of comparison with other studies this does not preclude the population differing in other respects. A hospital population group may have more persons with "severe" diabetes, more co-morbid conditions, or persons who are motivated to attend the diabetes clinic and comply with therapy.

On a socio-economic level different biases could potentially influence the deprived population relative to the more affluent group. Persons of low social class use primary care facilities more frequently but are less likely to attend well man or woman screening programs at which glucose, blood pressure and lipids are measured. Furthermore, attendance at clinics may be difficult for persons living in the peripheral housing estates on the outskirts of the city. Those with co-morbidity may be more motivated to attend or on the other hand assume diabetes management is in hand at other clinics and thus fail to attend the regular clinic. Unfortunately the overall effect of these biases are difficult to ascertain.

Survival Bias

These studies detected individuals who were alive at the time of the study. This could result in an underestimate of the effect of cardiovascular risk factors and the prevalence of coronary artery disease. An underestimate is likely as individuals with these conditions have a higher mortality. Further development of this hypothesis would suggest then that the survival bias would lead to an under ascertainment of risk factors, coronary artery disease in persons with diabetes from areas of low socio-economic status compared to those from areas with high socio-economic status. This would also influence data collection for diabetes prevalence.

Ecological fallacy

The ecological fallacy questions the validity of applying area based scores to individuals, thus an individual is given the average score for the district. Studies suggest this methodology is valid but at the extreme ends of the scoring system, the most affluent and the most deprived are drawn back towards the median score. This is equivalent to regression towards the mean. This regression could result in an underestimate of the effects of socio-economic status on health, but in practice only a relatively small number of the study group fall into these categories. Other measures of socio-economic status currently available within the UK such as social class and educational status, which is strictly a proxy overcome the problem of the ecological fallacy but have their own inherent problems.

Measuring diabetes prevalence

The study of diabetes prevalence in Middlesbrough was based on the recording of cases of known diabetes recorded in general practitioner records. This will probably have resulted in an under reporting of diabetes in the general population group. Although the results show a higher prevalence of diabetes compared to the population surveys in the South of England, the DARTS data would probably be more appropriate as a comparator. My study was commenced and completed before the DARTS study.

The detection of diabetes by inspection of GP records may be affected by use of primary care services. In general persons living in areas of low socio-economic status make a larger number of visits to primary care compared to those in more affluent areas but they have lower attendance rates at screening services eg well man or woman clinics where testing for diabetes takes place.

Calculating BDA membership rates

This study involved a comparison between the most affluent and deprived groups assuming a uniform prevalence rate. The previous study suggests that the diabetes prevalence rate is in fact higher among those of low socio-economic status relative to those from higher socio-economic status thus the differential between the most affluent and most deprived groups is likely to be even higher than that reported in the study. This further reinforces the importance of trying to improve representation among these individuals of low socio-economic status so that a better understanding of the specific problems faced by them may be appreciated. Therefore, proposals to improve the health of these individuals may be implemented.

Summary

These criticisms are important in drawing conclusions from the findings of my study. The composition of the study population is a major consideration in deciding whether the data may be generally applied. Clearly within the hospital population there are differences in morbidity and healthcare and it would seem intuitive to suggest that similar socio-economic differences would apply to those cared for exclusively in primary care. For example, differences between the socio-economic groups in coronary artery bypass grafting for individuals with coronary artery disease between the socio-economic groups suggests the possibility of bias in referral rates to tertiary cardiology centres. This may also be true for persons with diabetes so proportionately more diabetic persons from deprived areas with diabetes related morbidity do not get the benefit of specialist services to prolong the length and quality of life.

Conclusions and future research

The purpose of this thesis was to explore the impact of low socio-economic status on the health of patients with diabetes mellitus, a topic which has received little research attention. A strong association has been demonstrated between cardiovascular risk factors, coronary artery disease and diabetes prevalence, furthermore, some of this effect may be subject to intervention. Thus the hypothesis of this thesis has been confirmed, diabetic health is adversely affected by low socio-economic status resulting in an increased experience of coronary artery disease and that the development of the disease itself may be influenced by socio-economic status, a clear association having been established. It had been considered previously that the chronic effects of diabetes were related to the condition itself rather than to the effects of external factors. In chapter 3, I examined the distribution of cardiovascular risk factors among a range of socio-economic groups consisting of individuals with diabetes, smoking and obesity were more common in the most deprived groups, perhaps, more important the risk factors tended to cluster in the most deprived groups indicative of a greatly increased risk of developing coronary artery disease.

Chapter 4, confirmed the suspicion that individuals from the most deprived categories did indeed have a higher prevalence of coronary artery disease but from the cross-sectional design it is difficult to ascertain the contribution of deprivation to coronary artery disease prevalence rates, but, the association remains after accounting for major coronary artery disease risk factors. Effective intervention in the form of coronary artery bypass grafts was considerably lower in the lower socio-economic groups, it is therefore important to encourage appropriate intervention for these unfortunate individuals. Microvascular complications tended to be more common in the most deprived groups when examined together, although no individual complication of retinopathy, neuropathy or nephropathy was more common. Diabetic foot ulceration which carries a high risk of lower extremity amputation was most common in the most deprived groups.

In chapter 5, diabetes prevalence was examined in relation to socio-economic status in the geographical district of Middlesbrough. Diabetes was more common in the most deprived areas of Middlesbrough compared to the most affluent areas and increased in a stepwise fashion across the deprivation quintiles for both males and females. This was mainly the result of an increased prevalence of non-insulin dependent diabetes mellitus in the 40 - 70 year age group. Perhaps factors common to the pathogenesis of non-insulin dependent diabetes mellitus and coronary artery disease occur at increased rates in persons living in poverty compared to those who are more affluent.

The British Diabetic Association (BDA) has been important in representing the views of those with diabetes and their relatives as well as professionals involved in caring for diabetes. Improving the understanding of diabetes would empower the individual from a poor background with diabetes to take measures which would reduce diabetes associated morbidity and mortality. Chapter 6 illustrated the under-representation of the most deprived areas of Scotland. In addition it suggests that studies of BDA patient cohorts are likely to describe the best possible scenario for patients with diabetes.

Exploring this field further requires a prospective population based study in a defined geographical area to examine the rates of new coronary artery disease and microvascular complications or alternatively diabetes associated mortality. I along with my colleague Dr W.F. Kelly in Middlesbrough have been fortunate in securing funding from the BDA to examine mortality rates in 4,500 patients in Teesside. All the individuals identified in the district with diabetes have been flagged with the Office for Population Censuses and Studies (OPCS) and a copy of the death certificate will be forwarded to us allowing calculation of mortality rates within socio-economic groups.

Exploration of the biological relationship between socio-economic status and disease would be invaluable, increased levels of hormones which are counter-regulatory to insulin namely cortisol, adrenaline and growth hormone would have serious implications for diabetes but may offer the possibility of different therapeutic strategies in tackling the problems of poverty and health, however, this research field is very much in its infancy and it is yet to be established the levels of these hormones in different socio-economic groups of diabetic persons.

Clearly then socio-economic status has a considerable impact on diabetes mellitus and its complications, other factors outwith the scope of medicine impact upon this, however, it is imperative that doctors involved in diabetes care are aware of the problems poverty has on diabetes and provide optimal diabetes care for all.

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